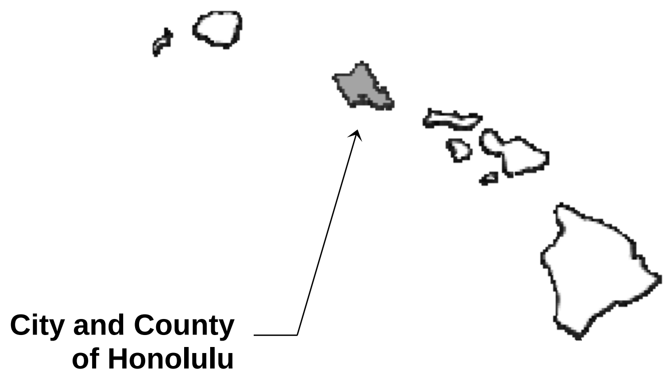
FLOOD INSURANCE STUDY

VOLUME 2 OF 4

CITY AND COUNTY OF HONOLULU, HAWAII

Community Name	Community Number
CITY AND COUNTY OF HONOLULU	150001



REVISED
November 5, 2014

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
15003CV002C

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study (FIS) may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

Part or all of this FIS may be revised and republished at any time. In addition, part of this FIS may be revised by the Letter of Map Revision process, which does not involve republication or redistribution of the FIS. It is, therefore, the responsibility of the user to consult with community officials and to check the community repository to obtain the most current FIS components.

This FIS report was revised on the Revised FIS Dates shown below. Users should refer to Section 10.0, Revisions Description, for further information. Section 10.0 is intended to present the most up-to-date information for specific portions of the FIS report. Therefore, users of this FIS report should be aware that the information presented in Section 10.0 supersedes information in Sections 1.0 through 9.0 of this FIS report.

Initial FIS Effective Date:	November 20, 2000
Revised FIS Dates:	September 30, 2004 June 2, 2005 (Flood Insurance Rate Maps only) January 19, 2011 November 5, 2014 – To change special flood hazard areas, to change base flood elevations, to add new detailed study areas, and to reflect updated topographic information.

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3.2 Hydraulic Analyses

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

For all streams studied by detailed methods in the City and County of Honolulu, the water-surface elevations of floods of the selected recurrence intervals were computed through use of the USACE HEC-2 step-backwater computer program (USACE, 1973). (Newer versions of the USACE HEC-RAS step-backwater computer program were used for more recent studies and revisions; see Section 10.)

Cross sections were determined from topographic maps and field surveys. All bridges, dams, and culverts were field surveyed to obtain elevation data and structural geometry. All topographic mapping used to determine cross sections is referenced in Section 4.1.

For most streams discharging into the ocean, the starting water-surface elevation was based upon the controlling elevation considering the Mean Higher Highwater Elevation, critical depth for supercritical flow, and normal depth for subcritical flow. The starting water-surface elevation for tributary streams was based upon a backwater analysis of the major stream. Other starting conditions include evaluation of control at bridges and culverts. Several large ponding areas near the coastline were evaluated for flood-storage capabilities.

The hydraulic analyses peculiar to the streams studied by detailed methods in the various study areas are as follows:

<u>Kahuku Area</u> – Hoolapa, Kalaeokahipa, Ohia, and Ohia (East) Streams

The hydraulic computations were based upon topographic maps and information obtained from a previous USACE study (USACE, 1971).

The hydraulic analysis for Ohia Stream was different from the other two streams in this study area. In the course of study, it was found that Ohia Stream, seaward of Kamehameha Highway, splits into two separate flows due to a low right overbank and the existence of a levee or berm. The split for the four different study floods was independently evaluated.

Hauula-Punaluu Area – Kaipapau, Waipilopilo, Hanahimoa, Kaluanui, Punaluu, and Wailele Streams

Except for Wailele Stream, the hydraulic computations were based upon topographic maps and information obtained from a previous USACE study (U.S. Department of Agriculture, 1973).

For Wailele Stream Left Overbank and Right Overbank, the cross-section data for the backwater analysis were obtained from topographic maps prepared from aerial photographs (R. M. Towill Corporation, 1986). Stream channel sections and all bridge and culvert geometry were obtained by field survey. The scale of the maps is 1"=200' with a contour interval of 4 feet.

Starting water-surface elevation was computed using a mean high tide level at the Pacific Ocean of +1.9 feet (Local Tidal Datum).

Flows from the adjacent flooding source of Laie-Maloo (Koloa) Stream is combined with Wailele Stream at Kamehameha Highway, where flood boundaries from these two sources merge. This assumes that the 1-percent annual chance flood is concurrent in both watersheds. Inclusion of flows from Laie-Wai Stream was not necessary due to the construction of a flood-control levee system by the USACE.

There are two large ponding areas inland of Kamehameha Highway that are independent of each other. The ponded water-surface elevations for the various frequency floods were computed and used as starting water-surface elevations for the backwater computations.

Revised Wailele Stream (upper) hydraulic methodology, restudied for the November 5, 2014, is described in Section 10.

Kahana Area – Kahana Stream

In computing the water-surface profile upstream of Kamehameha Highway, the northern bridge, which was obstructed by a sand dune during the field review, was assumed to be breached in the hydraulic computations. Residents in that area indicated that the channel was breached during large storms and that during the large floods that did occur, the northern bridge appeared to permit more flow to the ocean than did the southern bridge.

Kaaawa Area – Kaaawa Stream

The hydraulic analyses for this area were based on the topographic map furnished by the City and County of Honolulu (USACE, 1972) and upon technical data obtained from the Floodplain Information Report (USACE, 1969). The ponding area inland of the Kamehameha Highway was determined by using hydrologic data derived from the above-referenced Floodplain Information report and by evaluating the effects of the Kamehameha Highway culverts and bridges. Kamuau Stream was found to have adequate capacity to contain the base flood and therefore was not studied further.

Waikane-Waiahole Area – Waikane and Waiahole Streams

In computing the water-surface profiles for the streams studied by detailed methods in this study area, the cross sections used were obtained from a previous USACE report (U.S. Department of Agriculture, 1973). The resulting water-surface profiles are composites of several trials due to the flow regime switching between subcritical and supercritical flow.

Heeia Area – Heeia Stream

The computations for Heeia Stream were based upon the topographic map furnished by the USACE (U.S. Department of Agriculture, 1973). This map was updated to incorporate recent landfilling along the south bank upstream of Kamehameha Highway.

Kaneohe Area – Keaahala, Kaneohe, Kamooalii, Kawa and Tributary to Kawa Streams

The hydraulic analyses used for streams in this area were obtained from a previous report for the area (U.S. Department of Housing and Urban Development, 1971).

For Keaahala Stream, the topographic map prepared for the USACE Keaahala Stream Flood Control Project was used (USACE, 1970). Modifications to the topographic data were made near the outlet of the stream at Kaneohe Bay because of recent developments and additional topographic data. From Wailele Road to approximately 1,000 feet downstream of Kamehameha Highway, the City has completed a flood-control channel which was not indicated on the original topographic map and was incorporated into the analysis. From 1,000 feet downstream of Kamehameha Highway to approximately 300 feet upstream of the highway, the stream has been improved.

From approximately 300 feet upstream of Kamehameha Highway to Anoi Road, the channel improvement plans are completed; however, construction funds have not yet been appropriated, thus this reach was evaluated in its natural state.

Kawa Stream and its tributary were evaluated using topographic maps furnished by the USACE and the City. The USACE map was used for the lower reach from the mouth through the Bay View Golf Course, and the City map was used for the remainder of the study.

Keaahala Stream hydraulic methodology, restudied for the November 5, 2014 study, is described in Section 10.

Kailua-Lanikai Area – Kaelepulu Stream

The hydrologic analysis for this area was based upon the topographic maps provided by the City. The flooding in the Coconut Grove area was determined by analysis of backwater from Kaelepulu Stream. Kawainui Stream was analyzed with consideration given to the storm drain system presently under construction. The previous FIS covering this area (U.S. Department of Housing and Urban Development, 1971) was based solely upon ponding of the stormwater since this area was without a storm drain system at the time of the study.

Waimanalo Area – Waimanalo Stream, Waimanalo Streams A, B, C, and D, and Inoaole Stream

The hydraulic computations for this area were based upon topographic maps provided by the City and County of Honolulu. Several areas required updating to reflect subsequent residential developments.

Waimanalo: Stream A hydraulic methodology, restudied for the November 5, 2014 study, is described in Section 10.

Aina Haina Area – Wailupe and Kului Streams

The hydraulic computations for Wailupe and Kului Streams were based upon City and County of Honolulu topographic maps supplemented by as-built drawings for channel improvements and bridges.

Waialae-Kahala Area – Waialae-Iki, Kapakahi #1, Waialae-Nui Streams and Waialae Major Drain

The hydraulic computations were based upon the technical data and the topographic maps furnished by the USACE (USACE, 1972).

Waialae-Nui Stream hydraulic methodology, restudied for the November 5, 2014 study, is described in Section 10.

Kalihi-Moanalua Area – Kalihi, Kamanaiki, Lower and Upper Moanalua and Kahauiki Streams

The hydraulic computations for this area were based upon City and County of Honolulu topographic maps and information contained in previous reports covering the area (USACE, 1972; U.S. Department of Housing and Urban Development, 1972).

Channel and bridge improvements which were constructed with the H-1 Freeway were considered in the hydraulic computations.

Cross sections used in the backwater analysis for Kalihi Stream were derived from both aerial topographic maps prepared for this study and from supplemental field surveys. The scale of the maps was 1:2,400 with a contour interval of 4 feet. Cross-section geometry and bridge opening geometry were obtained from supplemental field surveys. For backwater computations, the starting water-surface elevations were based on a previous detailed report prepared for the USACE (USACE, 1977).

For the restudied portions of Kalihi and Kamanaiki Streams above North School Street, cross-section data for the backwater analysis were obtained from topographic maps prepared from aerial photographs (R. M. Towill Corporation, 1974; Sam 0. Hirota, Inc., 1977). Stream and channel sections and all bridge geometry were obtained by field surveys. The scale of the maps used was 1"=200' with a contour interval of 5 feet. All elevations were referenced to Local Tidal Datum.

The starting water-surface elevation was based on the water-surface elevation given at School Street by the previous detailed FIS of Kalihi Stream.

<u>Makaha Area</u> – West Makaha Streams and Makaha Stream

The hydraulic comutations for this area were based upon data obtained from the USACE and upon the topographic map furnishied by the City and County of Honolulu.

Updated Makaha Stream and West Makaha Stream hydraulic methodology is described in Section 10.

<u>Waialua-Haleiwa Area</u> – Kiikii, Kaukonahua, Poamoho, Paukauila, Helemano, and Opaeula Streams and the Anahulu River

The hydraulic analyses for this area were based upon the topographic map and technical data furnished by the USACE (U.S. Department of Housing and Urban Development, 1971; USACE, 1970). The channel bottom profiles for the streams in this area were obtained from the USACE dredging plan study prepared for Paukauila Stream.

<u>Waimea Area</u> – Waimea River

The hydraulic computations for this area were based upon topographic maps and cross-section data furnished by the USACE (USACE, 1972). The hydraulic computations were conducted assuming scouring at the mouth of the Waimea River.

Sunset Beach Area – Paumalu and Pahipahialua Streams

The hydraulic analyses for this area were based upon topographic data obtained from the City and County of Honolulu and upon technical data obtained from a previous USACE report (USACE, 1968).

Waianae Valley Area – Kaupuni Stream

Kaupuni Stream hydraulic methodology is described in Section 10.

Lualualei Valley Area – Maili and Mailiili Channels

Maili and Mailiili Channel hydraulic methodology is described in Section 10.

McCully Area – Makiki Stream

Cross sections used in the backwater analysis for Makiki Stream were derived from both aerial topographic maps furnished by the City and County of Honolulu and from supplemental field surveys. The scale of the maps was 1:2,400 with a contour interval of 5 feet (USACE, 1968). Cross-section geometry and bridge opening geometry were obtained from the State of Hawaii Department of Transportation and the City and County of Honolulu through as-built drawings, and were verified by field observation. For backwater computations, the starting water-surface elevations were based on known hydraulic controls. Due to the topography along Makiki Stream, overtopping of the banks results in unconfined flow. For this reason, the capacity of the stream was computed and the excess flow used to estimate shallow flooding.

Moiliili Area – Manoa Stream, Manoa-Palolo Drainage Canal, Palolo Stream

Cross sections used in the backwater analysis for Manoa Stream were derived as they were for Makiki Stream. Cross section and bridge opening geometry data were supplied by the USACE.

For the Manoa-Palolo Drainage Canal and Palolo Stream, cross sections used in the backwater computations were derived from topographic maps and supplemental field surveys (R. M. Towill Corporation, 1970). Information on bridges and culverts was obtained from the State of Hawaii Department of Transportation and the City and County of Honolulu through as-built drawings verified by field observation. For backwater computations, the starting water-surface elevations were based on known hydraulic controls. The channel "n" values for Manoa Stream and Manoa-Palolo Drainage Canal ranged from 0.020 to 0.035, and the overbank "n" values ranged from 0.040 to 0.060. The channel "n" values for Palolo Stream ranged from 0.020 to 0.040, and the overbank "n" value was 0.050.

Waikiki Area – Ala Wai Canal

Cross sections used in the backwater analysis for the Ala Wai Canal were derived from city and county topographic maps and from supplemental field surveys. Information on bridges and culverts was obtained from the State of Hawaii in the same manner as it was for Makiki Stream. The starting water-surface elevations were based on known hydraulic controls. Since the Ala Wai Canal is affected by Pacific Ocean tides, the backwater computations were started from an elevation of 0.0 foot (Local Tidal Datum). The channel "n" value for Ala Wai Canal was 0.035, and the overbank "n" value was 0.050.

In the upper reaches of the Ala Wai Canal, above its confluence with the Manoa-Pabolo Drainage Canal, the profiles of the 10-, 2-, 1-, and 0.2-percent annual chance floods are nearly identical. Since the flow from the upper Ala Wai Canal is relatively small compared to the flow from the Manoa-Palolo Drainage Canal, the rise in the water surface due to backwater effects is negligible.

Nanakuli Area – Nanakuli and Ulehawa Streams

Cross-section data for the backwater analysis for both streams were obtained from topographic maps prepared from aerial photographs (R. M. Towill Corporation, 1986). Stream channel sections and all bridge and culvert geometry were obtained by field survey. The scale of the maps is 1"=200' with a contour interval of 4 feet.

For Nanakuli Stream, the starting water-surface elevation was computed using a mean high tide level at the Pacific Ocean of +1.9 feet (Local Tidal Datum).

The 1-percent annual chance flood computations show that flooding in the upper portion of the study reach is contained within the channel. Downstream, the flood boundaries are shown to spread over a broad area behind Farrington Highway, mainly in the right overbank. Several closely spaced crossings present a significant obstruction to flow between Farrington Highway and the stream mouth.

For Ulehawa Stream, a cross section was taken in the well-defined, concrete-lined channel for computation of the starting water-surface elevation. The slope/area method was used with a channel slope of 0.00167 ft/ft.

The 1-percent annual chance flood computations show that flooding in the lower portion of the study reach is contained within the channel. The flood boundaries widen slightly in the middle and upper portions of the reach, affecting farms along the right overbank.

Other Areas

Nuuanu and Waolani Streams

Cross sections used in the backwater analysis for Nuuanu and Waolani Streams were derived from both aerial topographic maps prepared for this study (R. M. Towill Corporation, 1984) and from supplemental field surveys. Cross-section geometry and bridge opening geometry were obtained from supplemental field surveys. For backwater computations, the starting water-surface elevations were based on normal-depth calculations as no known hydraulic controls were available. The computations showed that floodwater quantities for the 1- and 0.2-percent annual chance floods exceeded the capacity of the two streams, indicating areas of special flood hazard and areas of shallow flooding. The topography of the study area tends to keep the flooding confined to areas close to the two streams.

Aiea and Kalauao Streams

Cross sections used in the backwater analysis for Aiea and Kalauao Streams were derived from both aerial topographic maps prepared for this study (R. M. Towill Corporation, 1984) and from supplemental field surveys. Cross-section geometry and bridge opening geometry were obtained from supplemental surveys. For backwater computations, the starting water-surface elevations were based on known hydraulic controls for Aiea Stream and a high seawater level of +1.9 feet from Kalauao Stream. The computations showed a narrow special flood hazard area for Aiea Stream with more extensive flooding on Kalauao Stream. The computations show that, downstream of Moanalua Road on Kalauao Stream, there are large areas of special flood hazard and shallow flooding.

Waikele Stream

Cross sections used in the backwater analysis for Waikele Stream were derived from both aerial topographic maps prepared for this study and from supplemental field surveys. The scale of the maps was 1:2,400 with a contour interval of 4 feet. Cross-section geometry and bridge opening geometry were obtained from supplemental field surveys. For backwater computations, the starting water-surface elevations were based on a high seawater level of +1.9 feet. The computations show extensive flooding, especially in the Waipahu Cultural Park area and downstream to the ocean. The 1-percent annual chance flood event computations show special flood hazard areas extending to the east of the stream to Waipahu Depot Road.

Honouliuli Stream

Cross sections used in the backwater analysis for Honouliuli Stream were derived from both aerial topographic maps prepared for this study (R. M. Towill Corporation, 1984) and from supplemental field surveys. Cross-section geometry and bridge opening geometry were obtained from supplemental field surveys. For backwater computations, the starting water-surface elevations were based on a high seawater level of +1.9 feet. The computations show extensive flooding throughout the study area. The large floodplain-type topography promotes unconfined flow, indicating a large portion of the floodplain as special flood hazard areas, with fewer shallow flooding areas because the stream capacity is much less than the 1- and 0.2-percent annual chance floods.

Makaleha and Unnamed Streams

Cross sections used in the backwater analysis for Makaleha and Unnamed Streams were derived from both aerial topographic maps prepared for this study (R. M. Towill Corporation, 1984) and from supplemental field surveys. Cross-section geometry and bridge opening geometry were obtained from supplemental field surveys. For backwater computations, the starting water-surface elevations were based on a high seawater level of +1.9 feet for both streams. The computations show extensive flooding, especially near the ocean. This is due to the limited stream capacity and the flat topography in the low-lying areas.

Malaekahana Stream and Kea'aulu Gulch

Cross sections used in the backwater analysis for Malaekahana Stream were derived from both aerial topographic maps prepared for this study (R. M. Towill Corporation, 1984) and from supplemental field surveys. Cross-section geometry and bridge opening geometry were obtained from supplemental field surveys. For backwater computations, the starting water-surface elevations were based on a high seawater level of +1.9 feet for both streams. The computations show extensive flooding throughout the study area. The stream is clearly incapable of carrying the storm runoff to the ocean, resulting in flooding of the agricultural adjacent areas.

Revised Malaekahana Stream and Kea'aulu Gulch hydraulic methodology, restudied for the November 5, 2014 study, is described in Section 10.

James Campbell Industrial Park Drainage Canal

JCIP Drainage Canal hydraulic methodology is described in Section 10.

Halawa Stream

Halawa Stream hydraulic methodology is described in Section 10.

Waimalu Stream

Waimalu Stream hydraulic methodology is described in Section 10.

Kaalaea, Haiamoa, Waihee, Kahaluu, and Ahuimanu Streams

Cross sections used in the backwater analysis for Kaalaea, Haiamoa, Waihee, Kahaluu, and Ahuimanu Streams were derived from both aerial topographic maps prepared for this study (R. M. Towill Corporation, 1984) and from supplemental field surveys. Cross-section geometry and bridge opening geometry were obtained from supplemental field surveys. Cross-section geometry and bridge opening geometry were obtained from supplemental field surveys. Cross-section geometry for the future flood-control structures were obtained from construction drawings provided by the SCS. For Ahuimanu and Kahalu Streams, cross-section data were obtained from the SCS for the A-1 Channel Improvement and the KA-2 Channel Improvement projects of the overall Kahaluu Watershed Project. For backwater computations, the starting water-surface elevations were based on a high seawater level of +1.9 feet for all streams except for Kahaluu and Waihee which used the water-surface elevations calculated for the flow exiting the new Kahaluu flood-control lagoon. The computations showed that all the streams overflow their banks and flood the adjacent flat areas. The computations also showed that the new flood-control channel on Ahuimanu Stream cannot contain the 1% annual chance flood event.

Kawainui Stream and Oneawa Channel

Cross sections used in the backwater analysis for Kawainui Stream were derived from both aerial topographic maps prepared for this study (R. M. Towill Corporation, 1984) and from supplemental field surveys. Cross-section geometry and bridge opening geometry were obtained from supplemental field surveys. For backwater computations, the starting water-surface elevations were based on known hydraulic controls. The computations show that, while there are areas of shallow flooding, the flood hazard areas do not extend past the streambanks into the developed areas except for a small area near Kaawakea Road.

Oneawa Channel hydraulic methodology is described in Section 10.

Kaloi Gulch

Cross-section data for the backwater analysis were obtained from topographic maps prepared from aerial photographs (R. M. Towill Corporation, 1986). Stream channel sections and all bridge and culvert geometry were obtained by field survey. The scale of the maps is 1"=200' with a contour interval of 4 feet.

The starting water-surface elevation was computed using the slope/area method with a slope of 0.0064 ft/ft.

There is a split flow condition created by the perched streambed. The method agreed upon by the FEMA Project Officer and the R. M. Towill Corporation was to have the entire 1-percent annual chance flood analyzed in each overbank due to the certainty of these flood flows overtopping the stream banks and the uncertainty of which bank would be overtopped.

Waikakalaua Stream

Cross-section data for the backwater analysis were obtained from topographic maps prepared from aerial photographs (R. M. Towill Corporation, 1986). Stream channel sections and all bridge and culvert geometry were obtained by field survey. The scale of the maps is 1"=200' with a contour interval of 4 feet.

The starting water-surface elevation was computed using the slope/area method with a slope of 0.02 ft/ft.

The Waikakalaua Stream flows through a relatively deep gulch with a narrow floodplain. The 1-percent annual chance computations show that the flows are contained within the channel along most of the study reach. The flood boundaries spread out in the middle of the study reach as a result of narrow bridge crossings.

North Halawa Stream

Cross-section data for the backwater analysis were obtained from 1"=480', 2-foot contour interval topographic maps from field surveys (R. M. Towill Corporation, 1984).

The starting water-surface elevation was computed using the slope/area method with a slope of 0.005 ft/ft. A cross section was taken in the well-defined concrete channel below the downstream end of the study reach to facilitate energy balance at the start of the reach.

The computations show that the 1-percent annual chance flood is contained entirely within the channel and does not significantly affect existing developments.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the FIRM (Exhibit 2).

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.

The water-surface elevations for the following streams studied by approximate methods were computed using the USACE HEC-2 computer program (USACE, 1973). Data used in these hydraulic computations were taken from or updated from previous reports covering these streams.

Kaaawa Stream	Poamoho Stream
Kaelepulu Stream	Punaluu Stream
Tributary Kaluanui Stream	Ohia Stream
Kaukonahua Stream	Opaeula Stream
Kului Tributary to Wailupe Stream	Waialae Iki Stream

For all other streams on the Island of Oahu studied by approximate methods, the 1-percent annual chance water-surface elevations were computed using normal-depth computations.

Areas of coastline subject to significant wave attack are referred to as coastal high hazard zones. The USACE has established the 3.0-foot breaking wave as the criterion for identifying the limit of coastal high hazard zones (USACE, 1975). The 3.0-foot wave has been determined as the minimum size wave capable of causing major damage to conventional wood frame and brick veneer structures.

Figure 24, "Transect Schematic," illustrates a profile for a typical transect along with the effects of energy dissipation and regeneration on a wave as it moves inland. This figure shows the wave crest elevations being decreased by obstructions, such as buildings, vegetation, and rising ground elevations, and being increased by open, unobstructed wind fetches. Figure 24 also illustrates the relationship between the local still water elevation, the ground profile and the location of the V/A boundary. This inland limit of the coastal high hazard area is delineated to ensure that adequate insurance rates apply and appropriate construction standards are imposed, should local agencies permit building in this coastal high hazard area.

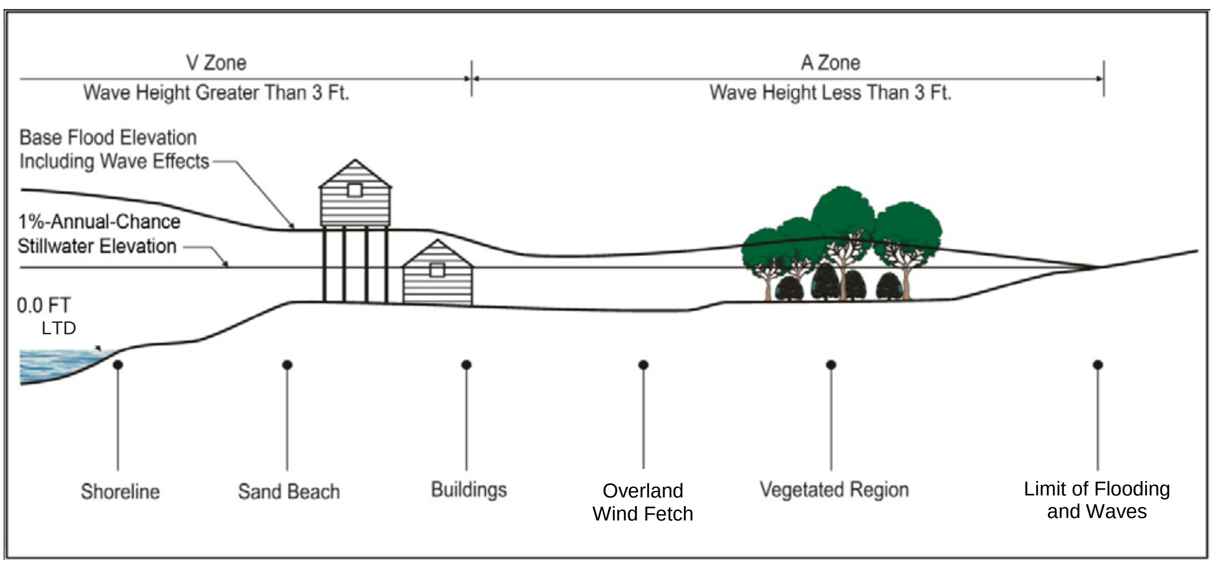

Figure 24: Transect Schematic

Deepwater wave characteristics associated to the 1-percent annual chance storm were developed using the hurricane prediction technique for slowly moving hurricanes as described in the Shore Protection Manual (USACE, 1984). The wave conditions are calculated based on hurricane parameters, such as central pressure deficit, forward translation speed, radius to maximum winds and maximum sustained speed. In particular for the Hawaiian Islands, Hurricane Iniki's parameters from the HURDAT database (1992) were utilized for the application of the prediction technique. FEMA guidelines for V Zone mapping define H_s as the significant wave height or the average over the highest one third of waves and T_s as the significant wave period associated with the significant wave height. Mean wave conditions are described as:

$$\overline{H} = H_S \times 0.626$$
$$\overline{T} = T_S \times 0.85$$

where $\overline{H}$ is the average wave height of all waves and $\overline{T}$ is the average wave period.

The transects were located with consideration given to the physical and cultural characteristics of the land so that they would closely represent conditions in their locality. Transects were spaced close together in areas of complex topography and dense development. In areas having more uniform characteristics, the transects were spaced at larger intervals. It was also necessary to locate transects in areas where unique flooding existed and in areas where computed wave heights varied significantly between adjacent transects. Transects are shown on each FIRM panel.

The transect profiles were obtained using bathymetric and topographic data from various sources. The greater part of the bathymetric data set was comprised of 255 individual surveys NOAA NOS hydrographic surveys, collected from 1900 to 2005. Soundings were originally in the mean lower low water (MLLW) or mean low water (MLW) datums. Relative datum differences were retrieved for NOS water level gages in the Hawaiian Islands, and an average conversion factor was determined for each datum (0.08 m decrease from MLW to MLLW, and 0.8 m increase in depth from MLLW to Local Tidal Datum). The USACE Joint Airborne LiDAR Bathymetry Technical Center of Expertise provided bathymetric LiDAR for the six islands. This dataset was collected in 1999 and 2000, and provided high-resolution coverage of the nearshore bathymetry surrounding the islands. Depths were adjusted from the MLLW datum to Local Tidal Datum and merged with the NOAA dataset. The USACE Honolulu District provided a 2004 hydrographic survey of Honolulu Harbor. Depths were adjusted from MLLW to Local Tidal Datum and merged into the comprehensive dataset. A 2004 multibeam survey of Pearl Harbor conducted by the U.S. Navy was provided by the NOAA National Geophysical Data Center. Depths were converted from MLLW to Local Tidal Datum and merged into the dataset. Once all datasets were assembled, overlapping data was removed to leave the best possible data in the nearshore areas of the islands. The topographic portion of the transect profiles was populated from LiDAR. These data were collected for floodplain mapping along the southern coasts of the six islands included in the study and extends from the shoreline to the approximate 10-meter contour. The LiDAR data were collected in 2006, post-processed to bare earth and quality controlled to meet FEMA mapping standards. LiDAR elevations were delivered in the Local Tidal Datum, therefore no conversion was necessary.

Beach erosion was applied as per standard FEMA (2003) and FEMA (2007) Guidelines and Specifications for Flood Hazard Mapping Partners methodology and VE Zone were mapped up to the extent of the Primary Frontal Dune (PFD).

Nearshore wave-induced processes, such as wave setup and wave runup, constitute a greater part of the combined wave envelope than storm surge due to the islands' high cliffs and location exposed to ocean waves. For this particular environment, the Direct Integrated Method (FEMA, 2007) was used to determine wave setup along the coastline.

Offshore coral reefs surround Hawaii and produce localized variation in wave setup values. A modified wave setup approach was applied in those locations where reefs extend above the breaking depth of the incident wave height. The criterion applied was based upon the methodology outlined by Gourlay (1996).

Wave height calculation used in this study follows the methodology described in the FEMA (2003) and the FEMA (2007) Guidelines and Specifications for Flood Hazard Mapping Partners.

RUNUP 2.0 was used to predict wave runup value on natural shore then adjusted to follow the FEMA (2005) "Procedure Memorandum No. 37" that recommends the use of the 2% wave runup for determining base flood elevations. For steep cliffs and in areas dominated by coral reefs, wave runup was determined using the Technical Advisory Committee for Water Retaining Structures (TAW) method (van der Meer, 2002). In presence of shore-protection structures, wave runup calculations were computed using the appropriate roughness coefficient for the structure. The Shore Protection Manual (SPM) Method was applied in cases of wave runup on vertical structures. For wave run-up at the crest of a slope that transitions to a plateau or downslope, run-up values were determined using the "Methodology for wave run-up on a hypothetical slope" as described in the FEMA (2003) and the FEMA (2007) Guidelines and Specifications for Flood Hazard Mapping Partners.

Figure 25, "Transect Location Map," illustrates the location of each transect. Along each transect, wave envelopes were computed considering the combined effects of changes in ground elevation, vegetation and physical features. Between transects, elevations were interpolated using topographic maps, land-use and land-cover data, and engineering judgment to determine the aerial extent of flooding. The results of the calculations are accurate until local topography, vegetation, or cultural development within the community undergo major changes. The transect data for the three islands are presented in Table 6, "Transect Descriptions," which describes the location of each transect. In addition, Table 6, provides the 1-percent annual chance stillwater, wave setup and maximum wave crest elevations for each transect along the island coastline. In Table 7, "Transect Data," the flood hazard zone and base flood elevations for each transect flooding source is provided, along with the 10-, 2-, 1-, and 0.2-percent annual chance stillwater elevations for the respective flooding source.

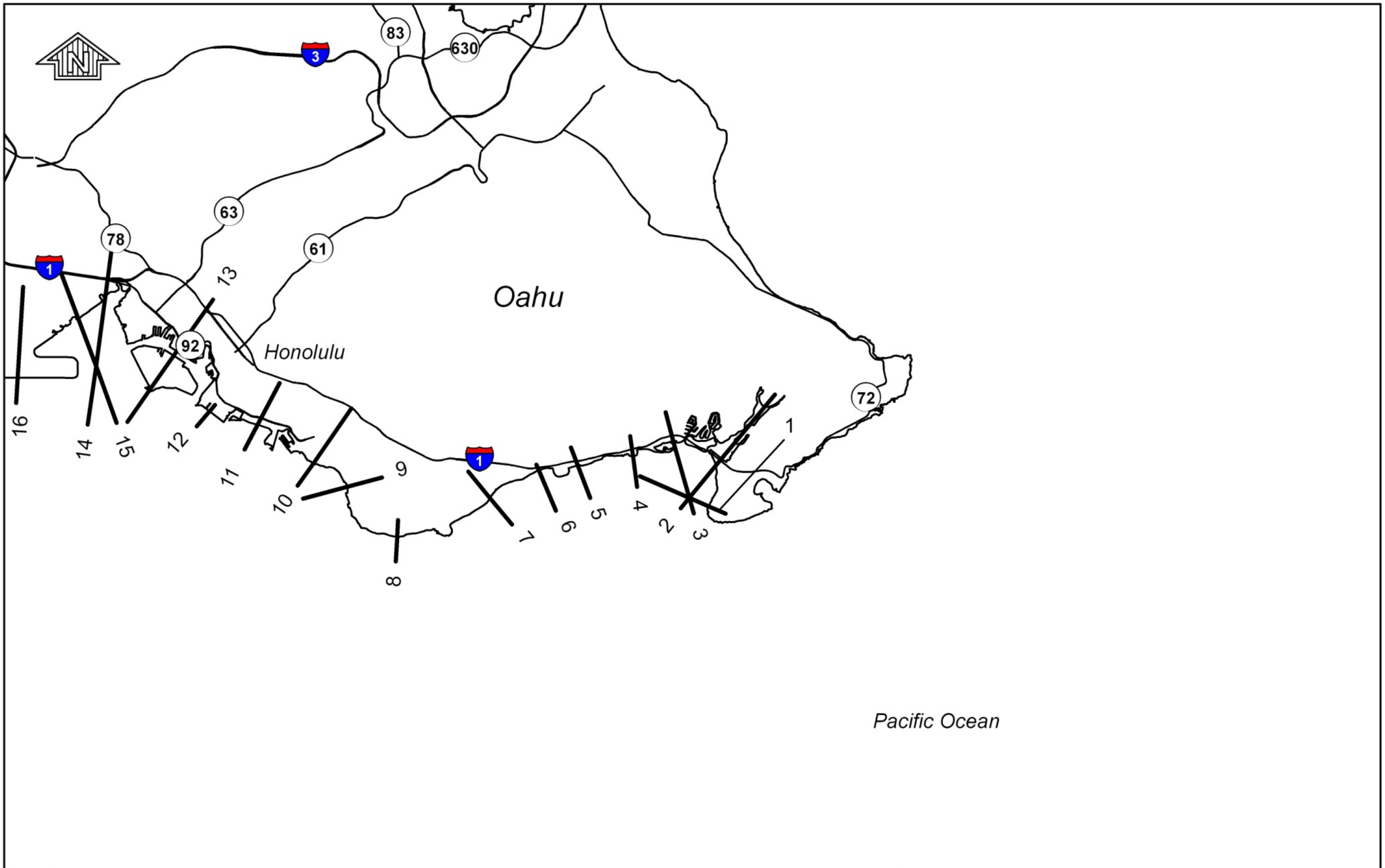

Figure 25

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HAWAII

ISLAND OF OAHU

TRANSECT LOCATION MAP 1

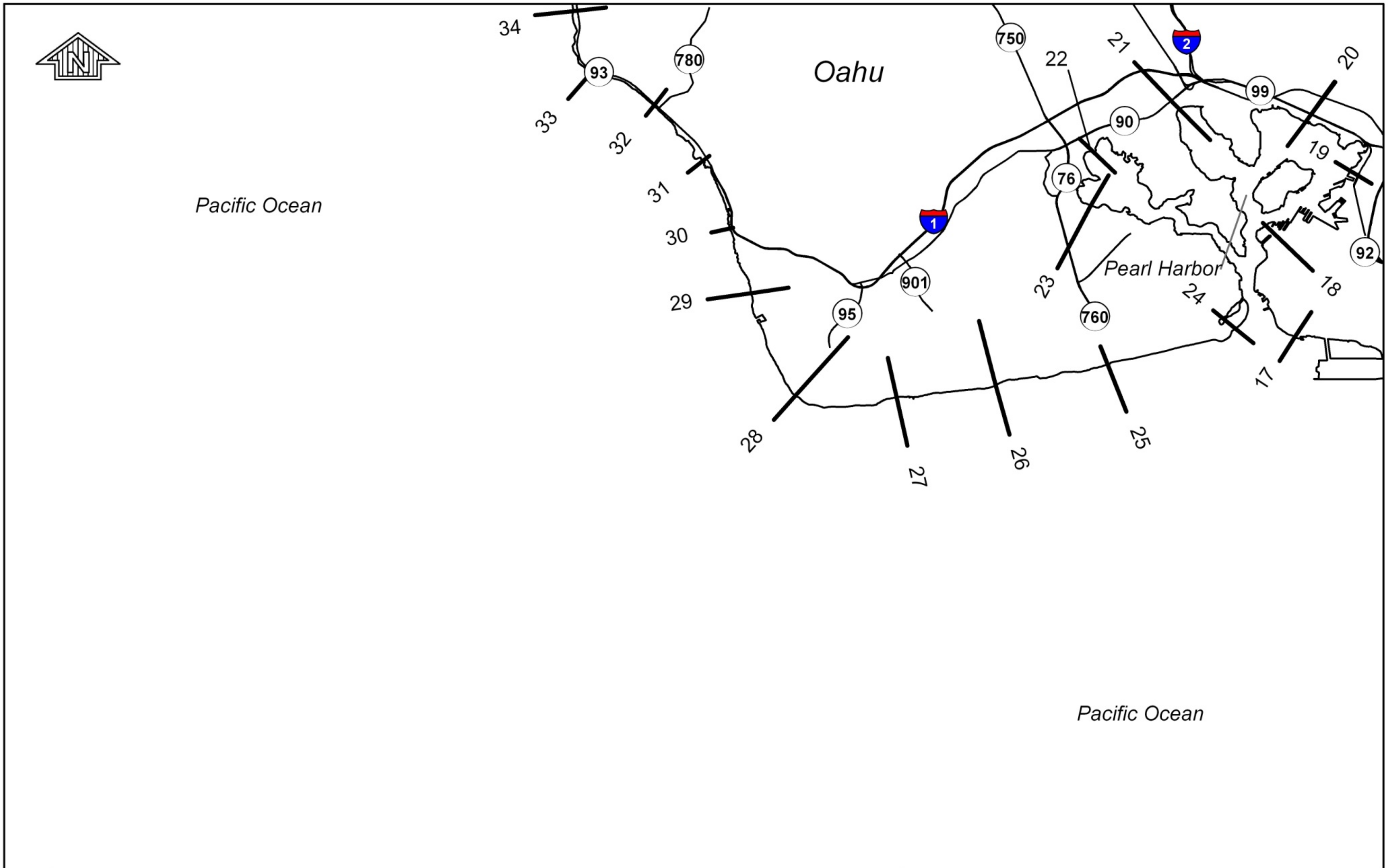

Figure 25

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HAWAII

ISLAND OF OAHU

Approximate Scale

0 2 4 8 Miles

TRANSECT LOCATION MAP 2

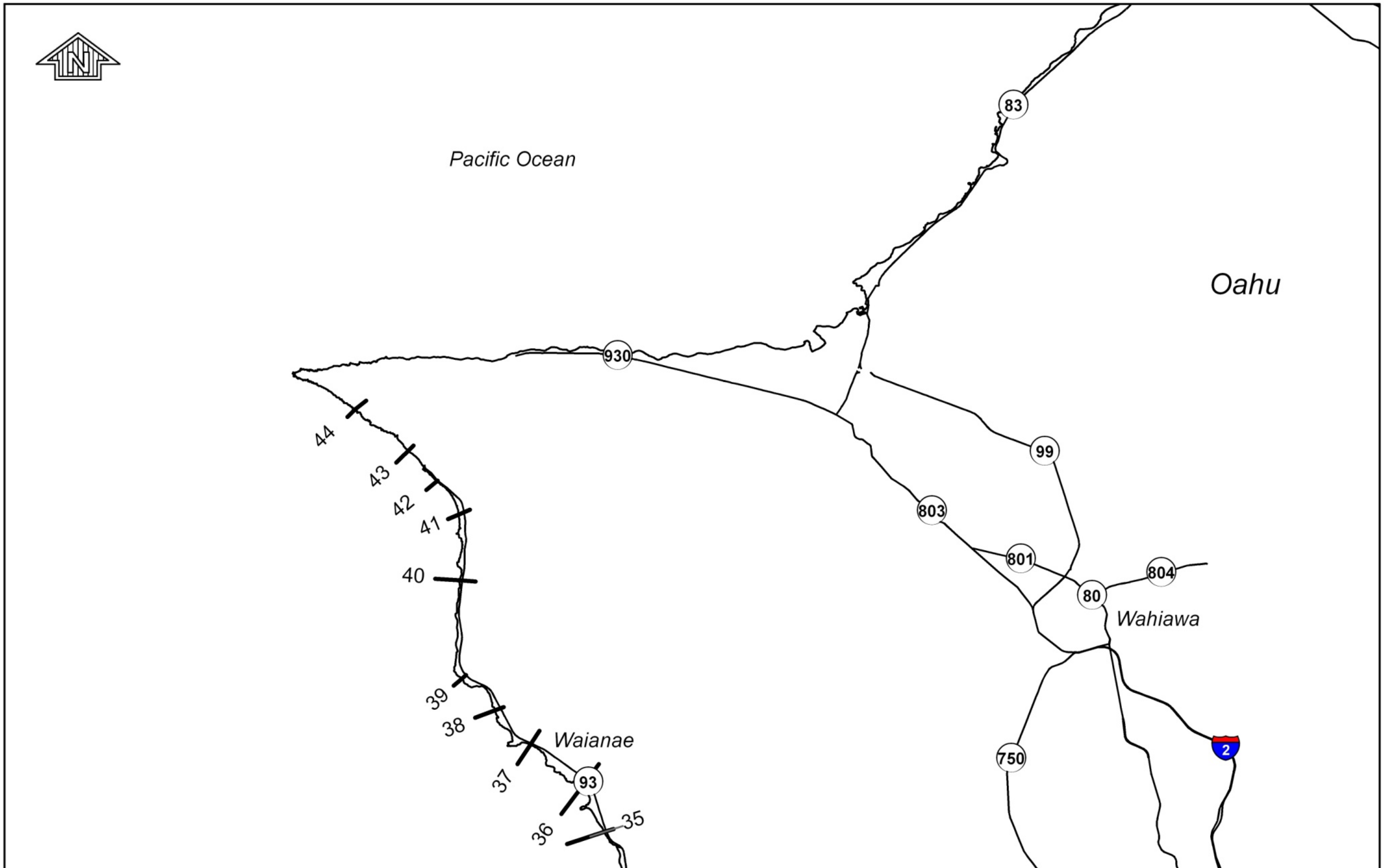

Figure 25

FEDERAL EMERGENCY MANAGEMENT AGENCY
CITY AND COUNTY OF HONOLULU, HAWAII
ISLAND OF OAHU

Approximate Scale
0 2 4 8 Miles

TRANSECT LOCATION MAP 3

Table 6: Transect Descriptions[†]

ISLAND OF OAHU				
		Elevation (feet Local Tidal Datum)		
Transect	Location	1-Percent Annual Chance Stillwater	Wave Setup	Maximum 1-Percent Annual Chance Wave Crest
1	On the Pacific Ocean coastline, on the south side of the island, approximately 300 feet north northwest of the intersection of Moloaa Street and Hanapepe Loop, located on Maunalua Bay, at N 21.26418°, W 157.711158°.	1.1	4.4	9.0[1]
2	On the Pacific Ocean coastline, on the south side of the island, approximately 1,620 feet east northeast of the intersection of Lunalili Road and Kalanianaole Highway (Hwy 72), located on Maunalua Bay, at N 21.276704°, W 157.70931°.	1.1	6.5	11.7
3	On the Pacific Ocean coastline, on the south side of the island, approximately 950 feet south southwest of the intersection of Summer Street and Bay Street, located in the Paiko Lagoon Wildlife Sanctuary, at N 21.282996°, W 157.721895°.	1.5	6.5	12.3
4	On the Pacific Ocean coastline, on the south side of the island, approximately 610 feet southeast of the intersection of Niuiki Circle with itself, located in Niu Valley, at N 21.279649°, W 157.734621°.	1.3	6.7	12.3
5	On the Pacific Ocean coastline, on the south side of the island, approximately 1,870 feet east of the intersection of Wailupe Circle with itself, located in Aina Haina, at N 21.277065°, W 157.751783°.	1.2	6.6	12.0
6	On the Pacific Ocean coastline, on the south side of the island, approximately 1,260 feet east of the intersection of Analii Street and Kaimoku Place, located in Wailupe Beach Park, at N 21.275393°, W 157.763782°.	1.3	6.7	12.3
7	On the Pacific Ocean coastline, on the south side of the island, approximately 490 feet south of the southeast end of Pueo Street, located in Kahala, at N 21.266851°, W 157.778832°.	1.3	6.7	12.1

[†]All elevations reflect the hurricane surge hazard only. Tsunami hazards may dominate in certain areas.
[1] Wave runup elevation

Table 6: Transect Descriptions† (continued)

ISLAND OF OAHU				
		Elevation (feet Local Tidal Datum)		
Transect	**Location**	**1-Percent Annual Chance Stillwater**	**Wave Setup**	**Maximum 1-Percent Annual Chance Wave Crest**
8	On the Pacific Ocean coastline, on the south side of the island, approximately 740 feet east southeast of a lighthouse, located in Diamond Head Beach Park, at N 21.254926°, W 157.807472°.	1.0	6.9	12.2
9	On the Pacific Ocean coastline, on the south side of the island, approximately 320 feet southwest of the intersection of Monsarrat Avenue and Kalakaua Avenue, located west of the Honolulu Zoo, at N 21.270254°, W 157.823029°.	1.2	5.9	10.8
10	On the Pacific Ocean coastline, on the south side of the island, approximately 630 feet southwest of the intersection of Beach Walk and Kalia Road, located on Waikiki Beach, at N 21.277568°, W 157.83338°.	1.1	6.5	11.6
11	On the Pacific Ocean coastline, on the south side of the island, approximately 630 feet southeast of the figure eight in Ala Moana Park Drive, located in Ala Moana Regional Park, at N 21.289588°, W 157.850556°.	1.2	6.9	12.4
12	On the Pacific Ocean coastline, on the south side of the island, approximately 1,430 feet east northeast of the intersection of Koula Street and Olomehani Street, located in Kakaako Waterfront Park, at N 21.293517°, W 157.865551°.	1.1	5.3	12.1[1]
13	On the Pacific Ocean coastline, on the south side of the island, approximately 1,550 feet southwest of the northwest corner of a parking lot at the west end of Sand Island Parkway, located in Sand Island State Park, at N 21.300094°, W 157.884049°.	1.1	6.5	11.7
14	On the Pacific Ocean coastline, on the south side of the island, approximately 1,120 feet south of the intersection of north Nimitz Highway (Hwy 92) and Dan K Inouye Drive, located in Keehi Lagoon Beach Park, at N 21.306413°, W 157.900636°.	1.5	6.6	13.2

†All elevations reflect the hurricane surge hazard only. Tsunami hazards may dominate in certain areas.
[1] Wave runup elevation

Table 6: Transect Descriptions[†] (continued)

ISLAND OF OAHU				
		Elevation (feet Local Tidal Datum)		
Transect	Location	1-Percent Annual Chance Stillwater	Wave Setup	Maximum 1-Percent Annual Chance Wave Crest
15	On the Pacific Ocean coastline, on the south side of the island, approximately 1,120 feet southwest of the southerly of two intersections of Lagoon Drive and Kalewa Street, located at the Honolulu International Airport, at N 21.306497°, W 157.899972°.	1.5	6.6	13.3
16	On the Pacific Ocean coastline, on the south side of the island, approximately 0.695 mile southeast of the southern end of Worchester Avenue, located at the Honolulu International Airport, at N 21.304014°, W 157.924652°.	1.2	6.6	12.0
17	On the Pacific Ocean coastline, on the south side of the island, approximately 480 feet southeast of the intersection of Harbor Drive and Seaman Avenue, located in Fort Kamehameha Military Reservation, at N 21.316479°, W 157.95636°.	1.3	3.2	7.0
18	On the Pacific Ocean coastline, on the south side of the island, approximately 290 feet northwest of the intersection of Crommelin Street and Ford Island Way, located at (Pearl Harbor?) Naval Reservation, at N 21.351306°, W 157.96512°.	1.7	0.0	5.8[1]
19	On the Pacific Ocean coastline, on the south side of the island, approximately 820 feet northwest of the intersection of Kalaloa Street and Arizona Memorial Place, located at Pearl Harbor, at N 21.368183°, W 157.939148°.	1.7	0.0	6.3[1]
20	On the Pacific Ocean coastline, on the south side of the island, approximately 750 feet southwest of the intersection of Hekaha Street and a bike trail through Blaisdell Park, located in Kalauao, at N 21.383464°, W 157.952708°.	1.8	0.0	2.8

[†]All elevations reflect the hurricane surge hazard only. Tsunami hazards may dominate in certain areas.
[1] Wave runup elevation

Table 6: Transect Descriptions† (continued)

ISLAND OF OAHU				
		Elevation (feet Local Tidal Datum)		
Transect	**Location**	**1-Percent Annual Chance Stillwater**	**Wave Setup**	**Maximum 1-Percent Annual Chance Wave Crest**
21	On the Pacific Ocean coastline, on the south side of the island, approximately 1,060 feet east northeast of the intersection of Poailani Circle and Waipio Point Access Road, located by Waipahu High School, at N 21.387249°, W 157.991705°.	2.1	0.0	3.5[1]
22	On the Pacific Ocean coastline, on the south side of the island, approximately 1,300 feet southeast of the intersection of Leoleo Street and Leokane Street, located in Waipaihu, at N 21.372867°, W 158.016998°.	2.4	0.0	3.6
23	On the Pacific Ocean coastline, on the south side of the island, approximately 1,240 feet northeast of the cul de sac at the end of Haiea Place, located in Lower Village, at N 21.357296°, W 158.019048° .123474°.	2.0	0.0	3.1
24	On the Pacific Ocean coastline, on the south side of the island, approximately 380 feet south of the intersection of Marina Drive and Iroquois Drive, located between Ewa Beach and Pearl Harbor Entrance, at N 21.319418°, W 157.97447°.	1.4	3.2	7.2
25	On the Pacific Ocean coastline, on the south side of the island, approximately 650 feet east of the intersection of Pupu Street and Hailipo Street, located on Ewa Beach, at N 21.308341°, W 158.013786°.	1.2	3.2	6.9
26	On the Pacific Ocean coastline, on the south side of the island, approximately 1,203 feet southwest of the intersection of Eisenhower Road and Essex Street, located Barbers Point Naval Air Station, at N 21.301996°, W 158.048299°.	1.2	4.6	8.9

†All elevations reflect the hurricane surge hazard only. Tsunami hazards may dominate in certain areas.
[1] Wave runup elevation

Table 6: Transect Descriptions† (continued)

ISLAND OF OAHU				
		Elevation (feet Local Tidal Datum)		
Transect	Location	1-Percent Annual Chance Stillwater	Wave Setup	Maximum 1-Percent Annual Chance Wave Crest
27	On the Pacific Ocean coastline, on the south side of the island, approximately 0.453 mile southeast of the intersection of Coral Sea Road and Point Cruz Road, located at Kalaeloa Airport — John Rogers Field, at N 21.298329°, W 158.078816°.	1.2	4.9	9.4
28	On the Pacific Ocean coastline, on the west side of the island, approximately 0.558 mile east southeast of the intersection of Kaomi Loop and Hanua Street, located west of Barbers Point Beach Park, at N 21.298745°, W 158.109946°.	1.1	3.9	7.6
29	On the Pacific Ocean coastline, on the west side of the island, approximately 1,820 feet southwest of the intersection of Aliinui Drive and Waipahe Place, located at the Ko Olina Golf Club, at N 21.330396°, W 158	1.1	3.8	9.1[1]
30	On the Pacific Ocean coastline, on the west side of the island, approximately 900 feet southwest of Kahe Point (elev. 277 feet), located at Kahe Point Beach Park, at N 21.350404°, W 158.130013°.	1.1	4.5	9.4[1]
31	On the Pacific Ocean coastline, on the west side of the island, approximately 510 feet south southwest of the intersection of Pohakunui Avenue and Piliokahi Avenue, located in Nanakuli, at N 21.371291°, W 158.138447°.	1.1	4.2	8.1
32	On the Pacific Ocean coastline, on the west side of the island, approximately 200 feet southwest of the intersection of Farrington Highway (Hwy 93) and Maaloa Street, located in Nanakuli, at N 21.388308°, W 158.153625°.	1.1	4.3	8.3
33	On the Pacific Ocean coastline, on the west side ofthe island, approximately 0.440 mile southeast of the intersection of Farrington Highway (Hwy 93) and Kaukama Road, located between Maili and Nanakuli, at N 21.398591°, W 158.172833°.	1.1	4.6	11.3[1]

†All elevations reflect the hurricane surge hazard only. Tsunami hazards may dominate in certain areas.
[1] Wave runup elevation

Table 6: Transect Descriptions† (continued)

ISLAND OF OAHU				
		Elevation (feet Local Tidal Datum)		
Transect	Location	1-Percent Annual Chance Stillwater	Wave Setup	Maximum 1-Percent Annual Chance Wave Crest
34	On the Pacific Ocean coastline, on the west side of the island, approximately 520 feet west-southwest of the intersection of Farrington Highway (Hwy 93) and Kimo Street, located in Maili, at N 21.417518°, W 158.178608°.	1.1	3.2	14.0[1]
35	On the Pacific Ocean coastline, on the west side of the island, approximately 460 feet south southwest of the intersection of Farrington Highway (Hwy 93) and Leihoku Street, located in Waianae, at N 21.433243°, W 158.184543°.	1.1	4.2	8.2
36	On the Pacific Ocean coastline, on the west side of the island, approximately 810 feet southwest of the intersection of Farrington Highway (Hwy 93) and Kaupuni St, located in Waianae, at N 21.447139°, W 158.191558°.	1.2	4.2	8.2
37	On the Pacific Ocean coastline, on the west side of the island, approximately 230 feet west of the intersection of Farrington Highway (Hwy 93) and Makaha Valley Road, located in Makaha, at N 21.460194°, W 158.207411°.	1.1	4.2	9.3[1]
38	On the Pacific Ocean coastline, on the west side of the island, approximately 800 feet west of the intersection of Farrington Highway (Hwy 93) and Upena Street, located in Makaha, at N 21.470615°, W 158.218625°.	1.1	4.3	17.1[1]
39	On the Pacific Ocean coastline, on the west side of the island, approximately 740 feet south-southwest of the intersection of Farrington Highway (Hwy 93) and Lawaia Street, located at Kepuhi Point, at N 21.480389°, W 158.228742°.	1.0	4.6	8.7

†All elevations reflect the hurricane surge hazard only. Tsunami hazards may dominate in certain areas.
[1] Wave runup elevation

Table 6: Transect Descriptions† (continued)

ISLAND OF OAHU				
		Elevation (feet Local Tidal Datum)		
Transect	Location	1-Percent Annual Chance Stillwater	Wave Setup	Maximum 1-Percent Annual Chance Wave Crest
40	On the Pacific Ocean coastline, on the west side of the island, approximately 0.744 mile north of the intersection of Farrington Highway (Hwy 93) and Keaau Homestead Road, located in Keaau, at N 21.510862°, W 158.229317°.	1.1	3.4	6.9
41	On the Pacific Ocean coastline, on the west side of the island, approximately 1,240 feet northwest of the intersection of Farrington Highway (Hwy 93) and Makua Valley Road, located at Kaena Point State Park, at N 21.531214°, W 158.22951°.	1.1	4.6	11.4[1]
42	On the Pacific Ocean coastline, on the west side of the island, approximately 0.434 mile southeast of the intersection of Farrington Highway (Hwy 93) and Satellite Tracking Station Road, located at Kaena Point State Park, at N 21.541334°, W 158.236493°.	1.1	5.2	13.4[1]
43	On the Pacific Ocean coastline, on the west side of the island, approximately 0.437 mile northwest of the intersection of Farrington Highway (Hwy 93) and Satellite Tracking Station Road, located in Kaena Point State Park, at N 21.551109°, W 158.244925°.	1.1	4.2	8.1
44	On the Pacific Ocean coastline, on the west side of the island, approximately 1.82 miles northwest of the intersection of Farrington Highway (Hwy 93) and Satellite Tracking Station Road, located in Kaena Point State Park, at N 21.563635°, W 158.261658°.	1.1	5.0	11.2[1]

†All elevations reflect the hurricane surge hazard only. Tsunami hazards may dominate in certain areas.
[1] Wave runup elevation

Table 7: Transect Data†

Flooding Source	Transect	Stillwater Elevation (feet LTD*) 10-Percent	2-Percent	1-Percent	0.2-Percent	Zone	Base Flood Elevation (feet LTD*)
City and County of Honolulu							
Pacific Ocean	1	0.7	0.8	1.1	2.0	VE	9[2]
						AE	9[2]
Pacific Ocean	2	0.7	0.8	7.6[1]	2.1	VE	10-12
						AE	8-10
		0.7	0.7	5.7[1]	1.4	AE	6-7
		0.7	0.7	2.1[1]	0.9	AE	2-5
		0.7	0.7	0.7	0.9	AE	1
Pacific Ocean	3	0.7	1.0	8.0[1]	3.4	VE	10-12
						AE	8-10
		0.7	1.0	5.6[1]	3.4	AE	6-7
Pacific Ocean	4	0.7	0.9	8.0[1]	2.8	VE	10-12
						AE	8-10
		0.7	0.9	6.7[1]	2.8	AE	7
Pacific Ocean	5	0.7	0.9	7.8[1]	2.6	VE	10-12
							8-10
		0.7	0.9	6.8[1]	2.6	AE	7
Pacific Ocean	6	0.7	0.9	8.0[1]	2.8	VE	10-12
						AE	8-10
Pacific Ocean	7	0.7	0.9	7.9[1]	2.7	VE	10-12
						AE	8-10
		0.7	0.9	5.7[1]	2.7	AE	6-7
Pacific Ocean	8	0.7	0.8	7.9[1]	2.0	VE	10-12
						AE	8-10
Pacific Ocean	9	0.7	0.9	7.0[1]	2.3	VE	9-11
						AE	7-9

†All elevations reflect the hurricane surge hazard only. Tsunami hazards may dominate in certain areas.
*Local Tidal Datum
[1]Includes wave setup
[2]Wave runup elevation

Table 7: Transect Data† (continued)

Flooding Source	Transect	Stillwater Elevation (feet LTD*)				Zone	Base Flood Elevation (feet LTD*)
		10-Percent	2-Percent	1-Percent	0.2-Percent		
City and County of Honolulu							
Pacific Ocean	10	0.7	0.8	7.6[1]	2.3	VE	10-12
						AE	8-10
		0.7	0.8	4.8[1]	2.3	AE	5-7
Pacific Ocean	11	0.7	0.9	8.1[1]	2.4	VE	10-12
						AE	8-10
		0.7	0.9	5.2[1]	2.4	AE	5-7
Pacific Ocean	12	0.7	0.9	1.1	2.2	VE	12[2]
						AE	12[2]
Pacific Ocean	13	0.7	0.8	7.6[1]	2.3	VE	10-12
						AE	8-10
		0.7	0.9	4.2[1]	2.8	AE	4-5
Pacific Ocean	14	0.7	0.9	7.8[1]	2.6	VE	11-13
						AE	8-11
		0.7	1.1	4.4[1]	4.3	AE	4-7
Pacific Ocean	15	0.7	0.9	7.8[1]	2.6	VE	11-13
						AE	8-11
Pacific Ocean	16	0.7	0.9	7.8[1]	2.5	VE	10-12
						AE	8-10
Pacific Ocean	17	0.7	0.9	4.5[1]	2.8	VE	7
						AE	6-7
		0.7	0.9	1.3	2.8	AE	5[2]
Pacific Ocean	18	0.7	1.0	1.7	4.1	VE	62
						AE	62
Pacific Ocean	19	0.7	1.0	1.7	4.4	VE	6[2]
						AE	6[2]
						AO	Depth 1
Pacific Ocean	20	0.7	1.1	1.8[1]	4.6	VE	3
						AE	2-3

†All elevations reflect the hurricane surge hazard only. Tsunami hazards may dominate in certain areas.
*Local Tidal Datum
[1]Includes wave setup
[2]Wave runup elevation

Table 7: Transect Data[†] (continued)

Flooding Source	Transect	Stillwater Elevation (feet LTD*) 10-Percent	2-Percent	1-Percent	0.2-Percent	Zone	Base Flood Elevation (feet LTD*)
City and County of Honolulu							
Pacific Ocean	21	0.7	1.2	2.1	5.0	VE	4[2]
						AE	4[2]
Pacific Ocean	22	0.7	1.4	2.4[1]	5.4	VE	4
						AE	2-4
Pacific Ocean	23	0.7	1.2	2.0[1]	4.6	VE	3
						AE	3
		0.7	1.2	2.0	4.6	AE	2[2]
Pacific Ocean	24	0.7	1.0	4.7[1]	3.0	VE	7
		0.7	1.0	1.4	3.0	AE	7[2]
						AE	1
Pacific Ocean	25	0.7	0.9	4.4[1]	2.6	VE	7
						AE	6-7
		0.7	0.9	1.2	2.6	AE	5[2]
Pacific Ocean	26	0.7	0.9	5.8[1]	2.4	VE	8-9
						AE	6-8
Pacific Ocean	27	0.7	0.9	6.1[1]	2.4	VE	8-9
						AE	6-8
Pacific Ocean	28	0.7	0.8	5.0[1]	1.9	VE	7-8
						AE	5-7
Pacific Ocean	29	0.7	0.8	1.1	2.0	VE	9[2]
						AE	9[2]
Pacific Ocean	30	0.7	0.9	1.1	2.0	VE	9[2]
						AE	9[2]
Pacific Ocean	31	0.7	0.8	5.3[1]	2.0	VE	7-8
						AE	5-7

[†]All elevations reflect the hurricane surge hazard only. Tsunami hazards may dominate in certain areas.
*Local Tidal Datum
[1]Includes wave setup
[2]Wave runup elevation

Table 7: Transect Data[†] (continued)

Flooding Source	Transect	Stillwater Elevation (feet LTD*) 10-Percent	2-Percent	1-Percent	0.2-Percent	Zone	Base Flood Elevation (feet LTD*)
City and County of Honolulu							
Pacific Ocean	32	0.7	0.9	5.4[1]	2.0	VE	8
		0.7	0.9	1.1	2.0	VE	7[2]
						AE	7[2]
Pacific Ocean	33	0.7	0.8	1.1	1.9	VE	11[2]
						AE	11[2]
Pacific Ocean	34	0.7	0.8	1.1	2.0	VE	14[2]
						AE	14[2]
Pacific Ocean	35	0.7	0.8	5.3[1]	2.1	VE	7-8
						AE	5-7
Pacific Ocean	36	0.7	0.9	5.3[1]	2.2	VE	7-8
						AE	5-7
		0.7	0.9	1.2	2.2	AE	1
Pacific Ocean	37	0.7	0.8	1.1	2.1	VE	9[2]
						AE	9[2]
Pacific Ocean	38	0.7	0.8	1.1	2.0	VE	17[2]
						AE	17[2]
Pacific Ocean	39	0.7	0.8	5.7[1]	1.9	VE	9
		0.7	0.8	1.0	1.9	VE	8[2]
						AE	8[2]
Pacific Ocean	40	0.7	0.8	4.4[1]	2.0	VE	7
						AE	4-7
Pacific Ocean	41	0.7	0.8	1.1	2.0	VE	11[2]
						AE	11[2]
Pacific Ocean	42	0.7	0.8	1.1	2.0	VE	13[2]
						AE	13[2]
Pacific Ocean	43	0.7	0.8	5.3[1]	2.0	VE	8
		0.7	0.8	1.1	2.0	AE	8[2]

[†]All elevations reflect the hurricane surge hazard only. Tsunami hazards may dominate in certain areas.
*Local Tidal Datum
[1]Includes wave setup
[2]Wave runup elevation

Table 7: Transect Data[†] (continued)

Flooding Source	Transect	Stillwater Elevation (feet LTD*) 10-Percent	2-Percent	1-Percent	0.2-Percent	Zone	Base Flood Elevation (feet LTD*)
City and County of Honolulu							
Pacific Ocean	44	0.7	0.8	1.1	2.0	VE	11[2]
						AE	11[2]

[†]All elevations reflect the hurricane surge hazard only. Tsunami hazards may dominate in certain areas.
*Local Tidal Datum
[1]Includes wave setup
[2]Wave runup elevation

Qualifying bench marks within a given jurisdiction that are cataloged by the National Geodetic Survey (NGS) and entered into the National Spatial Reference System (NSRS) as First or Second Order Vertical and have a vertical stability classification of A, B, or C are shown and labeled on the FIRM with their 6-character NSRS Permanent Identifier.

Bench marks cataloged by the NGS and entered into the NSRS vary widely in vertical stability classification. NSRS vertical stability classifications are as follows:

- Stability A: Monuments of the most reliable nature, expected to hold position/elevation well (e.g., mounted in bedrock)
- Stability B: Monuments which generally hold their position/elevation well (e.g., concrete bridge abutment)
- Stability C: Monuments which may be affected by surface ground movements (e.g., concrete monument below frost line)
- Stability D: Mark of questionable or unknown vertical stability (e.g., concrete monument above frost line, or steel witness post)

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

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

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

Behind-Levee Analyses

Some flood hazard information presented in prior FIRMs and in prior FIS reports for City and County of Honolulu and its incorporated communities was based on flood protection provided by levees. Based on the information available and the mapping standards of the National Flood Insurance Program (NFIP) at the time that the prior FISs and FIRMs were prepared, FEMA accredited the levees as providing protection from the flood that has a 1-percent annual chance of being equaled or exceeded in any given year. For FEMA to continue to accredit the identified levees with providing protection from the base flood, the levees must meet the criteria of the Code of Federal Regulations, Title 44, Chapter I, Section 65.10 (44 CFR 65.10), titled "Mapping of Areas Protected by Levee Systems."

On August 22, 2005, FEMA issued "Procedure Memorandum No. 34 — Interim Guidance for Studies Including Levees." The purpose of the memorandum was to help clarify the responsibility of community officials or other parties seeking recognition of a levee by providing information identified during a study/mapping project. Often, documentation regarding levee design, accreditation, and the impacts on flood hazard mapping is outdated or missing altogether. To remedy this, Procedure Memorandum No. 34 provides interim guidance on procedures to minimize delays in near-term studies/mapping projects, to help our mapping partners properly assess how to handle levee mapping issues.

While documentation related to 44 CFR 65.10 is being compiled, the release of a more up-to-date FIRM for other parts of a community or county may be delayed. To minimize the impact of the levee recognition and certification process, FEMA issued "Procedure Memorandum No. 43 — Guidelines for Identifying Provisionally Accredited Levees" on March 16, 2007. These guidelines allow issuance of the FIS and FIRM while levee owners or communities compile full documentation required to show compliance with 44 CFR 65.10. The guidelines also explain that a FIRM can be issued while providing the communities and levee owners with a specified timeframe to correct any maintenance deficiencies associated with a levee and to show compliance with 44 CFR 65.10.

FEMA contacted the communities within City and County of Honolulu to obtain data required under 44 CFR 65.10 to continue to show the levees as providing protection from the flood that has a 1-percent annual chance of being equaled or exceeded in any given year.

FEMA understood that it may take time to acquire and/or assemble the documentation necessary to fully comply with 44 CFR 65.10. Therefore, FEMA put forth a process to provide the communities with additional time to submit all the necessary documentation. For a community to avail itself of the additional time, it had to sign an agreement with FEMA. Levees for which such agreements were signed are shown on the final effective FIRM as providing protection from the flood that has a 1-percent annual chance of being equaled or exceeded in any given year and labeled as a Provisionally Accredited Levee (PAL). Communities have two years from the date of FEMA's initial coordination to submit to FEMA final accreditation data for all PALs. Following receipt of final accreditation data, FEMA will revise the FIS and FIRM as warranted.

FEMA coordinated with the local communities and other organizations to compile a list of levees based on information from the FIRM and community provided information.

Approximate analyses of "behind levee" flooding were conducted for all the levees to indicate the extent of the "behind levee" floodplains. The methodology used in these analyses is discussed below.

The Kam Highway embankment with inventory ID # 1 is located on the Kalaeokahipa Stream. Using topographic information from USGS 10m DEMs an approximate area of 1-percent annual chance flooding in the event of failure of the embankment was determined.

The Kam Highway embankment with inventory ID # 3 is located on the Wailele Stream. Using topographic information from USGS 10m DEMs an approximate area of 1-percent annual chance flooding in the event of failure of the embankment was determined by connecting the 1% annual chance floodplain upstream and downstream of the embankment.

The embankment with inventory ID # 4 is located on the Wailele Stream. Using topographic information from USGS 10m DEMs a part of the area of unshaded zone X behind the embankment was recommended as the approximate area of 1-percent annual chance flooding in the event of failure of the embankment.

The Kam Highway embankment with inventory ID # 6 is located on the Malaekahana Stream. Using topographic information from USGS 10m DEMs an approximate area of 1-percent annual chance flooding in the event of failure of the embankment was determined.

The Waialua Beach Road embankment with inventory ID # 9 is located on Paukauila Stream. Using topographic information from USGS 10m DEMs an approximate area of 1-percent annual chance flooding in the event of failure of the embankment was determined by connecting the 1% annual chance floodplain upstream and downstream of the embankment.

The Farrington Highway embankment with inventory ID # 10 is located on Kaukonahua Stream. Using topographic information from USGS 10m DEMs an approximate area of 1-percent annual chance flooding in the event of failure of the embankment was determined by connecting the 1% annual chance floodplain upstream and downstream of the embankment.

The Kam Highway embankment with inventory ID # 18 is located on the Kalauao Stream. Using detailed LiDAR topographic information an approximate area of 1-percent annual chance flooding in the event of failure of the embankment was determined by connecting the 1% annual chance floodplain upstream and downstream of the embankment.

The Kam Highway embankment with inventory ID # 19 and #35 are located on the Waiahole Stream. Using topographic information from USGS 10m DEMs an approximate area of 1-percent annual chance flooding in the event of failure of the embankment was determined by connecting the 1% annual chance floodplain upstream and downstream of the embankment.

The embankment with inventory ID # 20 is located adjacent to the Kahaluu Pond. Using topographic information from USGS 10m DEMs an approximate area of 1-percent annual chance flooding in the event of failure of the embankment was determined.

Levee with inventory ID # 21 is located on the Waihee Stream. Using topographic information from USGS 10m DEMs along with the base flood elevation along Waihee Stream an approximate area of 1-percent annual chance flooding in the event of failure of the embankment was determined.

Levee with inventory ID # 22 is located on the Keaahala Stream. Using topographic information from USGS 10m DEMs the base flood elevations along Keaahala Steram were mapped on the landside of the levee to delineate the approximate 1-percent annual chance floodplain in the event of failure of the embankment.

Levee with inventory ID # 23 is located on the Kawainui Canal. Using topographic information from USGS 10m DEMs an approximate hydrologic and hydraulic analysis was developed delineate the approximate 1-percent annual chance floodplain in the event of failure of the levee.

The Fort Weaver Road embankment with inventory ID # 26 is located on the Honouliuli Stream. Using detailed topographic information from LiDAR an approximate area of 1-percent annual chance flooding in the event of failure of the embankment was determined by connecting the 1% annual chance floodplain upstream and downstream of the embankment.

The East Moanalua Freeway embankment with inventory ID # 28 is located in the Moanalua Stream. Using detailed topographic information from LiDAR an approximate area of 1-percent annual chance flooding in the event of failure of the embankment was determined by connecting the 1% annual chance floodplain upstream and downstream of the embankment.

Levee with inventory ID # 29 is located in the Waialae-Nui Stream. Using topographic information from USGS 10m DEMs the base flood elevations along Waialae-Nui Stream were mapped on the landside of the levee to delineate the approximate 1-percent annual chance floodplain in the event of failure of the embankment.

The H1 Highway embankment with inventory ID # 32 is located on the Manoa Stream. Using detailed topographic information from LiDAR an approximate area of 1-percent annual chance flooding in the event of failure of the embankment was determined by connecting the 1% annual chance floodplain upstream and downstream of the embankment.

Levee with inventory ID # 34 is located on the Stream A. Using topographic information from USGS 10m DEMs an approximate area of 1-percent annual chance flooding in the event of failure of the levee was delineated on the landward side of the levee.

3.3 Vertical Datum

All FIS reports and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared.

All flood elevations shown in this FIS report and on the FIRM are referenced to LTD (Local Tidal Datum). Some FIRM panels in this study are referenced to NGVD 29. Structure and ground elevations in the community must, therefore, be referenced to the LTD or NGVD 29.

For the January 19, 2011, revision, the referenced vertical datum on the revised panels has been changed from NGVD 29 to LTD (Local Tidal Datum). No conversion factor is needed to compare Local Tidal Datum to NGVD 29, therefore Local Tidal Datum is equivalent to NGVD 29.

For more information on LTD, see the NOAA tidal information webpage at http://tidesandcurrents.noaa.gov/datum_options.html.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. To assist in this endeavor, each FIS provides 1-percent annual chance floodplain data, which may include a combination of the following: 10-, 2-, 1-, and 0.2-percent annual chance flood elevations; delineations of the 1- and 0.2-percent annual chance floodplains; and 1-percent annual chance floodway. This information is presented on the FIRM and in many components of the FIS, including Flood Profiles, Floodway Data tables, and Summary of Stillwater Elevation tables. Users should reference the data presented in the FIS as well as additional information that may be available at the local community map repository before making flood elevation and/or floodplain boundary determinations.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent annual chance flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent annual chance flood is employed to indicate additional areas of flood risk in the county. For the streams studied in detail, the 1- and 0.2-percent annual chance floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated.

Information used in delineating floodplain boundaries for each stream studied by detailed methods follows:

Kahuku Area – Hoolapa, Kalaeokahipa, Ohia, and Ohia (East) Streams

The floodplain boundaries for this area were delineated using topographic maps furnished by the USACE and information contained in a previous USACE report (USACE, 1971).

Hauula-Punaluu Area – Kaipapau, Waipilopilo, Hanahimoa, Kaluanui, Punaluu, and Wailele Streams

The flood boundaries for Wailele Stream cover a large area, including the Town of Laie. Most of Laie, in the downstream portion of the left overbank, is inundated by standing water and is designated Zone AO. Near the ocean outlets, velocities increase and create conditions of Zone AE flooding. Flooding information was delineated using topographic maps furnished by the R. M. Towill Corporation (R. M. Towill Corporation, 1986). Only the 1-percent annual chance flood was computed for Wailele Stream.

Revised Wailele Stream (upper) flood boundaries revised in November 5, 2014; see Section 10.

Other floodplain boundaries for this area and historic flooding information were delineated using topographic maps furnished by the USACE and in a previous USGS report (U.S. Department of Agriculture, 1973).

Kahana Area – Kahana Stream

The topographic maps used to delineate flooding along the Kahana Stream were obtained from the State of Hawaii. The technical data used to evaluate the Kahana Stream were obtained from a previous USACE letter report (USACE, 1973).

Kaaawa Area – Kaaawa Stream

The floodplain boundaries for streams in this area were based upon topographic maps furnished by the City and County of Honolulu. All technical data used to evaluate the Kaaawa Stream were obtained from a previous USACE study (USACE, 1969).

Waikane-Waiahole Area – Waikane and Waiahole Streams

The topographic maps used in delineating floodplain boundaries along the streams studied by detailed methods in this area were obtained from the USACE. All technical data used to evaluate streams studied by detailed methods in this area were taken from a previous study (U.S. Department of Agriculture, Map FP-16, 1973).

Heeia Area – Heeia Stream

Topographic maps and technical data used in delineating floodplain boundaries on Heeia Stream were obtained from a previous USACE report for the area (U.S. Department of Agriculture, Map FP-17, 1973).

Kaneohe Area – Keaahala and Kawa Streams, and Tributary to Kawa Stream

Topographic maps and technical data used in delineating floodplain boundaries along streams studied by detailed methods in this area were taken from previous publications (U.S. Department of Housing and Urban Development, 1971; USACE, 1970).

Revised Keaahala Stream flood boundaries revised in November 5, 2014; see Section 10.

Kailua-Lanikai Area – Kaelepulu Stream

The topographic maps used to delineate flood boundaries in this study area were furnished by the City and County of Honolulu. Technical data used to evaluate the detailed-study streams were obtained from previous studies covering the area (U.S. Department of Housing and Urban Development, May 1971).

Waimanalo Area – Waimanalo Stream, Waimanalo Streams A, B, C, and D, and Inoaole Stream

The topographic maps and technical data used in delineating flood boundaries in this area were obtained from a previous study (U.S. Department of Housing and Urban Development, June 1971).

Revised Waimanalo: Stream A flood boundaries revised in November 5, 2014; see Section 10.

Aina Haina Area – Wailupe and Kului Streams

The flood boundaries for the Wailupe Stream were delineated using topographic maps furnished by the City and County of Honolulu. All technical data used to study the Wailupe Stream were obtained from a previous USACE study (USACE, 1971).

Waialae-Kahala Area –Kapakahi, Waialae-Iki, Waialae-Nui Streams and Waialae Major Drain

The floodplain boundaries for streams studied by detailed methods in this area were delineated using topographic maps furnished by the USACE and technical data obtained from previous reports for the study area (USACE, 1972).

Revised Waialae-Nui Stream flood boundaries revised in September 30, 1995; see Section 10.

Revised Waialae-Nui Stream flood boundaries revised in November 5, 2014; see Section 10.

Kalihi-Moanalua Area – Kalihi, Kamanaiki, Lower and Upper Moanalua and Kahauiki Streams

The floodplain boundaries for streams studied by detailed methods in this area were delineated using topographic maps furnished by the USACE and technical data obtained from previous reports for the study area (USACE, 1972; U.S. Department of Housing and Urban Development, January 1971). Information on the H-1 Freeway project in the study area were obtained from a local consulting engineering firm.

For Kalihi and Kamanaiki Streams upstream of North School Street, the floodplain boundaries were delineated using flood elevations determined at each cross section; between cross sections, the boundaries were interpolated using the generated flood profiles and topographic maps supplied by the R. M. Towill Corporation (R. M. Towill Corporation, 1974). The flood boundary for both streams has been designated Zone AE.

Makaha Area – East and West Makaha Streams and Makaha Stream

The floodplain boundaries for streams studied by detailed methods in the area were delineated using topographic maps furnished by the City and County of Honolulu and technical data were obtained from previous reports for the study area (USACE, 1972).

Makaha Stream and East and West Makaha Streams flood boundaries revised in September 30, 1995; see Section 10.

Waialua-Haleiwa Area – Kiikii, Kaukonahua, Poamoho, Paukauila, Helemano, and Opaeula Streams and the Anahulu River

The floodplain boundaries for streams studied by detailed methods in this area were computed using topographic maps furnished by the USACE and upon technical data obtained from a previous USACE study (U.S. Department of Housing and Urban Development, March 1971; USACE, 1970).

Waimea Area – Waimea River

There is a levee along the north bank of Waimea River which provides flood protection to Kamehameha Highway downstream of its crossing. Upstream of the crossing, the levee provides some protection to the private road leading to the Waimea Falls Park. The larger floods, such as the 1- and 0.2-percent annual chance floods, would overtop this levee.

Sunset Beach Area – Paumalu and Pahipahialua Streams

The floodplain boundaries for streams studied by detailed methods in this area were computed using topographic maps obtained from the City and County of Honolulu and technical data obtained from a previous USACE study (USACE, 1968).

Waianae Valley Area – Kaupuni Stream

Kaupuni Stream flood boundaries described in Section 10.

Lualualei Valley Area – Maili and Mailiili Channels

Maili and Mailiili Channel flood boundaries described in Section 10.

Nanakuli Area – Nanakuli and Ulehawa Streams

The flood boundaries for these streams have been designated Zone AE. Flooding information was delineated using topographic maps furnished by the R. M. Towill Corporation (R. M. Towill Corporation, 1986). Only the 1-percent annual chance flood was calculated for these streams.

Other Areas

For Makiki Stream, Manoa Stream, Manoa-Palolo Drainage Canal, Palolo Stream, and Ala Wai Canal, the 1- and 0.2-percent annual chance floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:2,400, with a contour interval of 5 feet (R. M. Towill Corporation, 1970).

For the streams listed below, the 1- and 0.2-percent annual chance floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:2,400 with a contour interval of 4 feet (R. M. Towill Corporation, 1984).

Ahuimanu Stream	Kawainui Stream
Aiea Stream	Makaleha Stream
Haiamoa Stream	Malaekahana Stream
Honouliuli Stream	Nuuanu Stream
Kaalaea Stream	Unnamed Stream
Kahaluu Stream	Waihee Stream
Kalihi Stream	Waikele Stream
Kalauao Stream	Waolani Stream

For Malaekahana Stream, Kea'aulu Gulch, James Campbell Industrial Park Drainage Canal, Halawa Stream, Waimalu Stream, and Oneawa Channel flood boundaries revised for November 5, 2014 study are described in Section 10.

The 1- and 0.2-percent annual chance floodplain boundaries are shown on the FIRM (Exhibit 2). On this map, the 1-percent annual chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A, AE, AH, AO, and VE), and the 0.2-percent annual chance floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 1- and 0.2-percent annual chance floodplain boundaries are close together, only the 1-percent annual chance floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

For Kaloi Gulch, Waikakalaua Stream, and North Halawa Stream, only the 1-percent annual chance floodplain boundaries have been delineated using the flood elevations determined at each cross section.

For Kaloi Gulch, the floodplain boundaries were interpolated between cross sections using topographic maps supplied by the R. M. Towill Corporation (R. M. Towill Corporation, 1986). The entire region between the channel and the outer flood fringe was designated as Zone AH for 1 to 3 feet depth shallow sheetflow flooding. Due to the uncertainty of where flows may overtop the channel banks along the reach of the stream, the entire region between the channel and the computed outer flood limit was designated as an area of equal risk.

For Waikakalaua Stream, the floodplain boundaries were determined between cross sections using topographic maps supplied by the R. M. Towill Corporation (R. M. Towill Corporation, 1986). The flood boundary for this stream has been designated Zone AE.

For North Halawa Stream, the floodplain boundaries were determined between cross sections using topographic maps supplied by the R. M. Towill Corporation (R. M. Towill Corporation, 1984). The flood boundary for this stream has been designated Zone AE.

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

For areas where sheetflow and ponding conditions exist, flood boundaries were delineated using available topographic maps outlined in Sections 3.1 and 3.2.

The statistical methodology that was used to analyze the historical and synthetic tsunami data is described in the report titled Tsunami-Wave Elevation Frequency of Occurrence for the Hawaiian Islands, Tech Report H-77, August 1977, page 23.

The frequency of occurrence distribution used the ten largest tsunami occurring from 1837 to 1964 in Hilo and used a "least-square" method that can be represented by the equation:

$$h = -B - A \log_{io}^{F}$$

where:

h = elevation of maximum tsunami-wave crest above mean sea level 200 feet shoreward of the coastline

F = frequency per year of occurrence

Approximate analysis of "behind levee" flooding were conducted for all the levees in the City and County of Honolulu. The approximate 1-percent annual chance floodplain boundaries behind levees were determined by this analysis. The behind levee floodplain was assign either shaded Zone X if the levee is Provisionally Accredited levee (PAL), or Zone A if the levee is not a PAL. The behind levee floodplain were determined based on either riverside BFEs, or engineering judgment and topographic information obtained by LiDAR method.

4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 1-percent annual chance floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 1-percent annual chance flood can be carried without substantial increases in flood heights. Minimum federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this FIS are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this FIS were computed for certain stream segments on the basis of equal conveyance reduction from each side of the floodplain.

Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections (Table 8). The computed floodways are shown on the FIRM (Exhibit 3). In cases where the floodway and 1-percent annual chance floodplain boundaries are either close together or collinear, only the floodway boundary is shown.

The area between the floodway and 1-percent annual chance floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water surface elevation of the 1-percent annual chance flood by more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 26, “Floodway Schematic.”

For streams in which there are hazardous velocities or where 1-percent annual chance flooding is contained within the channel, encroachment was not recommended. Therefore, floodway boundaries for the following streams (or portions thereof) are recommended as the 1-percent annual chance flood boundaries:

Kapakahi Stream #1	Paumalu Stream
Moanalua Stream (Upper)	Waialae Major Drain

For certain areas of the Ohia, Ohia (East), Kalaeokahipa, Inoaole, and Wailele Streams, floodways were not recommended due to split flow or ponding. Therefore, no floodways are shown on the maps for these areas.

No Floodway Data Tables and cross sections were calculated for the following streams:

Ahuimanu Stream Tributary	Paumalu Stream
Flow Along Cane Haul Road	Waialae-Nui Stream
Kaelepulu Stream	Wailani Drainage Canal
Kului Stream	

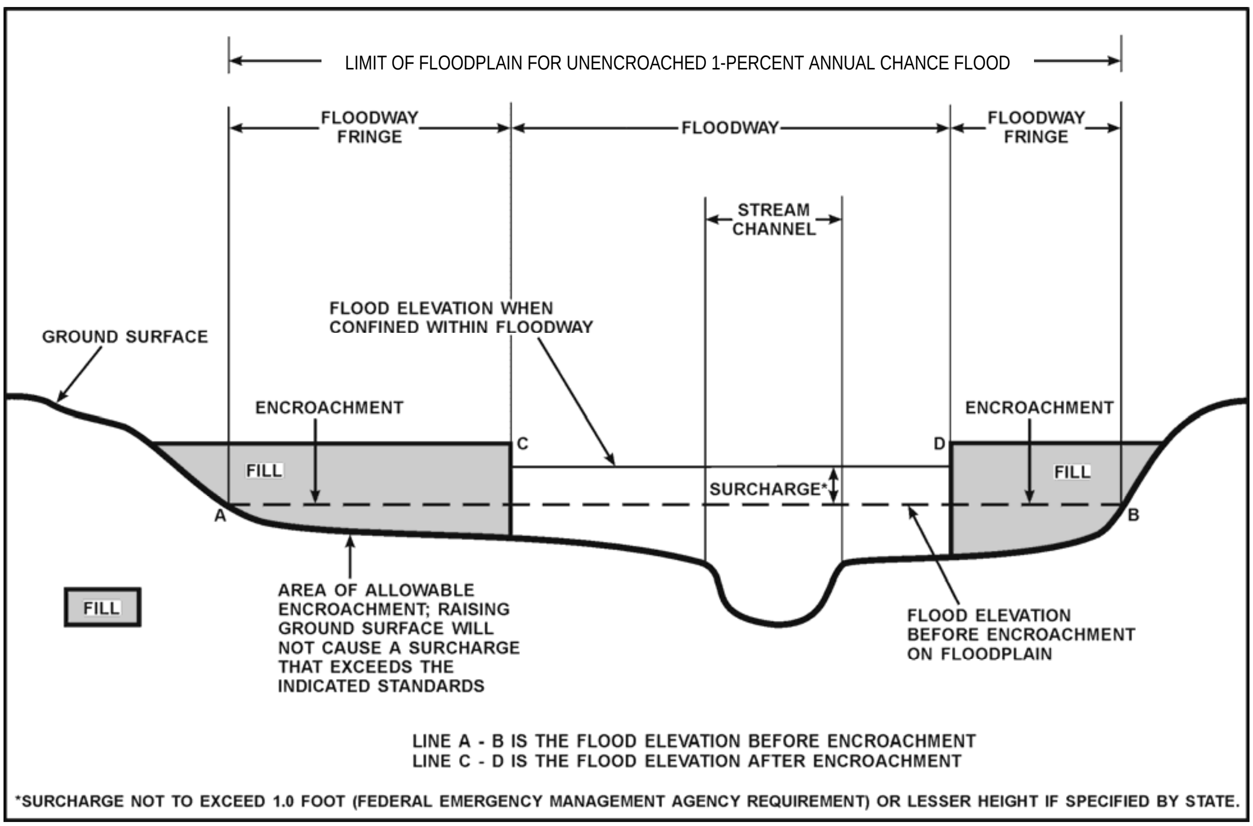

Figure 26: Floodway Schematic

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Hoolapa Stream								
A	-475[1]	298	404	5.0	11.4	11.2[5]	12.2	1.0
B	-25[1]	453	833	2.4	20.7	20.7	21.7	1.0
C	365[1]	264	370	5.4	34.4	34.7	35.5	0.8
Kalaeokahipa Stream								
A	225[2]	4,060	26,052	0.2	11.4	11.4	12.4	1.0
B	818[2]	3,140	13,704	0.3	11.4	11.4	12.4	1.0
C	1,616[2]	1,020	3,527	1.3	12.0	12.0	12.9	0.9
D	2,002[2]	709	1,833	2.5	14.2	14.2	15.0	0.8
E	2,620[2]	300	998	4.5	22.1	22.1	23.1	1.0
Ohia Stream								
A	6,065[3]	721	5,787	0.8	11.4	11.4	12.4	1.0
B	6,950[3]	456	2,271	2.2	13.8	13.8	14.7	0.9
Ohia Stream (East)								
A	3,422[3]	1,907	12,453	0.5	11.4	11.4	12.4	1.0
B	4,822[3]	1,060	6,797	0.9	12.7	12.7	13.6	0.9
C	5,272[3]	464	3,632	1.6	13.2	13.2	14.2	1.0
D	6,142[3]	755	5,848	1.0	16.0[4]	13.6	14.6	1.0
Kaipapau Stream								
A	1,060[3]	299	1,111	7.4	26.0	26.0	27.0	1.0
B	1,500[3]	324	1,131	7.3	35.7	35.7	36.7	1.0
C	2,000[3]	324	1,002	8.2	47.3	47.3	48.3	1.0
D	2,700[3]	175	793	10.3	67.0	67.0	68.0	1.0

[1]Feet above Kamehameha Highway
[2]Feet above confluence with Unnamed Stream
[3]Feet above mouth
[4]Controlled by Ohia Stream
[5]Elevation determined without consideration of ponding

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

HOOLAPA STREAM – KALAEOKAHIPA STREAM – OHIA STREAM - OHIA STREAM (EAST) – KAIPAPAU STREAM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Waipilopilo Stream								
A	500	189	408	6.6	10.5	10.5	11.5	1.0
B	770	207	834	3.2	14.6	14.6	15.6	1.0
Hanahimoa Stream								
A	1,050	121	696	9.9	18.8	18.8	19.4	0.6
B	1,600	107	881	7.8	31.1	31.1	32.0	0.9
Kaluanui Stream								
A	1,720	1,602	5,284	1.8	8.5	8.5	9.5	1.0
B	2,030	1,125	2,512	3.8	9.4	9.4	10.4	1.0
C	2,380	923	2,504	3.8	12.6	12.6	13.6	1.0
D	3,330	512	1,497	6.3	22.8	22.8	23.6	0.8
Punaluu Stream								
A	1,280	1,293	6,857	2.8	12.0	12.0	13.0	1.0
B	1,750	737	4,589	4.1	14.2	14.2	15.2	1.0
C	2,430	769	4,685	4.1	18.4	18.4	19.3	0.9
D	3,080	492	4,546	4.2	22.8	22.8	23.6	0.8
Kahana Stream								
A	3,600	1,117	8,760	1.7	9.8	9.8	10.3	0.5
B	3,900	1,259	7,558	2.0	10.0	10.0	10.5	0.5
C	4,800	1,266	7,943	1.9	10.7	10.7	11.2	0.5
D	5,800	1,264	7,618	2.0	11.6	11.6	12.1	0.5
E	7,000	589	3,005	4.9	13.8	13.8	14.3	0.5
F	7,800	338	2,462	5.7	19.9	19.9	20.9	1.0

[1]Feet above mouth

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

WAIPILOPILO STREAM – HANAHIMOA STREAM – KALUANUI STREAM - PUNALUU STREAM – KAHANA STREAM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Kaaawa Stream								
A	650	192	687	11.2	9.9	9.9	10.9	1.0
B	1,650	164	411	14.2	20.5	20.5	21.1	0.6
C	2,200	135	720	8.1	28.1	28.1	29.1	1.0
D	2,600	143	550	10.6	30.5	30.5	31.3	0.8
E	2,900	121	635	9.2	33.7	33.7	34.7	1.0
Waikane Stream								
A	2,200	460	1,807	5.7	25.0	25.0	26.0	1.0
B	2,400	417	2,455	4.2	27.2	27.2	27.7	0.5
C	2,900	349	1,651	6.2	32.6	32.6	33.4	0.8
D	3,500	216	1,604	6.4	38.2	38.2	39.2	1.0
E	4,400	206	1,343	7.7	50.4	50.4	51.4	1.0
Waiahole Stream								
A	1,500	289	1,343	8.2	17.4	17.4	18.2	0.8
B	1,800	205	1,306	8.4	20.2	20.2	21.2	1.0
C	2,300	320	1,207	9.1	23.3	23.3	23.8	0.5
D	2,900	238	1,460	7.5	30.7	30.7	31.7	1.0
E	3,600	264	1,589	6.9	35.6	35.6	36.6	1.0
Heeia Stream								
A	150	764	3,119	3.0	4.2	4.2	5.2	1.0
B	550	611	2,719	3.5	5.4	5.4	6.1	0.7
C	1,290	973	5,476	1.7	6.3	6.3	7.2	0.9
D	1,950	719	1,834	5.2	7.0	7.0	7.8	0.8
E	2,700	1,834	6,693	1.3	8.3	8.3	9.3	1.0

[1]Feet above mouth

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

KAAAWA STREAM – WAIKANE STREAM - WAIAHOLE STREAM – HEEIA STREAM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET LOCAL TIDAL DATUM)	WITHOUT FLOODWAY (FEET LOCAL TIDAL DATUM)	WITH FLOODWAY (FEET LOCAL TIDAL DATUM)	INCREASE (FEET)
Heeia Stream (continued)								
F	3,530	2,156	3,166	2.7	9.0	9.0	10.0	1.0
G	3,900	1,357	2,706	3.1	10.7	10.7	11.7	1.0
H	4,850	984	1,718	4.9	15.1	15.1	16.1	1.0
I	5,650	670	1,773	4.3	22.5	22.5	23.5	1.0
J	6,510	584	2,038	3.7	31.9	31.9	32.7	0.8
K	7,030	202	713	9.5	36.5	36.5	37.1	0.6
L	7,950	137	486	14.0	51.7	51.7	51.7	0.0
M	8,450	86	406	16.7	61.8	61.8	61.8	0.0
N	9,400	101	363	18.7	73.8	73.8	73.8	0.0
Kawa Stream								
A	0	90	502	8.9	3.0	3.0	4.0	1.0
B	600	69	437	10.1	5.1	5.1	5.7	0.6
C	1,100	58	467	9.4	7.9	7.9	8.9	1.0
D	2,020	187	968	4.5	8.8	8.8	9.7	0.9
E	2,380	68	431	10.2	9.0	9.0	9.2	0.2
F	2,590	316	1,864	2.4	10.8	10.8	11.4	0.6
G	2,800	259	1,398	3.1	10.8	10.8	11.4	0.6
H	3,390	136	536	8.2	11.9	11.9	12.9	1.0
I	3,920	100	327	13.5	15.0	15.0	16.0	1.0
J	4,415	60	245	18.0	23.0	23.0	23.0	0.0
K	5,600	59	311	14.1	45.9	45.9	45.9	0.0
L	6,240	48	201	16.9	55.5	55.5	55.5	0.0
M	7,100	41	138	16.7	61.7	61.7	61.7	0.0
N	7,900	33	175	13.2	84.3	84.3	84.3	0.0

[1] Feet above mouth

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

HEEIA STREAM – KAWA STREAM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET LOCAL TIDAL DATUM)	WITHOUT FLOODWAY (FEET LOCAL TIDAL DATUM)	WITH FLOODWAY (FEET LOCAL TIDAL DATUM)	INCREASE (FEET)
Keaahala Stream								
A	19	150	774	4.8	3.3	3.3	4.3	1.0
B	702	42	547	6.8	5.4	5.4	6.2	0.8
C	1,314	49	251	14.8	44.5	44.5	44.5	0.0
D	1,798	26	223	16.6	48.1	48.1	48.1	0.0
E	2,377	20	225	16.5	54.8	54.8	54.8	0.0
F	3,000	20	204	18.2	60.2	60.2	60.2	0.0
G	3,500	24	215	17.3	64.0	64.0	64.0	0.0
H	4,244	95	328	11.3	82.8	82.8	82.8	0.0
I	4,613	60	465	8.0	89.8	89.8	90.3	0.5
J	5,234	188	624	6.0	96.6	96.6	97.5	0.9
K	5,543	73	534	7.0	104.7	104.7	105.3	0.6
L	6,241	74	435	8.5	109.9	109.9	110.0	0.1
M	6,560	44	408	5.4	118.8	118.8	119.8	1.0
N	7,205	81	231	6.5	127.0	127.0	127.1	0.1
O	7,725	23	210	10.1	138.3	138.3	138.5	0.2

[1] Feet above confluence with Kaneohe Bay

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

KEAAHALA STREAM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET LOCAL TIDAL DATUM)	WITHOUT FLOODWAY (FEET LOCAL TIDAL DATUM)	WITH FLOODWAY (FEET LOCAL TIDAL DATUM)	INCREASE (FEET)
Tributary to Kawa Stream								
A	150	31	71	13.5	62.8	62.8	62.8	0.0
B	535	22	51	18.8	67.7	67.7	67.7	0.0
C	900	24	60	15.9	82.9	82.9	82.9	0.0
Waimanalo Stream								
A	280	863	6,754	2.3	13.0	13.0	14.0	1.0
B	820	1,074	11,170	1.4	13.3	13.3	14.3	1.0
C	1,930	1,103	9,738	1.7	13.4	13.4	14.4	1.0
D	3,000	287	3,334	4.7	13.5	13.5	14.5	1.0
E	4,100	387	3,101	5.0	14.0	14.0	15.0	1.0
F	5,000	464	4,719	3.3	15.1	15.1	16.1	1.0
G	6,040	1,648	18,221	0.9	15.5	15.5	16.5	1.0
H	7,350	1,001	8,140	0.9	15.5	15.5	16.5	1.0
I	8,330	162	771	9.9	24.8	24.8	25.7	0.9
J	9,300	164	679	10.0	31.6	31.6	32.6	1.0
K	10,250	168	542	12.5	41.0	41.0	42.0	1.0
L	11,360	91	409	13.4	53.0	53.0	53.4	0.4
M	12,130	57	457	12.0	62.8	62.8	63.8	1.0
N	12,740	50	434	12.7	72.5	72.5	73.5	1.0

[1] Feet above mouth

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

TRIBUTARY TO KAWA STREAM – WAIMANALO STREAM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET LOCAL TIDAL DATUM)	WITHOUT FLOODWAY (FEET LOCAL TIDAL DATUM)	WITH FLOODWAY (FEET LOCAL TIDAL DATUM)	INCREASE (FEET)
Waimanalo: Stream A								
A	1,000	460	1,650	2.4	15.7	15.7	16.7	1.0
B	1,500	205	1,223	3.3	16.6	16.6	17.3	0.7
C	2,500	73	515	7.8	20.9	20.9	21.8	0.9
D	3,000	32	284	14.1	22.4	22.4	23.0	0.6
E	3,500	38	368	10.9	30.4	30.4	30.9	0.5
F	4,001	72	486	8.3	36.9	36.9	37.3	0.4
G	4,484	42	173	9.4	43.1	43.1	43.3	0.2
H	5,004	85	344	4.7	51.7	51.7	52.7	1.0
I	5,688	120	405	4.0	67.2	67.2	68.2	1.0
J	5,910	67	231	7.0	73.2	73.2	73.3	0.1
K	6,469	41	159	10.2	88.6	88.6	88.7	0.1
L	6,939	54	250	6.5	99.9	99.9	100.6	0.7
M	7,391	60	193	8.4	112.1	112.1	112.2	0.1
N	7,905	24	138	11.8	125.1	125.1	125.4	0.3
O	8,298	40	219	7.4	141.6	141.6	141.9	0.3
Waimanalo Stream: Stream B								
A	175[2]	52	233	12.9	37.3	37.3	38.3	1.0
B	300[2]	119	437	6.9	43.0	43.0	44.0	1.0
C	1,050[2]	41	233	12.9	55.5	55.5	56.5	1.0
D	1,250[2]	90	244	12.3	61.7	61.7	62.7	1.0
E	2,070[2]	400	88	27.3	75.6	75.6	75.6	0.0
F	2,530[2]	122	240	10.0	91.0	91.0	92.0	1.0
G	2,910[2]	41	93	11.8	101.3	101.3	102.3	1.0
H	3,410[2]	47	190	5.8	119.3	119.3	120.3	1.0

[1] Feet above confluence with Waimanalo Stream

[2] Feet above confluence with Waimanalo: Stream A

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

WAIMANALO: STREAM A – WAIMANALO STREAM: STREAM B

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Waimanalo Stream: Stream C								
A	2,600[1]	145	564	3.1	18.9	18.9	19.9	1.0
B	3,200[1]	100	190	9.2	21.1	21.1	21.9	0.8
C	4,060[1]	129	178	9.8	30.4	30.4	31.4	1.0
D	4,410[1]	40	170	10.2	38.3	38.3	39.3	1.0
E	5,000[1]	57	175	9.9	46.1	46.1	47.1	1.0
F	5,665[1]	101	166	7.3	60.8	60.8	61.8	1.0
G	6,530[1]	20	70	17.4	82.6	82.6	83.5	0.9
H	6,880[1]	20	68	17.9	97.4	97.4	98.4	1.0
I	7,530[1]	10	59	20.7	117.0	117.0	117.0	0.0
Waimanalo Stream: Stream D								
A	300[2]	300	535	3.5	19.8	19.8	20.8	1.0
B	900[2]	354	591	3.1	29.6	29.6	30.4	0.8
C	1,260[2]	257	414	4.5	35.6	35.6	36.6	1.0
D	1,500[2]	71	140	13.3	37.4	37.4	38.4	1.0
E	2,020[2]	95	229	8.1	49.3	49.3	50.3	1.0
F	2,500[2]	111	208	6.3	55.7	55.7	56.7	1.0
G	3,000[2]	30	96	13.6	63.4	63.4	64.2	0.8
H	3,640[2]	20	51	14.9	76.7	76.7	77.6	0.9
I	4,320[2]	150	76	10.0	94.5	94.5	95.4	0.9
J	4,670[2]	180	39	19.5	105.9	105.9	105.9	0.0
K	5,080[2]	83	200	3.8	125.3	125.3	126.3	1.0

[1]Feet above confluence with Inoaole Stream
[2]Feet above confluence with Stream C

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

WAIMANALO STREAM: STREAM C – WAIMANALO STREAM: STREAM D

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Waimanalo Stream: Inoaole Stream								
A	6,360[1]	500	1,687	3.0	21.1	21.1	22.1	1.0
B	6,800[1]	193	640	7.8	25.7	25.7	26.7	1.0
C	7,850[1]	203	458	10.9	41.5	41.5	42.3	0.8
D	8,570[1]	114	606	8.3	59.9	59.9	60.9	1.0
Wailupe Stream								
A	600[1]	1,174	*	*	6.8	6.4[3]	7.3	0.9
B	1,200[1]	844	2,956	2.8	8.8	8.8	9.7	0.9
C	3,080[1]	460	1,010	8.1	31.3	31.3	32.2	0.9
Waialae-Iki Stream								
A	800[1]	1,001	2,967	1.0	8.0	6.6[3]	7.6	1.0
B	1,400[1]	297	920	3.3	8.0	6.8[3]	7.8	1.0
C	2,000[1]	280	1,180	2.5	15.6	15.6	16.3	0.7
Kalihi Stream								
A	3,150[2]	670	1,725	10.7	23.1	23.1	24.1	1.0
B	3,700[2]	390	1,901	9.7	23.4	23.4	24.1	0.7
C	4,300[2]	221	1,451	12.7	31.5	31.5	32.5	1.0
D	5,757[2]	137	1,734	9.3	52.8	52.8	52.8	0.0
E	6,312[2]	85	875	18.3	57.1	57.1	57.1	0.0
F	6,567[2]	84	894	17.8	61.4	61.4	61.4	0.0
G	6,977[2]	63	849	18.7	70.6	70.6	70.9	0.3
H	7,317[2]	169	1,435	11.0	76.8	76.8	77.0	0.2
I	7,977[2]	198	966	16.1	95.9	95.9	95.9	0.0
J	9,300[2]	86	913	18.5	109.4	109.4	109.4	0.0
K	10,110[2]	93	911	18.1	124.7	124.7	124.7	0.0

[1]Feet above confluence with Pacific Ocean
[2]Feet above confluence with Keehi Lagoon
[3]Elevation computed without consideration of wave effects
*Data not computed

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

WAIMANALO STREAM: INOAOLE STREAM – WAILUPE STREAM - WAIALAE-IKI STREAM – KALIHI STREAM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Kalihi Stream (continued)								
L	10,535	137	998	16.5	133.0	133.0	133.0	0.0
M	10,810	87	895	18.4	137.6	137.6	137.6	0.0
N	12,255	67	812	19.7	166.9	166.9	166.9	0.0
O	13,465	57	693	20.0	206.2	206.2	206.2	0.0
P	14,405	65	920	14.5	231.4	231.4	231.4	0.0
Q	15,460	80	757	17.6	259.4	259.4	259.4	0.0
R	16,385	62	742	17.2	283.8	283.8	283.8	0.0
S	17,645	67	683	18.3	322.5	322.5	322.5	0.0
T	19,035	75	688	17.5	374.9	374.9	374.9	0.0
U	19,050	125	909	13.2	401.5	401.5	401.5	0.0
V	20,505	153	1,273	9.1	423.7	423.7	424.5	0.8
W	22,250	40	534	20.8	452.4	452.4	452.4	0.0
X	22,665	68	633	17.4	491.8	491.8	491.8	0.0
Y	23,760	60	556	19.2	514.9	514.9	514.9	0.0
Moanalua Stream (Lower)								
A	1,300	218	1,712	7.5	5.5[3]	5.2[4]	5.6	0.4
B	1,900	235	1,675	7.7	5.5[3]	6.2[4]	6.4	0.2
C	2,700	609	3,575	3.3	9.7	9.7	9.8	0.1
D	3,500	620	3,512	3.4	9.9	9.9	10.2	0.3
E	4,100	295	1,793	6.7	10.3	10.3	10.7	0.4
F	4,600	170	1,490	9.1	12.0	12.0	12.0	0.0
G	5,170	493[2]	3,259	4.1	13.6	13.6	14.1	0.5
H	5,750	917[2]	3,024	4.5	15.0	15.0	15.3	0.3
I	6,465	1,451[2]	4,502	3.0	22.4	22.4	22.7	0.3
J	6,755	570	1,508	6.8	22.5	22.5	22.5	0.0
K	7,210	79	611	15.9	24.4	24.4	24.4	0.0

[1]Feet above confluence with Keehi Lagoon
[2]Combined floodway width (Moanalua Stream and Manaiki Stream)
[3]Elevation computed without consideration of wave effects
[4]Elevation computed without consideration of tidal effects from Pacific Ocean

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

KALIHI STREAM – MOANALUA STREAM (LOWER)

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Kahauiki Stream								
A	900[1]	112	920	4.4	7.1	7.1	7.2	0.1
B	1,480[1]	508	1,922	2.1	7.4	7.4	7.6	0.2
C	1,905[1]	658	2,198	1.8	9.8	9.8	9.8	0.0
D	2,400[1]	664	1,345	3.0	10.1	10.1	10.1	0.0
East Makaha Stream								
A	800[2]	462	958	4.4	16.0	16.0	16.8	0.8
B	1,500[2]	327	958	4.4	24.7	24.7	24.7	0.0
C	1,900[2]	355	1,083	3.9	28.5	28.5	28.5	0.0
D	2,600[2]	152	646	6.5	38.5	38.5	38.5	0.0
E	3,300[2]	203	750	5.6	53.4	53.4	53.4	0.0
F	4,300[2]	80	476	8.8	80.2	80.2	80.2	0.0
Kiikii Stream								
A	3,860[3]	434	4,329	7.6	10.6	10.6	11.6	1.0
B	7,400[3]	502	6,053	5.5	15.7	15.7	16.5	0.8

[1]Feet above confluence with Moanalua Stream (Lower)
[2]Feet above confluence with Pacific Ocean
[3]Feet above mouth

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

KAHAUIKI STREAM – EAST MAKAHA STREAM – KIIKII STREAM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Kaukonahua Stream								
A	7,920[1]	136	2,420	10.3	16.0	16.0	17.0	1.0
B	8,800[1]	90	1,541	16.2	17.1	17.1	17.1	0.0
C	9,500[1]	1,459	7,224	3.5	20.5	20.5	21.4	0.9
D	10,350[1]	1,375	4,894	5.1	21.8	21.8	22.8	1.0
E	11,125[1]	711	3,907	6.4	28.5	28.5	29.5	1.0
F	11,900[1]	627	3,858	6.5	30.4	30.4	31.2	0.8
G	13,840[1]	136	1,744	14.3	43.8	43.8	44.8	1.0
Poamoho Stream								
A	750[1]	1,010	6,622	2.7	16.1	16.1	17.1	1.0
B	1,420[1]	1,053	5,126	3.5	16.7	16.7	17.7	1.0
C	2,290[1]	467	2,532	7.1	21.4	21.4	22.3	0.9
D	3,100[1]	504	5,429	3.3	30.1	30.1	30.8	0.7
Paukauila Stream								
A	4,270[2]	581	3,279	5.8	8.4	8.4	9.3	0.9
B	5,400[2]	328	3,273	5.8	10.7	10.7	11.7	1.0
C	6,470[2]	248	2,807	6.8	12.0	12.0	13.0	1.0
Helemano Stream								
A	7,430[2]	323[3]	4,022	4.7	14.6	14.6	15.5	0.9
B	8,350[2]	575	5,934	2.7	15.1	15.1	16.1	1.0

[1]Feet above mouth
[2]Feet above confluence with Kaika Bay
[3]Combined Helemano Stream/Opaeula Stream floodway

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

KAUKONAHUA STREAM – POAMOHO STREAM - PAUKAUILA STREAM – HELEMANO STREAM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Opaeula Stream								
A	520[1]	663[3]	7,155	2.6	13.7	13.7[4]	14.7	1.0
B	1,120[1]	89	1,074	9.3	14.4	14.4	15.3	0.9
C	1,470[1]	84	1,086	9.2	15.3	15.3	16.2	0.9
D	2,860[1]	89	1,148	8.7	27.5	27.5	28.4	0.9
E	3,220[1]	81	934	10.7	27.8	27.8	28.7	0.9
Anahulu River								
A	2,400[2]	522	5,223	3.3	12.2	12.2	13.2	1.0
B	3,160[2]	251	2,587	6.6	12.7	12.7	13.7	1.0
C	4,200[2]	230	2,626	6.5	15.6	15.6	16.6	1.0
D	4,800[2]	287	3,654	4.7	20.9	20.9	21.9	1.0
E	5,200[2]	334	3,294	5.2	21.5	21.5	22.5	1.0
Waimea River								
A	1,210[2]	270	1,909	6.55	7.8	7.8	8.6	0.8
B	1,710[2]	276	2,789	4.48	9.3	9.3	10.1	0.8
C	2,450[2]	101	888	12.61	10.3	10.3	11.3	1.0
D	2,800[2]	100	966	11.59	13.3	13.3	14.3	1.0
Pahipahialua Stream								
A	1,600[2]	157	381	5.3	32.0	32.0	33.0	1.0
B	2,200[2]	52	237	8.4	46.7	46.7	47.7	1.0

[1]Feet above confluence with Paukauila Stream
[2]Feet above mouth
[3]Combined Opaeula Stream/Helemano Stream floodway
[4] Elevation computed without consideration of backwater effects from Helemano Stream

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

OPAEULA STREAM – ANAHULU RIVER - WAIMEA RIVER – PAHIPAHIALUA STREAM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Manoa-Palolo Drainage Canal								
A	1,490	2,760	8,650	2.6	8.2	8.2	9.2	1.0
B	2,700	660	2,228	10.2	13.5	13.5	14.1	0.6
C	3,225	448	2,279	10.0	17.4	17.4	17.7	0.3
D	3,750	100	1,234	18.5	19.8	19.8	19.8	0.0
E	4,325	116	1,319	17.3	23.6	23.6	24.0	0.4
Manoa Stream								
F	4,740	110	2,036	11.2	29.3	29.3	30.3	1.0
G	5,290	115	1,777	7.7	34.9	34.9	35.5	0.6
H	5,890	280	1,519	9.0	39.4	39.4	39.7	0.3
I	6,690	74	733	18.0	45.1	45.1	45.1	0.0
J	7,290	162	935	14.1	52.6	52.6	52.6	0.0
K	7,740	90	776	16.8	61.8	61.8	61.8	0.0
L	8,490	93	618	20.6	72.1	72.1	72.1	0.0
M	9,290	53	617	20.6	89.8	89.8	89.8	0.0
N	10,090	108	789	15.5	107.0	107.0	107.0	0.0
O	10,690	82	556	21.2	115.7	115.7	115.7	0.0
P	11,290	126	1,307	9.0	130.7	130.7	130.7	0.0
Q	11,890	93	622	18.3	134.8	134.8	134.8	0.0
R	12,490	140	799	13.8	146.4	146.4	146.4	0.0
S	12,990	693	2,035	5.4	151.3	151.3	151.3	0.0
T	13,490	238	1,461	7.3	154.4	154.4	155.4	1.0
U	13,890	152	1,449	7.3	158.1	158.1	158.1	0.0
V	14,490	643	1,815	5.5	167.2	167.2	167.2	0.0
W	15,090	693	1,684	5.9	173.4	173.4	173.4	0.0
X	15,640	55	428	22.0	174.0	174.0	174.0	0.0

[1]Feet above confluence with Ala Wai Canal

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

MANOA-PALOLO DRAINAGE CANAL – MANOA STREAM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Manoa Stream (continued)								
Y	16,490[1]	160	717	12.0	185.5	185.5	185.5	0.0
Z	17,290[1]	82	564	15.0	195.0	195.0	195.0	0.0
AA	18,690[1]	57	405	16.8	214.7	214.7	214.7	0.0
AB	19,290[1]	47	364	18.7	222.9	222.9	222.9	0.0
AC	20,690[1]	69	446	14.6	253.7	253.7	253.7	0.0
AD	21,340[1]	94	602	11.2	266.4	266.4	266.4	0.0
Palolo Stream								
A	-320[2]	50	315	16.8	52.8	52.8	52.8	0.0
B	80[2]	53	387	13.6	76.6	76.6	76.6	0.0
C	740[2]	57	376	14.0	84.9	84.9	84.9	0.0
D	1,410[2]	34	306	17.3	95.5	95.5	95.5	0.0
Ala Wai Canal								
A	6,700[3]	265	6,797	0.6	5.8	5.8	5.8	0.0
B	7,200[3]	265	6,322	0.5	5.8	5.8	5.8	0.0
C	7,700[3]	265	4,088	0.7	5.8	5.8	5.8	0.0
D	8,200[3]	265	4,261	0.7	5.8	5.8	5.8	0.0
E	8,670[3]	225	5,247	0.8	5.8	5.8	5.8	0.0
F	9,170[3]	190	4,002	0.9	5.8	5.8	5.8	0.0
G	9,350[3]	225	2,321	1.2	5.8	5.8	5.8	0.0

[1]Feet above confluence with Ala Wai Canal
[2]Feet from St. Louis High School Access Road
[3]Feet above mouth

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

MANOA STREAM – PALOLO STREAM – ALA WAI CANAL

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Nuuanu Stream								
A	60[1]	114	1,132	11.0	17.7	17.7	17.7	0.0
B	110[1]	94	1,141	10.9	18.0	18.0	18.0	0.0
C	375[1]	63	603	13.3	19.8	19.8	19.8	0.0
D	679[1]	62	523	15.3	26.6	26.6	26.6	0.0
E	954[1]	87	555	14.4	49.8	49.8	49.8	0.0
F	1,262[1]	54	472	16.8	56.7	56.7	56.7	0.0
G	1,622[1]	85	557	14.2	65.5	65.5	65.5	0.0
H	2,140[1]	49	552	14.1	75.0	75.0	75.0	0.0
I	2,812[1]	54	468	16.7	89.5	89.5	89.5	0.0
J	3,202[1]	107	776	10.0	98.3	98.3	98.7	0.4
K	3,762[1]	53	579	13.4	107.6	107.6	107.6	0.0
Waolani Stream								
A	240[2]	43	292	15.0	22.1	22.1	22.2	0.1
B	440[2]	42	235	18.4	29.3	29.3	29.3	0.0
C	770[2]	43	289	14.7	45.9	45.9	45.9	0.0
D	1,195[2]	69	678	6.1	61.8	61.8	61.8	0.0
E	1,801[2]	116	425	9.4	73.4	73.4	73.5	0.1
F	2,256[2]	32	247	15.8	91.3	91.3	91.3	0.0
G	2,506[2]	73	358	10.7	112.3	112.3	112.5	0.2
H	3,296[2]	50	273	13.4	143.1	143.1	143.1	0.0
I	3,601[2]	49	276	13.0	153.1	153.1	153.1	0.0
J	3,966[2]	50	391	8.9	171.6	171.6	172.2	0.6
K	4,313[2]	77	426	8.0	182.7	182.7	183.1	0.4

[1]Feet above North School Street
[2]Feet above confluence with Nuuanu Stream

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

NUUANU STREAM – WAOLANI STREAM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Aiea Stream								
A	0[1]	24	324	8.2	29.5	29.5	29.5	0.0
B	382[1]	33	190	13.8	35.6	35.6	35.6	0.0
C	687[1]	31	184	14.1	43.5	43.5	43.5	0.0
D	1,192[1]	31	444	5.7	64.7	64.7	64.7	0.0
E	1,302[1]	27	170	14.9	66.8	66.8	66.8	0.0
F	1,517[1]	43	211	11.9	76.5	76.5	76.5	0.0
G	1,932[1]	40	194	12.7	91.3	91.3	91.3	0.0
H	2,352[1]	93	486	5.0	109.8	109.8	109.8	0.0
I	2,678[1]	209	710	3.4	121.3	121.3	122.3	1.0
J	3,048[1]	42	193	12.1	130.6	130.6	130.6	0.0
K	3,893[1]	139	334	6.7	160.1	160.1	160.4	0.3
L	4,393[1]	43	184	11.9	173.4	173.4	173.4	0.0
Kalauao Stream								
A	*	*	*	*	*	*	*	*
B	1,265[2]	61	42	8.2	6.2	6.2	6.8	0.6
C	1,563[2]	200	1,051	3.3	12.6	12.6	12.6	0.0
D	1,773[2]	33	305	11.4	13.5	13.5	13.5	0.0
E	2,101[2]	181	1,118	3.1	17.8	17.8	17.8	0.0
F	2,691[2]	38	343	10.1	22.9	22.9	22.9	0.0
G	3,279[2]	183	907	3.8	30.1	30.1	30.3	0.2
H	3,569[2]	65	455	7.5	32.7	32.7	32.9	0.2
I	4,264[2]	44	403	8.4	47.8	47.8	47.9	0.1

[1]Feet above Moanalua Road
[2]Feet above East Loch, Pearl Harbor
*Data Not Available

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

AIEA STREAM – KALAUAO STREAM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Waikele Stream								
A	100	870	3,124	4.9	2.9	2.9	3.4	0.5
B	1,577	1,300	9,280	1.6	11.9	11.9	11.9	0.0
C	3,032	84	879	17.4	12.9	12.9	12.9	0.0
D	3,292	873	4,519	5.8	16.3	16.3	16.3	0.0
E	4,362	964	7,279	3.6	20.8	20.8	21.8	1.0
F	5,262	261	2,642	9.9	22.7	22.7	23.6	0.9
G	5,378	294	2,426	10.8	32.8	32.8	33.5	0.7
H	6,192	198	4,361	6.0	36.6	36.6	37.5	0.9
I	6,922	112	2,543	10.2	38.6	38.6	39.4	0.8
J	7,402	437	7,378	3.5	40.7	40.7	41.5	0.8
Honouliuli Stream								
A	305	1,770	5,146	1.6	6.1	6.1	6.9	0.8
B	850	1,104	4,070	2.0	6.5	6.5	7.3	0.8
C	1,470	661	1,844	4.3	11.7	11.7	12.5	0.8
D	1,921	430	2,213	3.6	13.1	13.1	13.6	0.5
E	2,621	600	4,390	1.8	14.5	14.5	14.5	0.0
F	3,991	305	842	9.3	21.0	21.0	21.5	0.5
G	4,651	241	1,066	7.4	27.6	27.6	28.6	1.0
H	5,151	370	1,631	4.8	32.7	32.7	33.6	0.9
I	6,774	340	1,343	5.8	64.0	64.0	64.3	0.3
J	7,164	122	803	9.6	64.7	64.7	65.2	0.5
K	7,374	75	514	15.1	68.9	68.9	69.6	0.7
L	7,558	48	572	13.5	75.2	75.2	75.2	0.0

[1]Feet above confluence with West Loch, Pearl Harbor

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

WAIKELE STREAM – HONOULIULI STREAM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET LOCAL TIDAL DATUM)	WITHOUT FLOODWAY (FEET LOCAL TIDAL DATUM)	WITH FLOODWAY (FEET LOCAL TIDAL DATUM)	INCREASE (FEET)
Makaleha Stream								
A	860	2,192	5,635	0.9	11.7	11.7	11.8	0.1
B	1,365	1,860	6,645	0.8	11.7	11.8	11.8	0.1
C	2,055	1,666	5,336	1.0	11.7	11.7	11.9	0.2
D	3,810	51	333	14.6	29.5	29.5	29.5	0.0
E	4,203	42	433	11.0	35.8	35.8	35.8	0.0
F	5,235	75	551	8.4	49.1	49.1	49.1	0.0
G	5,705	281	1,106	4.1	54.7	54.7	54.7	0.0
H	6,790	44	296	14.8	73.6	73.6	73.6	0.0
I	8,345	74	335	12.5	111.8	111.8	111.8	0.0
Unnamed Stream								
A	2,575	1,573	2,825	1.4	9.4	9.4	9.9	0.5
B	3,585	1,016	3,591	1.1	9.9	9.9	10.3	0.4
C	4,269	850	2,218	1.7	10.0	10.0	10.8	0.8
D	6,505	2,016	4,742	0.7	10.9	10.9	11.9	1.0
E	7,538	950	1,865	1.7	21.3	21.3	21.3	0.0
F	8,300	862	1,040	2.9	24.4	24.4	24.4	0.0
Malaekahana Stream								
A	5,088	1,550	11,045	0.9	13.3	13.3	14.3	1.0
B	5,416	1,638	6,570	1.5	13.4	13.4	14.3	0.9
C	5,955	1,142	3,885	2.5	14.0	14.0	15.0	1.0
D	7,423	366	1,932	4.9	25.7	25.7	25.7	0.0
E	8,096	635	2,843	3.4	32.5	32.5	32.5	0.0
F	8,737	479	1,649	5.8	39.4	39.4	39.4	0.0
G[2]	9,627	--	--	--	--	--	--	--
H[2]	10,735	--	--	--	--	--	--	--

[1] Feet above confluence with Pacific Ocean

[2] Floodway not computed

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

MAKALEHA STREAM – UNNAMED STREAM – MALAEKAHANA STREAM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Kaalaea Stream								
A	450[1]	507	1,719	3.8	5.2	5.2	5.2	0.0
B	660[1]	380	1,554	4.2	9.5	9.5	10.1	0.6
C	1,120[1]	152	621	10.2	15.8	15.8	16.4	0.6
D	2,940[1]	188	631	9.0	41.4	41.4	41.7	0.3
E	4,280[1]	188	652	8.1	62.0	62.0	62.3	0.3
F	5,000[1]	219	926	5.5	79.1	79.1	79.1	0.0
G	5,743[1]	225	954	5.0	98.8	98.8	99.6	0.8
H	6,109[1]	49	318	14.6	106.2	106.2	106.2	0.0
Haiamoa Stream								
A	100[1]	1,413	3,271	1.0	4.1	4.1	4.3	0.2
B	439[1]	1,108	3,013	1.0	5.7	5.7	6.7	1.0
C	1,150[1]	803	1,641	1.5	6.8	6.8	7.4	0.6
D	1,855[1]	235	796	2.4	10.9	10.9	11.5	0.6
E	2,280[1]	70	*	*	17.4	17.4	17.4	0.0
Waihee Stream								
A	430[2]	345	775	7.4	13.7	13.7	13.7	0.0
B	1,080[2]	695	1,359	3.3	20.2	20.2	20.3	0.1
C	2,090[2]	212	739	5.8	32.3	32.3	32.8	0.5
D	2,899[2]	173	972	4.2	45.8	45.8	46.2	0.4
E	3,259[2]	282	1,252	3.1	49.8	49.8	50.0	0.2
F	4,489[2]	88	408	8.7	65.7	65.7	66.2	0.5
G	5,107[2]	113	578	6.0	76.4	76.4	77.3	0.9
H	6,039[2]	287	857	3.8	88.6	88.6	88.9	0.3
I	6,349[2]	120	332	9.5	95.6	95.6	95.6	0.0

[1]Feet above confluence with Kaneohe Bay
[2]Feet above confluence with Kahaluu Pond
*Data not available

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

KAALAEA STREAM – HAIAMOA STREAM - WAIHEE STREAM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Waihee Stream Tributary								
A	300[1]	85	167	7.1	25.0	21.4[4]	21.5	0.1
B	530[1]	67	253	4.3	25.0	22.7[4]	23.7	1.0
C	1,056[1]	114	233	4.3	28.6	28.6	28.6	0.0
Kahaluu Stream								
A	1,395[2]	20	135	25.1	32.6	32.6	32.6	0.0
B	1,855[2]	20	190	17.6	44.7	44.7	44.7	0.0
C	2,945[2]	49	160	20.1	62.1	62.1	62.1	0.0
D	3,925[2]	52	161	19.5	79.5	79.5	79.5	0.0
E	4,955[2]	50	242	12.5	106.0	106.0	106.0	0.0
F	5,610[2]	54	243	12.2	122.1	122.1	122.1	0.0
G	6,745[2]	39	148	19.4	147.4	147.4	147.4	0.0
Ahuimanu Stream								
A	2,000[3]	197	1,269	14.6	7.3	7.3	7.3	0.0
B	3,210[3]	200	1,527	12.1	20.6	20.6	20.6	0.0
C	4,030[3]	65	757	19.5	30.7	30.7	30.7	0.0
D	5,622[3]	966	7,146	2.0	41.6	41.6	42.3	0.7
E	6,012[3]	569	3,985	2.6	42.2	42.2	42.8	0.6
F	6,897[3]	126	730	13.1	48.0	48.0	48.0	0.0
G	7,657[3]	100	816	10.8	60.7	60.7	60.7	0.0
H	8,247[3]	44	454	18.4	67.6	67.6	67.6	0.0

[1]Feet above confluence with Waihee Stream
[2]Feet above confluence with Ahuimanu Stream
[3]Feet above confluence with Kaneohe Bay
[4]Elevation computed without consideration of backwater effects from Waihee Stream

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

WAIHEE STREAM TRIBUTARY – KAHALUU STREAM – AHUIMANU STREAM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Kawainui Stream								
A	313[1]	110	906	2.3	4.5	4.5	4.5	0.0
B	1,061[1]	101	823	2.4	4.7	4.7	4.7	0.0
C	1,885[1]	83	668	2.7	5.7	5.7	5.7	0.0
D	3,598[1]	195	1,291	1.1	6.0	6.0	6.0	0.0
E	4,388[1]	222	1,397	0.9	6.1	6.1	6.2	0.1
F	5,488[1]	210	1,221	0.9	6.1	6.1	6.2	0.1
G	6,023[1]	52	375	2.5	6.1	6.1	6.2	0.1
Waikakalaua Stream								
A	114[2]	156	1,079	5.2	550.8	550.8	550.8	0.0
B	332[2]	36	326	17.2	553.9	553.9	553.9	0.0
C	672[2]	64	824	6.8	560.7	560.7	560.7	0.0
D	1,230[2]	56	530	10.5	576.7	576.7	576.7	0.0
E	1,624[2]	43	508	11.0	581.3	581.3	581.3	0.0
F	1,824[2]	42	426	13.1	581.4	581.4	581.4	0.0
G	2,424[2]	43	462	12.1	588.3	588.3	588.3	0.0
H	2,811[2]	54	521	10.7	592.3	592.3	592.3	0.0
I	3,587[2]	37	360	15.4	603.2	603.2	603.2	0.0
J	4,237[2]	78	926	6.0	611.1	611.1	612.1	1.0
K	4,697[2]	70	543	10.2	612.9	612.9	613.5	0.6
L	5,285[2]	90	658	8.4	618.8	618.8	618.8	0.0
M	6,297[2]	78	597	9.2	631.2	631.2	631.2	0.0
N	6,893[2]	67	573	9.6	633.5	633.5	633.5	0.0
O	7,269[2]	53	378	14.5	635.8	635.8	635.8	0.0

[1]Feet above confluence with Kaelepulm Stream
[2]Feet above downstream edge of Kamehameha Highway Bridge

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

KAWAINUI STREAM – WAIKAKALAUA STREAM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Kaloi Gulch								
A	3.98	198	961	2.5	36.2	36.2	36.2	0.0
B	4.06	249	1,969	1.2	38.4	38.4	38.7	0.3
C	5.97	107	265	9.1	41.3	41.3	41.3	0.0
D	6.12	55	413	5.8	46.0	46.6	46.6	0.6
E	6.43	88	243	10.0	47.5	47.5	47.5	0.0
F	6.54	390	2,779	0.9	50.2	50.2	51.0	0.8
G	7.80	120	565	4.2	51.3	51.3	52.2	0.9
H	8.60	*	*	*	66.4	*	*	*

[1]Thousands of feet above Geiger Road
*Data not available

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

KALOI GULCH

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
North Halawa Stream								
A	620[1]	107	786	12.6	75.4	75.4	75.5	0.1
B	858[1]	99	664	14.9	78.7	78.7	78.7	0.0
C	1,092[1]	97	758	13.0	83.7	83.7	83.7	0.0
D	1,532[1]	133	1,259	7.8	93.5	93.5	93.5	0.0
E	2,029[1]	88	835	11.8	100.9	100.9	100.9	0.0
F	2,397[1]	66	583	16.9	105.1	105.1	105.1	0.0
G	2,948[1]	89	812	12.1	117.7	117.7	117.7	0.0
H	3,389[1]	60	602	16.3	126.8	126.8	126.8	0.0
I	3,917[1]	138	1,195	8.2	141.0	141.0	141.0	0.0
Nanakuli Stream								
A	981[2]	721	4,274	1.8	15.1	15.1	15.1	0.0
B	1,513[2]	513	2,948	2.5	15.2	15.2	15.2	0.0
C	2,277[2]	625	1,755	4.2	15.8	15.8	15.8	0.0
D	3,175[2]	336	1,082	6.8	22.1	22.1	22.9	0.8
E	3,859[2]	539	1,109	6.6	31.2	31.2	31.2	0.0
F	4,651[2]	95	656	11.1	40.9	40.9	41.9	1.0
G	5,135[2]	167	1,209	6.0	52.3	52.3	52.7	0.4
H	5,439[2]	71	487	14.9	61.9	61.9	61.9	0.0
I	5,655[2]	76	540	13.4	70.3	70.3	70.3	0.0

[1]Feet above Moanalua Freeway Overpass
[2]Feet above confluence with Pacific Ocean

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

NORTH HALAWA STREAM – NANAKULI STREAM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Ulehawa Stream								
A	0[1]	64	325	11.6	4.5	4.5	4.5	0.0
B	1,040[1]	89	711	5.1	11.2	11.2	11.3	0.1
C	1,728[1]	80	423	8.2	13.3	13.3	13.6	0.3
D	2,256[1]	188	1,195	2.8	16.3	16.3	16.8	0.5
E	3,512[1]	159	768	4.1	18.2	18.2	18.5	0.3
F	4,808[1]	145	773	3.8	24.4	24.4	24.7	0.3
G	5,668[1]	171	689	4.1	27.4	27.4	27.7	0.3
H	6,920[1]	94	288	9.0	37.0	37.0	37.0	0.0
I	7,832[1]	75	301	8.1	41.0	41.0	41.6	0.6
Kamanaiki Stream								
A	220[2]	64	361	13.7	195.1	195.1	195.1	0.0
B	425[2]	49	309	16.0	211.2	211.2	211.2	0.0
C	685[2]	89	596	8.3	228.0	228.0	228.5	0.5
D	825[2]	189	706	7.0	238.1	238.1	238.5	0.4
E	1,025[2]	157	1,022	4.6	249.9	249.9	250.2	0.3
F	1,225[2]	61	369	12.7	249.9	249.9	249.9	0.0
G	1,600[2]	132	521	9.0	263.7	263.7	263.9	0.2
H	2,450[2]	38	302	15.5	297.8	297.8	297.8	0.0
I	3,250[2]	41	274	15.9	339.4	339.4	339.4	0.0
J	3,480[2]	80	457	9.5	355.3	355.3	355.7	0.4
K	3,770[2]	54	430	9.7	370.9	370.9	371.5	0.6
L	14,685[2]	64	391	10.4	426.2	426.2	426.2	0.0

[1] Feet above Ulehawa Channel
[2] Feet above confluence with Kalihi Stream

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

ULEHAWA STREAM – KAMANAIKI STREAM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Makaha Stream and West Makaha Stream								
A	0[1]	894	--[3]	--[3]	13.4	13.4	13.8	0.4
B	340[1]	1,092	5,201	2.0	14.2	14.2	15.2	1.0
C	1,215[1]	1,717	1,538	6.7	22.6	22.6	23.3	0.7
D	2,140[1]	570	1,229	7.9	42.1	42.1	42.7	0.6
E	2,890[1]	655	1,009	9.7	57.7	57.7	58.4	0.7
F	3,711[1]	442	1,061	9.2	82.8	82.8	83.3	0.5
G	4,791[1]	286	922	10.0	119.2	119.2	119.7	0.5
H	5,361[1]	138	764	12.0	138.8	138.8	138.9	0.1
I	6,211[1]	162	695	12.3	167.2	167.2	167.3	0.1
J	7,611[1]	203	753	11.4	216.8	216.8	216.8	0.0
K	8,241[1]	330	966	7.7	237.2	237.2	237.8	0.6
Kapakahi Stream #2								
A	1,000[2]	1,097	1,686	7.5	2.2[4]	1.9[5]	2.1	0.2
B	2,500[2]	1,219	4,027	3.2	3.8	3.8	4.4	0.6
C	3,310[2]	919	3,234	3.9	4.4	4.4	4.9	0.5
D	4,310[2]	1,890	6,334	2.4	9.7	9.7	10.2	0.5
E	4,970[2]	2,920	4,816	3.0	10.7	10.7	11.2	0.5
F	5,600[2]	549	2,358	5.1	14.6	14.6	15.5	0.9

[1]Feet above Farrington Highway
[2]Feet above West Loch, Pearl Harbor
[3]Not calculated
[4]Elevation computed without consideration of wave effects
[5]Elevation computed without consideration of tidal effects from West Loch, Pearl Harbor

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

MAKAHA STREAM AND WEST MAKAHA STREAM - KAPAKAHI STREAM #2

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Manaiki Stream								
A	225[1]	493[3]	3,259	4.1	13.6	13.6	14.1	0.5
B	885[1]	917[3]	3,024	4.5	15.0	15.0	15.3	0.3
C	1,405[1]	1,451[3]	4,502	3.0	22.4	22.4	22.7	0.3
D	1,685[1]	604	681	7.2	25.9	25.9	25.9	0.0
Waiawa Stream								
A	460[2]	400	2,604	7.5	5.4/5.4/5.3[4]	5.4	6.4	1.0
B	1,180[2]	590	3,826	5.1	11.0/11.0/10.9[4]	11.0	11.6	0.6
C	1,883[2]	810	4,962	3.9	13.6/13.6/13.6[4]	13.6	14.4	0.8
D	2,633[2]	780	7,374	2.6	14.9/14.9/15.0[4]	14.9	15.9	1.0
E	3,005[2]	920	10,738	2.1	15.4/15.4/15.5[4]	15.4	16.4	1.0
F	3,815[2]	1,350	14,201	1.6	15.8/15.8/16.0[4]	15.8	16.8	1.0
G	4,265[2]	1,230	13,155	2.6	16.3/16.3/16.4[4]	16.3	17.2	0.9
H	4,495[2]	1,370	11,069	3.1	16.7	16.7	17.6	0.9
I	5,155[2]	640	3,703	9.2	20.6	20.6	20.6	0.0
J	6,077[2]	260	3,379	10.1	26.9	26.9	27.5	0.6
K	7,411[2]	330	4,729	7.2	36.9	36.9	37.9	1.0
L	8,891[2]	290	5,355	6.3	42.0	42.0	42.7	0.7
M	9,575[2]	670	10,462	3.2	43.5	43.5	44.4	0.9
N	10,425[2]	620	8,143	2.8	44.0	44.0	44.9	0.9
O	10,945[2]	300	4,341	5.3	44.5	44.5	45.4	0.9
P	11,798[2]	530	5,345	4.3	46.2	46.2	47.1	1.0
Q	12,328[2]	640	4,330	5.3	48.6	48.6	49.6	1.0
R	13,048[2]	450	2,338	9.8	53.3	53.3	53.3	0.0
S	13,488[2]	460	3,424	6.7	57.8	57.8	58.0	0.2

[1]Feet above confluence with Moanalua Stream
[2]Feet above Middle Loch
[3]Combined floodway width (Manaiki Stream and Moanalua Stream)
[4]Water-surface elevation with both levees in place/east levee failed/west levee failed conditions

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

MANAIKI STREAM – WAIAWA STREAM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (LOCAL TIDAL DATUM)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Panaikauahi Gulch								
A	940	398	4,467	3.2	44.3	44.3	45.3	1.0
B	1,484	128	1,124	12.6	49.6	49.6	49.6	0.0
C	2,356	255	2,143	4.1	56.0	56.0	56.3	0.3
D	3,066	96	711	12.5	73.0	73.0	73.0	0.0
E	3,773	95	1,416	9.5	96.7	96.7	96.9	0.2

[1]Feet above confluence with Waiawa Stream

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

FLOODWAY DATA

PANAIKAUAHI GULCH

4.3 Tsunami and Hurricane Inundation Boundaries

Inundation limits from the 1-percent annual chance tsunami were computed from most of the shoreline of the Island of Oahu. The methodology employed in this computation is described in Section 3.1. The 1-percent annual chance tsunami inundation boundaries were delineated using methods outlined in <u>Tsunami Inundation Prediction</u> (C. L. Bretschneider, undated).

Previous mapping of the tsunami hazard was merged with the detailed hurricane coastal hazard study in this revision. This was accomplished by comparing the zone type, base flood elevation, and inland flooding extent of coincident tsunami and hurricane storm surge hazards. The higher of the two elevations was retained and presented on the Flood Insurance Rate Map. If in a tsunami hazard-dominated area, the inland limit of the hurricane storm surge flooding extends further landward than the tsunami hazard, the Tsunami base flood elevation is show and the flooding extent is extended to where the hurricane hazard is mapped. This is to reflect the increased hazard generated by the use of updated topographic data. The VE Zone was extended and mapped to the inland limit of the Primary Frontal Dune for both tsunami and hurricane hazards. In cases where elevations were similar, engineering judgment was applied to facilitate the most appropriate representation of the higher hazard.

Users of the FIRM should also be aware that coastal flood elevations are provided in the Summary of Coastal Stillwater Elevations table (Table 5) in this report. If the elevation on the FIRM is higher than the elevation shown in this table, a wave height, wave run-up, and/or wave setup component likely exists, in which case, the higher elevation should be used for construction and/or floodplain management purposes.

As defined in the July 1989 *Guidelines and Specifications for Wave Elevation Determination and V Zone Mapping*, the coastal high hazard area (Zone VE) is the area where wave action and/or high velocity water can cause structural damage *(Guidelines and Specifications for Wave Elevation Determination and V-Zone Mapping,* FEMA, 1989). It is designated on the FIRM as the most landward of the following three points:

The point where the 3.0 ft or greater wave height could occur;

The point where the eroded ground profile is 3.0 feet or more below the maximum run-up elevation; and

The primary frontal dune as defined in the NFIP regulations.

These three points are used to locate the inland limit of the coastal high hazard area to ensure that adequate insurance rates apply and appropriate construction standards are imposed, should local agencies permit building in this area.

The inundation limits for the 1-percent annual chance tsunami or hurricane are based on existing conditions. Any modification or alteration to existing conditions may have a significant effect on the tsunami inundation limits. For example, any regarding or reduction of surface roughness in onshore areas, such as that caused by the removal of native vegetation, could increase the extent of inundation. Similarly, dredge and fill operations offshore could increase the extent of inundation due to the effects of coastal bathymetry on tsunami or hurricane wave setup. On the other hand, existing or planned coastal features such as natural, reefs, seawalls, groins, jetties, or beach stabilization projects, may have a mitigating effect on tsunami or hurricane inundation.

5.0 INSURANCE APPLICATIONS

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

Zone A

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

Zone AE

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

Zone AH

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

Zone AO

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

Zone A99

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

Zone V

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

Zone VE

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

Zone X

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

Zone D

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

6.0 FLOOD INSURANCE RATE MAP

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

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

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

The countywide FIRM presents flooding information for the entire geographic area of the City and County of Honolulu. Previously, separate Flood Hazard Boundary Maps and/or

FIRMs were prepared for each identified flood-prone incorporated community within the county. This countywide FIRM also includes flood hazard information that was presented separately on Flood Boundary and Floodway Maps (FBFMs), where applicable. Historical data relating to the maps prepared for the City and County of Honolulu, up to and including the November 20, 2000, countywide FIS, are presented in Table 9, "Community Map History."

7.0 OTHER STUDIES

Numerous Flood Hazard Area reports, FISs, and Floodplain Information reports were used in the preparation of this FIS. Most of the past studies were computed without the aid of a computer, and the few that were run on the computer utilized an earlier version of the currently used HEC-2 computer program. Other than the degree of accuracy between manual and computer computation, and the variation in computer programs used, other possible causes of variation from the previously published data may be from differences in assumptions made and physical changes to the terrain, such as recent flood-control projects, which may affect the hydraulic computations.

One prior flood report for Makiki Stream has been prepared (City and County of Honolulu, 1967). The 1967 City and County of Honolulu Makiki Stream report proposed channel improvements within the length of study to accommodate a discharge of 5,000 cfs, almost a tenfold increase from the present capacity of 510 cfs. Water-surface elevations and flooding under present channel conditions were not developed for the aforementioned report.

For Manoa Stream, the Manoa-Palolo Drainage Channel, and Palolo Stream waterways, several studies have been prepared. The first report, a 1965 USACE survey on flood control in the Manoa and Palolo Valleys, summarized the existing and proposed flood-control measures for these watersheds (USACE, 1965). While no hydraulic and hydrologic bases of comparison are presented, the flood-control history of the areas is well documented. The second, the 1971 FIS for Moiliili-Waikiki (Type 10) by R. M. Towill Corporation, presented the FIA 1971 version of flood insurance zoning (U.S. Department of Housing and Urban Development, July 1971). The results of that report are superseded by this FEMA-guided FIS. The third report is the Manoa Stream Park Conceptual Plan (Architects Hawaii, Ltd., and Hawaii Design Associates, Inc., 1976).

As the result of an advisory committee comprised of local (City and County of Honolulu and State) agencies, community associations, and Federal (USACE) authority, the conceptual plan presented the development scheme for the future. The fourth and most recent flood study is the 1977 Flood Hazard Study for the Manoa Stream basin (M&E Pacific, Inc., 1977). A HEC-2 backwater analysis was performed for the report, from King Street to Paradise Park. The present study utilizes the exact hydrologic and hydraulic data from the 1977 Flood Hazard Study and added the segment from King Street to the Ala Wai Canal, defined as the Manoa-Palolo Drainage Canal. Thus, the results for the common areas are identical.

For the Ala Wai Canal, no direct flood study has been conducted. Past studies were performed for dredging to maintain the water quality and the stream-carrying capacity of the canal. The most recent dredging studies provide a determination of the dredged capacity of the canal (Sun, Low, Tom and Hara, Inc., 1977; State of Hawaii, 1977). The dredged capacity of 13,000 cfs is reported to be the 10% annual chance flood event flow capacity. For this study, the 10-year discharge is 12,970 cfs at the confluence of Moiliili Drain and the Ala Wai Canal.

A FIS was prepared in 1975 by the USACE for FEMA and the City and County of Honolulu. The study utilized detailed and approximate methods and included, by the approximate method, the following 12 streams.

Nuuanu Stream

Existing studies for this area were done many years ago by the USACE. The basic data is now unavailable.

Waolani Stream

Existing studies for this area were done many years ago by the USACE. The basic data is now unavailable.

Kalihi Stream

In 1972, the USACE and the Department of Land and Natural Resources (DLNR) of the State of Hawaii produced the Kalihi-Moanalua Flood Hazard Area, Kalihi, Oahu, Hawaii, Map, FP-8 (USACE, 1972). The map includes flood outlines and elevations and calculated flood flows for the 2% and 1%- annual chance flood event and the Standard Project Flood Peak Discharges for Kalihi Stream from King Street to the stream mouth. The log-Pearson Type III method was used to determine these flows, using USGS gaging station data. The flows are presented below:

	Q_{50} (cfs)	Q_{100} (cfs)	Standard Project (cfs)
Kalihi Stream at Mouth	15,000	17,000	25,000

In 1977, the USACE completed the Flood Hazard Study, Kalihi Stream and Kamanaiki Stream, Oahu, Hawaii (USACE, 1977). The study determined the flooding hazard from School Street into the upper portion of the Kalihi Stream watershed.

A FIS (Type 15) for the Kalihi-Moanalua Area, Island of Oahu, Hawaii, was prepared for FEMA in 1971 (U.S. Department of Housing and Urban Development, 1971). Flood profiles and stages were provided but no flow data. Supporting data is no longer available.

Table 9: Community Map History

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
City and County of Honolulu	June 5, 1970	June 4, 1971	September 3, 1980	January 6, 1983 September 4, 1987 September 28, 1990 September 30, 1995 November 20, 2000 September 30, 2004 June 2, 2005 January 19, 2011 November 5, 2014

TABLE 9

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF HONOLULU, HI

COMMUNITY MAP HISTORY

Aiea Stream

In 1971, the USACE prepared the Flood Insurance Study, (Type 10), Aiea Area, Island of Oahu, Hawaii (USACE, 1971) for FEMA. Flood profiles were provided but no flows were given. Supporting data is no longer available.

Kalauao Stream

In 1971, the USACE and the DLNR produced the Kalauao Flood Hazard Area, Kalauao, Oahu, Hawaii, Map FP-7 (USACE, 1971). The map provided flood outlines, elevations, and frequency curves for the 50- and 100-year peak discharges. No standard Project Flood Peak Discharge was calculated due to ongoing construction of the H-1 Freeway berm.

Waikele Stream

In 1982, the USACE prepared the Waikele Stream, Flood Management Study, Waipahu, Oahu, Hawaii (USACE, 1982). The study provided flood profiles and a flood flow frequency curve.

Kaalaea, Haiamoa, Waihee, Kahaluu and Ahuimanu Streams

In 1969, the SCS and the City and County of Honolulu prepared the Watershed Work Plan, Kahaluu Watershed (U.S. Department of Agriculture, 1969). The work plan provided flood profiles as well as design flows.

Complete hydrologic or hydraulic data is not available for Kaalaea and Haiamoa. Stream gage data for Waihee, Kahaluu, and Ahuimanu is available from the USGS.

Kawainui Stream

In 1971, the USACE prepared for FEMA the Kailua Flood Insurance Study (Type 10) (U.S. Department of Housing and Urban Development, May 1971). Flood profiles and stages were given.

Other Areas

The West Oahu Soil Conservation District (presently Soil Conservation Service) and the City and County of Honolulu prepared a study entitled Watershed Work Plan Waianae Nui Watershed in January 1960 (West Oahu Soil Conservation District, 1960). This plan included flood improvement proposals for Ulehawa and Nanakuli Streams.

In September 1975, the USACE prepared a flood hazard map for the DLNR which delineated the 1% annual chance flood event (USACE, 1975). The study also includes flood frequency-discharge curves and flood profiles.

In 1977, the consulting firm of VTN-Pacific prepared a study entitled Halawa Stream Maintenance Dredging Design Alternatives and Hydraulic Analysis for the City and County of Honolulu (VTN-Pacific, 1977). The purpose of the study was to recommend required maintenance dredging to restore stream capacity and provide flood protection. The study location was situated in the lower reach of the Halawa watershed, below the confluence of the north and south forks.

8.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this FIS can be obtained by contacting FEMA, Federal Insurance and Mitigation Division, 1111 Broadway, Suite 1200, Oakland, California 94607-4052.

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10.0 REVISION DESCRIPTIONS

This section has been added to provide information regarding significant revisions made since the original FIS was printed. Future revisions may be made that do not result in the republishing of the FIS report. To assure that the user is aware of all revisions, it is advisable to contact the appropriate community repository of flood-hazard data as listed on the Flood Insurance Rate Map Index.

10.1 First Revision

This study was revised on September 30, 1995, to modify the 1% annual chance flood boundary delineations and add base (1%) flood elevations (BFEs) and floodway boundaries along Kapakahi Stream #2, Makaha Stream, West Makaha Stream, and Wailani Drainage Canal. No floodway was computed for Wailani Drainage Canal. The hydrologic and hydraulic analyses were performed by R. M. Towill. The work was compiled in July 1993.

The 1-percent annual chance flows along Makaha Stream were determined from a statistical analysis of USGS gage data at Gage Nos. 16211600 and 16211700. The analysis was done in accordance with procedures outlined in Bulletin No. 17B (Water Resources Council, 1981). No gage data was available on the remaining three streams. Therefore, the 100-year flows were determined using the regression equations contained in the USGS Report WRI 8-45 (U.S. Geological Survey, 1980). Flows used in the hydraulic analysis of Kapakahi Stream #2 were increased to account for overflow from Waikele Stream.

Cross-section data for Makaha Stream and West Makaha Stream were obtained from topographic maps prepared from aerial photographs (R. M. Towill Corporation, 1991). Additional stream channel information and all bridge and culvert geometry were obtained by field survey.

The USACE HEC-2 step-backwater computer program (R. M. Towill Corporation, 1991) was used to compute the BFEs. The starting water-surface elevation was computed using a mean high-tide level at the Pacific Ocean of 1.9 feet.

The upper portion of the Makaha Stream study reach is contained within a shallow gulch. Downstream floodwaters overflow into the Makaha West Golf Course. These flows combine with floodwaters from the West Makaha Stream. Along Kapakahi Stream #2 at the abandoned railroad bridge, overflow from the Kapakahi Stream #2 is conveyed within the Wailani Drainage Canal. Overflow from Waikele Stream enters the upper reaches of Kapakahi Stream #2.

All floodways were computed using an equal reduction in conveyance in each overbank. Floodways were not generated from Wailani Drainage Canal due to splitflow condition.

10.2 Second Revision

This study was revised on November 20, 2000, to convert the FIRM for the City and County of Honolulu, Hawaii, to digital format.

Digital Conversion

The mapping for the City and County of Honolulu has been prepared using digital data. Previously published FIRM data produced manually have been converted to vector digital data by a digitizing process. These vector data were fit to raster digital images of the USGS quadrangle maps of the county area to provide horizontal positioning.

Road and highway name and centerline data have been provided by the City and County of Honolulu. The centerline data were computer plotted with the digitized floodplain data to produce the countywide FIRM.

As part of this digital conversion, the panel layout of the FIRM has been revised. The new layout for the FIRM was based on the layout of the USGS quadrangle maps of the City and County of Honolulu. Individual map panel scales were determined so that the flood data represented were at similar scale to that shown on the previously effective FIRM.

Additional Study Areas

This revision also incorporated detailed flood hazard information along Waiawa Stream from Middle Loch to approximately 4,500 feet upstream of confluence of Panakauahi Gulch; along overflow area of Waiawa Stream; along Panakauahi Gulch from its confluence with Waiawa Stream to approximately 800 feet upstream of Cane Haul Road; along Moanalua Stream from approximately 250 feet downstream of Moanalua Road to approximately 180 feet upstream of Jarrett Road; and along Manaiki Stream from its confluence with Moanalua Stream to approximately 260 feet upstream of Mahiole Street.

The hydrologic and hydraulic analyses for this restudy were performed by the R. M. Towill Corporation for FEMA under Contract No. EMW-93-C-4221. That work was completed in May 1997. The information prepared by R. M. Towill Corporation was modified by Michael Baker Jr., Inc., to conform to current FEMA standards. The modifications were completed in August 1999.

Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for the flooding sources. The 1-percent annual chance peak discharges for the study streams were determined using Plate 6 of the City and County of Honolulu's Storm Drainage Standards (City and County of Honolulu, 1988). The 0.2-percent annual chance peak discharges for Waiawa Stream were determined using USGS stream gage data for gage #16216000 on Waiawa Stream (U.S. Department of the Interior, 1994). A ratio was calculated between the land 0.2-percent annual chance discharges to determine the 0.2-percent annual chance peak discharges for the ungaged areas along the Waiawa Stream. The 0.2-percent annual chance peak discharges for Moanalua and Manaiki Streams were obtained using peak discharge-drainage area relationship for the lower reaches of Moanalua Stream and Kahauiki Stream (USACE, 1982).

Hydraulic Analyses

Waiawa Stream, Overflow area of Waiawa Stream, Panakauahi Gulch, Manaiki, and Moanalua Stream

Cross-section data for the backwater analysis were obtained from topographic maps with a scale of 1"=200' and a contour interval of 4 feet, photogrammetrically surveyed from aerial photographs (R. M. Towill Corporation, 1993). Additional contours were obtained from the City and County of Honolulu topographic maps. Stream channel sections were obtained by field survey. Bridge and culvert geometry was obtained from as-built construction plans or field reconnaissance.

Water-surface elevations of the 1- and 0.2-percent annual chance floods were computed using the USACE computer program HEC-2 (USACE, 1990). The starting water-surface elevations for Waiawa Stream were an estimated high tide elevation at Middle Loch. The starting water-surface elevation for Moanalua Stream was based on the previous profiles in the FIS for City and County of Honolulu, Hawaii (FEMA, 1990).

The cross sections for the lower reaches of Moanalua and Manaiki Streams were combined into single cross sections to obtain a consistent water-surface elevation. Moanalua Stream carries the majority of the flow and was assumed to be the main channel.

Roughness coefficients (Manning's "n" values) for Waiawa Stream, Overflow of Waiawa Stream, Panakauahi Gulch, along Cane Hual Road, Moanalua Stream, and Manaiki Stream were chosen by engineering judgment and based on field observations of the streams and floodplain areas. Roughness values for the studied streams are shown as follows:

Table 10: Manning's "n" Values

Flooding Source	Channel "n"	Overbank "n"
Flow along Cane Hual Road	0.060	0.100
Manaiki Stream	0.013 – 0.040	0.080 – 0.150
Moanalua Stream	0.013 – 0.026	0.080 – 0.150
Overflow of Waiawa Stream	0.700	0.700
Panaikauahi Gulch	0.050 – 0.070	0.030 – 0.100
Split flow of Waiawa Stream	0.100	0.100
Waiawa Stream	0.040 – 0.080	0.080 – 0.150

The deck of the wooden bridge crossing over to the abandoned sewage treatment plant (located west of Waiawa Stream) has been completely burned and no longer exists. However, the HEC-2 runs have been performed assuming that the bridge would be reconstructed. The bridge geometry for this section has been estimated from topographic maps and field surveys taken when the bridge deck still existed.

The levees constructed along the overbanks of the lower reach of the Waiawa Stream do not meet the requirements of NFU regulations for freeboard. In addition, no stability analyses were submitted for the levees. The 1-percent annual chance flood levels for the channel area between the levees were computed with the both levees in place scenario. The 1-percent annual chance flood levels in the area where the abandoned sewage treatment plant lies, west of the existing levee, were computed assuming the east levee in place and west levee failed scenario. The 1-percent annual chance flood levels for the Lehua Avenue area, east of the existing levee, were computed assuming the west levee in place and east levee failed scenario.

At approximately 1,700 feet above the Middle Loch along the Waiawa Stream some of the floodwater splits from main stream and flows along the low ground. Half of the split flow goes back to main channel and half flows directly to the Middle Loch. At approximately 3,300 feet above Middle Loch along the Waiawa Stream, a discharge of approximately 3,600 cfs leaves the main stream and flows onto the U.S. Naval Reservation area. At the low-lying area below Leeward Community College, approximately one third of the stream flow leaves the main stream channel, floods the area and exits out to Pearl Harbor. Also, flood waters flow over Cane Haul Road in the Panakauahi Gulch. Some of the flood water diverges from the main stream channel and flows down the road. This water returns to the main channel further downstream.

For Waiawa Stream, overflow area of Waiawa Stream, Panakauahi Gulch, and Moanalua Stream, the 1- and 0.2-percent annual chance floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps at a scale of 1'=200", with a contour interval of 4 feet (R. M. Towill Corporation, 1993).

The floodway for each stream was computed using a proportional reduction in conveyance in each overbank. Encroachment stations are assigned based on the maximum surcharge of one foot along the entire study reach. Since the combined cross sections were used for the lower reaches of Moanalua and Manaiki Streams, the entire area between the streams are considered a part of the floodway. Separate floodways were computed for the upstream reaches of Moanalua and Manaiki Streams. Floodways were not generated for Wailani Drainage Canal due to split flow conditions.

10.3 Third Revision

The September 30, 2004 revision was performed to incorporate new ortho-imagery available for portion so Honolulu County, provided by the City of Honolulu Department of Planning and Permitting, Honolulu Land Information System.

Base Map Update

For the majority of the panels, the base map information used to update the DFIRM was provided in digital format by the City and County of Honolulu Department of Planning and Permitting, Honolulu Land Information System (HoLIS). Imagery was derived from U.S. Geological Survey (USGS) Digital Orthophoto Quadrangles produced at a scale of 1:12,000 from photography dated 2001 or later, except on panels 0090, 0105, 0195, 0351, 0352, 0353, 0354, and 0370 where this imagery was not available; therefore, Digital Line Graphs submitted by the County of Honolulu were used. Street centerlines and surface water features were compiled at a scale of 1:4,800 from orthophotography dated 2001.

For the remaining panels, base map information used to update the FIRM was derived from USGS 1:24,000-scale Digital Line Graphs. Additional information may have been derived from other sources. Minor adjustments may have been made to specific base map features.

The digital FIRM was projected using Universal Transverse Mercatur Zone 4 coordinates. The horizontal datum for the FIRM is the North American Datum of 1983, GRS80 Spheroid.

The base map conversion work for this restudy was performed by the RMTC/URS Joint Venture for FEMA Region IX under Contract No. EM-2003-CO-0046.

10.4 Fourth Revision

The January 19, 2011 revision was performed to incorporate new ortho-imagery available for portions of City and County of Honolulu from mosaicked 2-foot ground resolution satellite imagery that meets 1:12,000 scale horizontal accuracy standards provided by DigitalGlobe and the United State Department of Agriculture Natural Resources Conservation Service. This information was collected between April 2005 and July 2006. This revision also included new detailed coastal hurricane storm surge and wave height analysis and approximate analyses of "behind levee" flooding. That work was performed by the RMTC/URS a Joint Venture for FEMA Region IX under Contract No. EM-2003 CO -0046. Detailed description of the revision and methodologies was previously incorporated into the preceeding sections of this FIS at the time of the revision, therefore not repeated in this section.

10.5 Fifth Revision

This revision (November 5, 2014) to the City and County of Honolulu FIS report was originally planned to perform a “with and without levee analysis’ for levee systems along Keaahala and Waialae-nui Streams. During the project coordination meeting held with the County on August 24, 2010, the County contended that levees do not exist along Keaahala Stream. A field investigation conducted in December of 2010 confirmed Keaahala Stream does not have any levees. A separate field investigation also confirmed that levees do not exist along Waialae-Nui Stream. Therefore, this study was modified such that new detailed studies (hydrologic and hydraulic) on these reaches were performed as a result of this new information. Independent QA/QC on two studies performed by the USACE was also performed as part of this revised FIS. These studies included the Kaiwainui Marsh Flood Control Project study (Kawainui Marsh Levee area and Oneawa Channel) and the Keaaulu Gulch and Malaekahana Stream studies. The resulting flood mapping was incorporated in this revised FIS. The USACE studies included both hydrologic and hydraulic analyses. Finally, new hydrologic and hydraulic analyses were performed for approximately 5 stream miles of previous Zone A flood zones and replaced with Zone AE. These previous Zone A streams include Wailele Stream, Kaupuni Stream, Mailiili Channel, Maili Channel, Waimalu Stream, Oneawa Channel (scoped as Kawainui Canal and part of the USACE Kawainui Marsh Flood Control Project study), JCIP Drainage Canal (scoped as Drainage Canal), Halawa Stream, and Waimanalo: Stream A. This work was perfomed by BakerAECOM under contract HSFEHQ-09-D-0368.

Base map information shown on this FIRM was provided in digital format by the U.S. Department of Agriculture, Natural Resources Conservation Service, National Geospatial Management Center. This imagery was derived from mosaicked 50-centimeter ground resolution satellite imagery.

The projection used in the preparation of this map was Hawaii State Plane Zone 3 (FIPSZONE 5103). The horizontal datum was NAD 83, GRS80 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries.

Engineering Methods: Hydrologic Analyses

Halawa Stream, JCIP Drainage Canal, Kaupuni Stream, Maili Channel, Mailiili Channel, Wailele Stream, Waimalu Stream, Waimanalo: Stream A

The portions of Halawa Stream, the JCIP Drainage Canal, Kaupuni Stream, Maili Channel, Mailiili Channel, upper Wailele Stream, Waimalu Stream, and Waimanalo: Stream A were analyzed using the Regional Regression equations that were developed and referenced in the *Flood-Frequency Estimates for Streams on Kaua'i, O'ahu, Moloka'i, Maui, and Hawai'i, State of Hawai'i,* Scientific Investigations Report 2010-5035 (SIR). Precipitation values (only required for the leeward side, Region 3) were obtained from the *Rainfall Atlas of Hawai'i: State of Hawai'i, Department of Land and Natural Resources, Report R76.* The mean annual rainfall isohyets were converted into a raster and intersected with the drainage basins. An average mean annual rainfall was developed using the statistics calculated for each basin. Peak flow results are summarized in Table 3: Summary of Discharges.

Keaahala Stream

Keaahala Stream was analyzed using a rainfall-runoff model created using the USACE HEC-HMS software. The model was constructed using a 24-hour duration NRCS Type I hypothetical storm distribution, NRCS runoff curve numbers, as well as NRCS unit hydrograph and lag time. For Keaahala Stream, peak flows from the rainfall-runoff model compared favorably to the previous FIS frequency-discharge/drainage-area curves and also to the results of a frequency analysis performed on USGS gage 16274499. Peak flow results are summarized in Table 3: Summary of Discharges.

Waialae-Nui Stream

Waialae-Nui Stream was modeled using a rainfall-runoff model created using the USACE HEC-HMS software. The model was constructed using a 24-hour duration NRCS Type I hypothetical storm distribution, NRCS runoff curve numbers, as well as NRCS unit hydrograph and lag time. For Waialae-Nui Stream, peak flows from the rainfall-runoff model were compared to the most recent regional regression estimates, with final discharges for the 1-percent annual chance storm falling within the standard error for the regression equations. A gage analysis was also performed on adjacent watersheds with similar landuse and soil characteristics. Discharges from the rainfall-runoff model fell within the 95-percent confidence intervals of this gage analysis comparison. Peak flow results are summarized in Table 3: Summary of Discharges.

Malaekahana Stream and Kea'aulu Gulch (USACE study)

The hydrologic estimates for Malaekahana Stream and Kea'aulu Gulch reanalyzed for the November 5, 2014 study were developed by the USACE and reviewed and incorporated into this revision. Flood discharges were developed through a detailed statistical analysis of several discharge calculation & estimation methods performed by the USACE in their January 2010 report *Flood Hazard Evaluation Malaekahana Stream, Oahu, Hawaii*. The different methodologies included a HEC-HMS rainfall-runoff model, a flood frequency analysis, use of USGS regional regression equations, weighted regional regression equations, and analysis of City and County of Honolulu storm discharge standards. The results of the various estimates were graphed and "best" fit lines estimated for each return frequency. Peak flow results are summarized in Table 3: Summary of Discharges.

Oneawa Channel (USACE Study)

The hydrologic analysis for Oneawa Channel reanalyzed for the November 5, 2014 study were developed by the USACE and reviewed and incorporated into this revision. The analysis was performed as described in their October 2012 report *Levee System Evaluation Report, Kawainui Marsh Flood Control Project, Oahu, Hawaii* and the USACE's *Kawainui Marsh Flood Control Project Final Detailed Project Report* dated July 1992. An unsteady HEC-RAS analysis was performed on the channel, routing inflow hydrographs from the upstream Kawainui Marsh drainage areas through the marsh and downstream through the Oneawa Channel. Peak flow results area summarized in Table 3: Summary of Discharges. These peak flows represent estimated "max" flow values for the various annual chance floods.

<u>Engineering Methods: Hydraulic Analyses</u>

Halawa Stream

A new detailed study was performed for Halawa Stream in the City and County of Honolulu, Hawaii.

Field surveys were performed for all hydraulically significant structures along the study reach of Halawa Stream. These surveys were taken at the upstream face, on top of the road/structure, and at the downstream face of each structure.

Additional stream cross section surveys of the channel and overbanks were taken at specified intervals along the study reach.

Roughness factors (Manning "n" values) used in hydraulic calculations were chosen based on engineering judgment and based on aerial photography and field observations from the surveyed sections and structures. The main channel sections for Halawa Stream were assigned a Manning's 'n' value of 0.035 and the overbank 'n' values were assigned values ranging from 0.070 – 0.1 based on the land cover as seen on aerial photography.

The downstream boundary condition for Halawa Stream was set to Normal Depth S = 0.007 ft/ft for all profiles to determine known elevations for approach sections not used as model cross-sections. The slope was calculated using the slope of the adjacent overbanks at the downstream end of the study reach upstream of confluence with the Pacific Ocean. These elevations were set as known elevations for each profile and input at the downstream-most model cross-section for the corresponding profiles.

JCIP Drainage Canal

A new detailed study was performed for JCIP Drainage Canal in the City and County of Honolulu, Hawaii.

There were no hydraulically significant structures along the study reach. Survey of a representative cross-section was taken of the channel and overbanks.

Roughness factors (Manning "n" values) used in hydraulic calculations were chosen based on engineering judgment and based on aerial photography and field observations from the surveyed sections and structures. The main channel sections for JCIP Drainage Canal were assigned a Manning's 'n' value of 0.035 and the overbank 'n' values were assigned values ranging from 0.065 – 0.080 based on the land cover as seen on aerial photography.

The downstream boundary condition for the JCIP Drainage Canal was set to Normal Depth S = 0.00037 ft/ft for all profiles. The slope was calculated using the channel bottom ground elevations at the downstream end of the study reach upstream of confluence with the Pacific Ocean.

Kaupuni Stream

A new detailed study was performed for Kaupuni Stream in the City and County of Honolulu, Hawaii.

Field surveys were performed for all hydraulically significant structures along the study reach of Kaupuni Stream. These surveys were taken at the upstream face, on top of the road/structure, and at the downstream face of each structure. Additional stream cross section surveys of the channel and overbanks were taken at specified intervals along the study reach.

Roughness factors (Manning "n" values) used in hydraulic calculations were chosen based on engineering judgment and based on aerial photography and field observations from the surveyed sections and structures. The main channel sections for Kaupuni Stream were assigned a Manning's 'n' value of 0.015 and the overbank 'n' values were assigned values ranging from 0.045 – 0.1 based on the land cover as seen on aerial photography.

The downstream boundary condition for Kaupuni Stream was set to Normal Depth S = 0.0012 ft/ft for all profiles. The slope was calculated using the channel bottom ground elevations at the downstream end of the study reach upstream of confluence with the Pacific Ocean.

Maili Channel

A new detailed study was performed for Maili Channel in the City and County of Honolulu, Hawaii.

Field surveys were performed for all hydraulically significant structures along the study reach of Maili Channel. These surveys were taken at the upstream face, on top of the road/structure, and at the downstream face of each structure. Additional stream cross section surveys of the channel and overbanks were taken at specified intervals along the study reach.

Roughness factors (Manning "n" values) used in hydraulic calculations were chosen based on engineering judgment and based on aerial photography and field observations from the surveyed sections and structures. The main channel sections for Maili Channel were assigned a Manning's 'n' value of 0.013 and the overbank 'n' values were assigned values ranging from 0.050 – 0.08 based on the land cover as seen on aerial photography.

The downstream boundary condition for Maili Channel was set to Normal Depth S = 0.0005 ft/ft for all profiles. The slope was calculated using the channel bottom ground elevations at the downstream end of the study reach upstream of confluence with the Pacific Ocean.

Mailiili Channel

A new detailed study was performed for Mailiili Channel in the City and County of Honolulu, Hawaii.

Field surveys were performed for all hydraulically significant structures along the study reach of Mailiili Channel. These surveys were taken at the upstream face, on top of the road/structure, and at the downstream face of each structure. Additional stream cross section surveys of the channel and overbanks were taken at specified intervals along the study reach.

Roughness factors (Manning "n" values) used in hydraulic calculations were chosen based on engineering judgment and based on aerial photography and field observations from the surveyed sections and structures. The main channel sections for Mailiili Channel were assigned a Manning's 'n' value of 0.013 and the overbank 'n' values were assigned values ranging from 0.070 – 0.080 based on the land cover as seen on aerial photography.

The downstream boundary condition for Mailiili Channel was set to Normal Depth S = 0.0008 ft/ft for all profiles. The slope was calculated using the channel bottom ground elevations at the downstream end of the study reach upstream of confluence with the Pacific Ocean.

Wailele Stream

New detailed study was performed for Wailele Stream in the City and County of Honolulu, Hawaii.

Surveyed cross sections of the stream channel and overbanks were surveyed at intervals along the study reach.

Roughness factors (Manning "n" values) used in hydraulic calculations were chosen based on engineering judgment and based on aerial photography and field observations from the surveyed sections and structures. The main channel sections for Wailele Stream were assigned a Manning "n" values ranging from of 0.045 while overbank "n" values ranged from 0.050-0.070 depending on the dominant land cover.

Due to the backwater condition that exists at the effective study tie-in for Wailele, the downstream boundary condition was run for all profiles using normal depth (S=0.011 ft/ft). The difference in the profile water surface elevations at cross section 5125 for the normal depth run were applied to the most downstream cross section (cross section 4508) to calculate the known water surface elevation. These differences were applied to the effective 100-year known water surface elevation of 44.8 ft.

Waimalu Stream

A new detailed study was performed for Waimalu Stream in the City and County of Honolulu, Hawaii.

Field surveys were performed for all hydraulically significant structures along the study reach of Waimalu Stream. These surveys were taken at the upstream face, on top of the road/structure, and at the downstream face of each structure. Additional stream cross section surveys of the channel and overbanks were taken at specified intervals along the study reach.

Roughness factors (Manning "n" values) used in hydraulic calculations were chosen based on engineering judgment and based on aerial photography and field observations from the surveyed sections and structures. The main channel sections for Waimalu Stream were assigned a Manning's 'n' value of 0.013 and the overbank 'n' values were assigned values ranging from 0.04 – 0.1 based on the land cover as seen on aerial photography.

The downstream boundary condition for Waimalu Stream was set to Normal Depth S = 0.0003 ft/ft for all profiles. The slope was calculated using the channel bottom ground elevations at the downstream end of the study reach upstream of confluence with the Pacific Ocean.

Waimanalo: Stream A

A new detailed study was performed for Waimanalo: Stream A in the City and County of Honolulu, Hawaii.

Field surveys were performed for all hydraulically significant structures along the study reach of Stream A. These surveys were taken at the upstream face, on top of the road/structure, and at the downstream face of each structure. Additional stream cross section surveys of the channel and overbanks were taken at specified intervals along the study reach.

Roughness factors (Manning "n" values) used in hydraulic calculations were chosen based on engineering judgment and based on aerial photography and field observations from the surveyed sections and structures. The main channel sections for Stream A were assigned manning's 'n' values ranging from 0.017 to 0.070 while the overbank 'n' values range from 0.05 to 0.1 based on the land cover.

Stream A flows into Waimanalo Stream. The downstream boundary condition for Stream A was set to normal depth with slope of 0.0015 ft/ft developed from channel bottom slope at the downstream.

Keaahala Stream

A new detailed study was performed for Keaahala Stream in the City and County of Honolulu, Hawaii.

Field surveys were performed for all hydraulically significant structures along the study reach of Keaahala Stream. These surveys were taken at the upstream face, on top of the road/structure, and at the downstream face of each structure. Additional stream cross section surveys of the channel and overbanks were taken at specified intervals along the study reach.

Roughness factors (Manning "n" values) used in hydraulic calculations were chosen based on engineering judgment and based on aerial photography and field observations from the surveyed sections and structures. The main channel sections for Keaahala Stream were assigned manning's 'n' values ranging from 0.015 to 0.070 and the overbank 'n' values were assigned a value of 0.080 based on the land cover as seen on aerial photography.

The downstream boundary condition for the Keaahala Stream was set to Normal Depth S = 0.00295 ft/ft for all profiles. The slope was calculated using the channel bottom ground elevations between station 702 and station 363.

Waialae-Nui Stream

A new detailed study was performed for Waialae-Nui Stream in the City and County of Honolulu, Hawaii.

Field surveys were performed for all hydraulically significant structures along the study reach of Waialae-Nui Stream. These surveys were taken at the upstream face, on top of the road/structure, and at the downstream face of each structure. Additional stream cross section surveys of the channel and overbanks were taken at specified intervals along the study reach.

Roughness factors (Manning "n" values) used in hydraulic calculations were chosen based on engineering judgment and based on aerial photography and field observations from the surveyed sections and structures. The main channel sections for Waialae-Nui Stream were assigned manning's 'n' values ranging from 0.015 to 0.060 while the overbank 'n' values range from 0.045 to 0.1 based on the land cover.

Waialae-Nui Stream flows into Kapakahi Stream #1. The downstream boundary condition for Waialae-Nui Stream was set to normal depth with slope of 0.021 ft/ft developed from channel bottom slope at the downstream end of the model. The model was run in a mixed flow regime, and so the upstream boundary condition was set to critical depth.

Malaekahana Stream and Kea'aulu Gulch (USACE study)

The hydraulic analysis for Malaekahana Stream and Kea'aulu Gulch was developed by the USACE in their January 2010 report.*Flood Hazard Evaluation Malaekahana Stream, Oahu, Hawaii*. USACE HEC-RAS modeling was performed for the two streams as a system, and floodway calculated for a portion of Malaekahana Stream. Detailed study limit description, methodology, and assumptions used for parameter estimation are provided in the USACE report. The hydraulic analysis and resulting mapping were reviewed and incorporated into this revision.

Oneawa Channel (USACE Study)

The hydraulic analysis for Oneawa Channel was developed by the USACE as described in their October 2012 report *Levee System Evaluation Report, Kawainui Marsh Flood Control Project, Oahu, Hawaii* and the USACE's *Kawainui Marsh Flood Control Project Final Detailed Project Report* dated July 1992. An unsteady HEC-RAS analysis was performed on the channel, routing inflow hydrographs from the upstream Kawainui Marsh drainage areas through the marsh and downstream through the Oneawa Channel. Detailed study limit description, methodology, and assumptions used for parameter estimation are provided in the USACE report. The hydraulic analysis and resulting mapping were reviewed and incorporated into this revision.

Base map information shown on these revised FIRM panels was derived from multiple sources including the City and County of Honolulu, HI effective database. Base map imagery for Honolulu County, HI was provided in digital format by the U.S. Department of Agriculture, Natural Resources Conservation Service, National Geospatial Management Center. This imagery was derived from mosaicked 50-centimeter ground resolution satellite imagery. These data were collected by DigitalGlobe between September 2010 and January 2011.

This FIS also incorporates the determinations of letters issued by FEMA resulting in map changes (Letter of Map Revision [LOMR]), as shown in Table 11, "Letters of Map Revsion."

Table 11: Incorporated Letters of Map Revision

Communities Affected	Flooding Source(s)	Effective Date	Case Number
City and County of Honolulu	Keaahala Stream Unnamed Tributary to Keaahala Stream	March 16, 2012	11-09-3899P[1]

[1] Incorporated into this revision