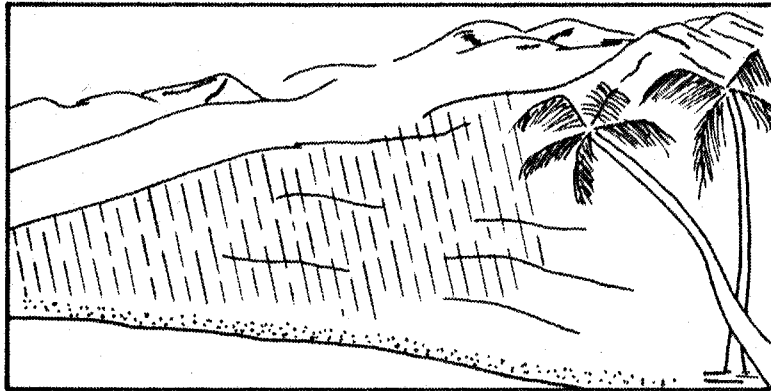


# MAIN REPORT AND TECHNICAL APPENDIX

## FLOOD PLAIN INFORMATION STUDY KOLOA-POIPU, KAUAI, HAWAII



PREPARED FOR  
BOARD OF LAND AND NATURAL RESOURCES  
STATE OF HAWAII



BY  
U. S. ARMY ENGINEER DISTRICT, HONOLULU  
CORPS OF ENGINEERS  
HONOLULU, HAWAII

OCTOBER 1966

FLOOD PLAIN INFORMATION STUDY

KOLOA-POIPU, KAUAI, HAWAII

MAIN REPORT

FLOOD PLAIN INFORMATION  
KOLOA-POIPU, KAUAI, HAWAII

MAIN REPORT

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FLOOD PLAIN INFORMATION  
KOLOA-POIPU, KAUAI, HAWAII

MAIN REPORT

I. INTRODUCTION

1. AUTHORIZATION

This report has been prepared by the Corps of Engineers at the request of the State of Hawaii Board of Land and Natural Resources. Section 206, Public Law 86-645 (Flood Control Act of 1960), grants authority to the Secretary of the Army, through the Chief of Engineers, to gather and distribute information concerning past floods and flood hazards in flood-prone areas. The Hawaii Board of Land and Natural Resources and the Chief of Engineers have reviewed and approved the release of this report.

2. PURPOSE OF STUDY

Purposes of the study are:

- a. To provide information on hazards to life and property in the Koloa-Poipu area caused by overland, sheet-flow flooding.
- b. To provide a basis for local planning decisions.
- c. To outline measures to minimize flood damages.
- d. To reduce future expenditures of the Federal and local governments in protecting developments that may be constructed in the area in the absence of regulations or knowledge of potential hazards.

In this report the term of reference "Koloa-Poipu" is restricted to that coastal area within the district of Koloa from Waikomo Stream to Pihakekua. This area is commonly known as Poipu.

3. USE OF REPORT

The main portion of this report outlines flood problems and presents general guidelines to reduce future flood losses. This portion of the report is primarily intended for use by present and prospective land owners and residents, as well as developers, investors, realtors, governmental bodies and others with interest in the area. The technical appendix is included primarily for engineers or others who may find this information useful in designing or planning future improvements in the Koloa-Poipu area.

This report is not intended to extend any Federal control or jurisdiction in flood plain planning or regulation. In addition, it in no way obligates the Federal Government to further investigating, planning, designing, constructing, operating or maintaining any facilities discussed unless such action is authorized by Congress.

The Board of Land and Natural Resources was designated as the coordinating agency for the State of Hawaii by Act 148, Session Laws of Hawaii, 1963. This agency will distribute copies of the report to interested parties and individuals upon request.

#### 4. ACKNOWLEDGMENTS

The cooperation of the following agencies and individuals for their help in compiling this report is gratefully acknowledged.

Department of Agriculture - Soil Conservation Service  
Department of Commerce - U.S. Weather Bureau  
Department of Interior - Fish and Wildlife Service  
" " - U.S. Geological Survey  
" " - National Park Service  
State of Hawaii - Department of Land and Natural Resources  
" " - Department of Transportation  
" " - University of Hawaii  
County of Kauai, Hawaii  
Newspapers - The Garden Island Publishing Company, Ltd.  
" - Honolulu Star-Bulletin  
" - Honolulu Advertiser  
Grove Farm Sugar Plantation Company  
Residents of the Koloa-Poipu area

## II. FLOOD HISTORY

#### 5. GENERAL

Koloa-Poipu is on the south side of the island of Kauai, about 8 miles from Lihue, as shown on plate 1. The 1960 population of Kauai was 28,200 with about 4,400 and 400 people living in the Koloa and Poipu areas, respectively. Almost the entire population of Poipu reside in the low, level areas along the coast with the heavier concentration towards the east in the vicinity of Poipu Beach. In recent years Poipu has developed into a popular resort. New residences, hotels and related business establishments have been constructed and new developments are being planned for the near future. The New Poipu Road, built in 1964, is the only major roadway servicing this resort area. The Old Poipu Road is no longer a through street. The New Poipu Road is a paved, 2-lane highway, 600 to 1200 feet north of the Old Poipu Road (see plate 2) and contains culverts at 5 different locations, including a double celled, 10-foot radius culvert at Waikomo Stream. The Old Poipu Road has a 5-span timber bridge crossing Waikomo Stream. Waikomo Stream, which defines the western boundary of the study area, drains an area of 10.4 square miles.

Poipu has a total drainage area of 3.47 square miles extending about 3.5 miles northward from the ocean shore (see plate 1). Over 95 percent of the drainage area is comprised of brush and sugar cane fields. See figures 1, 2, and 3 for views of the drainage basin.

Plates 1 and 2 show the locations from which photographs were taken. Present land use in the lower part of the basin consists of residential housing, beach homes, resort hotels and motels with supporting businesses, recreational facilities and a public park.

## 6. RAINFALL

Rainfall records through the southern part of Kauai show that the mean annual rainfall ranges from 35 inches along the coast at Poipu to 80 inches at the northern drainage divide, 800 feet above mean sea level. Storms that cause flooding are usually of short duration and high intensity.

## 7. FLOODS

The flood problem of the Koloa-Poipu area is confined mainly to the coastal land below the 10-foot contour, comprising about 75 acres. Since there are no defined stream channels, the area is normally dry. Runoff in the form of a "sheet" of water occurs only when heavy rain falls in a short period of time. As the water flows overland, it fills the many depressions behind the old Poipu Beach Road, forming ponds with flood waters entering low-lying houses and business establishments. These low areas do not have outlets to the sea so the water may stand in the ponds for several days and be a nuisance and health hazard. Figures 4 through 10 show views of the general area and some areas that are often flooded (see plate 2).

Figures 4 and 5 are views of residences on the west side of the study area. Flooding in this area is caused by sheet flow and is usually limited to the yards. There is little danger of ponding in this area.

Figures 6 and 7 show low-lying areas on both sides of Hapa Road that are affected by recurring floods. When heavy rain occurs, the surface water from the basin passes through culverts under the New Poipu Road and into the coastal ponding areas. Overflow water from the lakes thus formed finds its way to the ocean across the Old Poipu Road and through the densely populated beach front causing damages to property. The New Poipu Road culverts are not the cause of flooding in the lower areas for floods occurred before the construction of the New Poipu Road.

Figures 8, 9, and 10 are views of the area called Bacle Tract. This area is more seriously affected by floods than other areas of Poipu. In times of heavy rain, water is funneled into the residential area at the eastern side of Bacle Tract through a swale and ponds at the intersection of Kuai Road and Poipu Beach Road, causing damages to property, isolating homes and making roads impassable. Overflow water finds its way through the beach front properties to the ocean. The remaining water must be removed by pumping into the ocean.

During the past 12 years, there were 6 significant storms in the area. This indicates that, on the average, every 2 years the Koloa-Poipu area is subject to property damage and losses by floods. Small floods causing minor damages are not included in the above statistics.

Newspaper records and the U. S. Weather Bureau's Climatological Data were used to obtain historical data on floods and rainfall in Koloa-Poipu, Kauai. The following excerpts describe past storms in and near the flood plain study area.

November 28, 1954 - High winds and heavy rains caused flooding of the lowlying Poipu area across the highway from the beach. Two homes were flooded and several others were in danger of being flooded. Two automobiles belonging to a family were almost completely submerged. The two cars were in the garage. One family, after a busy effort of moving furniture, finally had to be evacuated from their home by boat. The boat was also used to remove possessions from another home that was flooded. Water draining off the fields and wastelands into Poipu, the coastal basin, created a vast lake. The rain had let up when the water rose between 9 a.m. and 10 a.m. to flood stage, making the highway impassable at a point shortly beyond the YMCA Memorial Building. Fire Department trucks ran their pumps without pause from Sunday until 2 a.m. Tuesday.

November 8-9, 1955 - The water rose this morning to cover a wide stretch of the Poipu Road, isolating families living beyond the Poipu Beach area. No relief was yet in sight as the heavy rainstorm of yesterday and today is expected to continue through Thursday. For the Poipu residents, traffic probably will be blocked for another three days or more. A boat has been brought in to ferry people across the flooded section. One family has been evacuated because of rising flood water but otherwise property damage was less than in the last Poipu flooding, although the water is higher. One reason is that some of the residents took warning yesterday and moved their cars to safer ground. The rainfall recorded at the airport for the 24 hours up to 8 a.m. today was 10 inches. Most of the rain (about 4 inches) fell between 2 and 8 p.m. yesterday. Between 2 and 8 a.m. today rainfall measured about 6 inches. The flooding of the Poipu Road extended from the house just west of Kuai Road to No Name Road. The deepest water on the road was about 4 feet at the dip in the road. One car got stalled running into deep water but was pulled back to safety. Traffic was halted and a few walked out to walk through property along the beach. The Koloa Fire Department arrived to start pumping the big lake. Some homes sustained damages to furniture.

January 17-18, 1957 - Kona weather brought extremely heavy rainfall to many parts of the island. The highest one-day totals were recorded at Grove Farm's Makaulepu gauge, which had 11.97 inches Friday morning. The gauge at Makahuena Point had 11.23 inches for a similar period. The 7-day rainfall at Makaulepu was 16.6 inches. The heavy rains turned the eastern half of Poipu into lakes. Poipu Road was turned into a canal by the heavy rainstorm, giving the Fire Department trucks a big pumping job.



April 14, 1965 - Heavy rains and high winds caused some damage on the south and west sides of the island early Tuesday morning. The rains caused flooding in the Poipu area. About 2.5 inches of rain fell in the Koloa area during the storm which lasted something over an hour. The result was flooding in the Bacile Tract area. Traffic was blocked on Poipu Road for sometime Tuesday until the water could be pumped by the Fire Department.

November 14, 1965 - Runoff water in the Poipu area accumulated near the Waiohai Hotel on Sunday afternoon but caused no damage. County trucks were called to pump the water out of low spots.

November 19, 1965 - Heavy rains which fell on Kauai in the morning have caused flooding at Poipu. Runoff water accumulated in the Waiohai Hotel grounds at Bacile Tract and the Weliweli area of Poipu just before day-break. Local residents said the flood was the highest they have seen in the Bacile Tract area, which has no natural or man-made outlet to the sea. County firemen began pumping the water at 6 a.m. and were still pumping at 6:30 p.m. Residents of the flooded area were evacuated from the low-lying areas. At least two cars were under water and one resident's furniture was floating around his yard. Working men and women living east of the flood zone had to hike across yards and thumb rides to work Friday morning. Most of the Koloa area received 3.5 inches of rain or more overnight.

An inspection of the area topography determined the various paths water travels on its way to the ocean. Six concentration points exist along Old Poipu Road with drainage areas ranging from 0.08 to 1.87 square miles. These areas are shown on plate 1.

Flood flow which would result from the most intense storm considered reasonably characteristic of the Koloa-Poipu region is called the "Standard Project Flood" by the U.S. Army Corps of Engineers. Values of the standard project flood for Areas A through F and Waikomo Stream are given in table 1. The frequency of occurrence of various magnitudes of flood flows are also listed in table 1. This information will serve as a guideline to determine flood plain areas in which a greater degree of flood risk may be permissible. Since floods are random in nature, frequency is only a prediction based on studies of past floods. The assignment of a 10-year frequency to a given stream flow does not mean that the flood will occur every 10 years. Instead, it is an indication that the particular peak discharge, expressed in cubic feet per second, will be exceeded on an average of about once in every 10 years. This means that during a long period of time, say 100 years, a 10-year flood will be exceeded about 10 times. Frequency estimates for Koloa-Poipu (Areas A thru F) and Waikomo Stream were based on the frequency curve for Hanapepe Stream gaging station, which is about 8 miles northwest of Koloa, and has been in operation since 1918. The technical appendix contains the flow frequency curves for the study subareas and Waikomo Stream.

Table 1. Flood Flow-Frequency Relationships

Recurrence Interval in Years	Area A (C.P. 1) Drainage Area 0.45 sq. mi.	Area B (C.P. 2) Drainage Area 0.11 sq. mi.	Area C (C.P. 3) Drainage Area 0.22 sq. mi.	Area D (C.P. 4) Drainage Area 0.08 sq. mi.	Area E (C.P. 5) Drainage Area 0.74 sq. mi.	Area F (C.P. 6) Drainage Area 1.87 sq. mi.	Waikomo Stream (C.P. 7) Drainage Area 10.4 sq. mi.
Peak Flow in Cubic Feet Per Second							
10	670	190	360	140	1,100	2,450	9,900
50	1,030	290	560	220	1,670	3,800	15,700
100	1,200	340	650	250	1,950	4,500	18,200
Standard Project Flood	1,490	440	820	330	2,530	5,350	26,400

Concentration points for the 6 subareas and Waikomo Stream are shown on plate 2.

## 8. STREAM FLOOD

The lower reach of Waikomo Stream does not have the capacity to contain discharges in the magnitude of the standard project flood (26,400 c.f.s.) or of the 100-year frequency flood (18,200 c.f.s.). The cross sectional area of the stream and the culvert and bridge openings under the highways are inadequate. The New Poipu Road culvert, for instance, has a capacity to pass only about 7,000 c.f.s. As a result, any unusual storm could cause stream overflow. See figures 11, 12 and 13 for views of the stream. Flooding in the lower reach of Waikomo Stream would inundate the area between the stream and drainage Area A and cause water to flow southward on the east bank along and across the Old Poipu Road as far east as Area B. This flood area contains only a few houses. Areas east of drainage Area B would not be affected by flooding of Waikomo Stream.

## 9. RESERVOIR

Waita Reservoir, just north of the Poipu drainage areas, was constructed prior to 1900 to store irrigation water for the growing of sugar cane. In 1910 the reservoir was expanded to the present size. This privately owned reservoir has a maximum capacity of 2,300,000,000 gallons of water. Through the years the dam has not sustained major damage, nor has it overflowed except for a more or less controlled release through the spillway on the southwest corner. The highest water level in the reservoir was recorded in 1917 when it rose to 5 feet below the top of the dam. This is only about 1.5 feet above normal water level. The data included in the report on sizes and frequencies of future floods are based on the assumption that the dam will not fail or be overtopped. Plate 1 shows the location of the reservoir, and figures 14, 15, and 16 show views of the spillway and dam.

## 10. TSUNAMI

Another potential source of flooding is the tsunami which runs onto the beach and coastal lowland areas of the Hawaiian Islands. The tsunami has never caused much damage in the Koloa-Poipu area, but the possibility still exists that the entire coastal development could be severely damaged by tsunami. During the past 147 years, 43 tsunami have been known to affect the Hawaiian Islands. Seven were designated very severe, 2 severe, 8 moderate, and 26 slight, judged by the amount of physical damage inflicted.

An indication of the damage caused by tsunami is shown by the losses to the city of Hilo, Hawaii on 23 May 1960. There were 61 people killed, 537 buildings destroyed and \$22 million damages sustained when this tsunami caused the water to reach an elevation of 28 feet above mean sea level.

### III. FUTURE IMPROVEMENTS IN THE FLOOD PLAIN

#### 11. GENERAL

The drainage configuration and corresponding flood flows are based on the present land use of the area. Future improvements that materially change the route of flood flows through an area may cause adjacent areas to be affected more severely than at the present time.

Future improvements planned for the flood plain are discussed in the following paragraphs.

#### 12. GENERAL PLAN

The State Planning Office, together with the Department of Transportation, submitted a plan of development to the State Legislature in January 1961 entitled "The General Plan of the State of Hawaii." It was adopted and released to the Department of Planning and Economic Development for use in planning land utilization policies. In 1962 the Planning and Traffic Commission of the County of Kauai formulated a General Plan for the county. Since the County General Plan was formulated in close coordination with the State, the plans are in agreement. Each sets forth a long-range, comprehensive, coordinated program in land use to serve as a guide for future planning and development. The objectives are, briefly, to promote a healthier and more attractive community socially, physically, and economically. The plans are flexible to changes in population and economic climate of the locality. The county has the responsibility of implementing the plans by adopting controls such as zoning regulations.

#### 13. RESIDENTIAL SUBDIVISION

At Poipu, the General Plan designates the area west of Pau-a-laka Gardens and north of the Old Poipu Road up to about the 40-foot contour a residential area. A portion of this residential area is being subdivided by private developers into about 50 half-acre lots, or a total of 25 acres. The land will be sold in fee simple and individuals interested in buying land should be aware of potential floods and tsunامي in building along this coastal flood plain. This subdivision land lies between elevations 10 and 40 feet above m.s.l.

Plans for a new subdivision called "Weliweli Houselots" have recently been approved by the county of Kauai and the State of Hawaii. The plan calls for 99 houselots over a total area of about 31 acres to the north of and adjoining Bacle Tract. This tract of land, oriented with the long axis (3400 feet) north to south, is entirely within Drainage Area F, between the 20 and 100 foot contours.

#### 14. HIGHWAY MODIFICATION

A new highway about 1200 feet from the shore has been completed. The old coastal road, which is from 100 to 600 feet

inland, is still in use but plans are to eliminate the coastal road and develop the entire 1200 feet of land between the new highway and the shore.

#### 15. RESORT DEVELOPMENT

The Kauai General Plan presents 5 planning areas for Kauai. Of these five, the Koloa area is expected to have the greatest growth in population and economy. It is estimated that by 1980 a population of about 25,000 may be reached. This forecast is attributed largely to the expected growth of the resort areas of Kukuiula and Poipu. In keeping with this thinking, the General Plan designates two sections totaling about 68 acres of the Poipu study area for the development of resorts. One section extends from the Pau-a-laka Gardens to the eastern end of the golf course and from the shore to about the 20-foot contour. The second section extends from the western side of Bacile Tract to the hills of Pihakekua and from the shore to the northern limits of Bacile Tract.

This report is specifically directed towards those parties and individuals, both private and governmental, who are interested in the development of the Koloa-Poipu area. Future flood losses can be greatly reduced if proper and adequate precautions are taken regarding planned development in the flood-prone areas. Flood plain zoning ordinances could be enacted that would prohibit building residences in an area which is subject to periodic flooding that would endanger the health or safety of the occupants.

#### IV. GUIDE LINES FOR USE OF FLOOD PLAIN AND REDUCING FUTURE FLOOD LOSSES

#### 16. GENERAL

The preceding discussion of the actual and potential floods and tsunami in the Koloa-Poipu area emphasizes the need for regulations to control land use in the flood plain. The enactment and enforcement of the proper laws and ordinances are the responsibility of local authorities. The following discussion assumes that part of the existing flood plain will be reserved for the free passage of flood waters with a minimum of obstruction to its flow. Methods to preserve this area are outlined under the heading of flood plain regulations. Avenues of investigation for the protection of existing improvements are also presented.

#### 17. FLOOD PLAIN REGULATIONS

The police powers of state and local governments to enact and enforce laws and ordinances regulating land use furnish methods to carry out the concepts of paragraph 16. Included within the scope of flood plain regulation are zoning ordinances, subdivision regulations, channel and floodway encroachment statutes and building codes.

The intent of these restrictions is to deny uses of the land or property in the Koloa-Poipu flood plain that would tend to multiply the loss of life and property through development without adequate consideration of flood hazards.

a. Zoning ordinances. Zoning ordinances control the type of land use that will be permitted in an area. Regardless of the method used, specific instructions concerning what land use activity will be permitted within the restricted areas should be included.

b. Subdivision regulations. Proposed subdivisions that lie in flood-prone areas should have regulations that clearly define the degree of risk and extent of flooding involved. Such items as minimum lot, street or structural elevations, outline of flood plain for various frequencies of flow, and minimum surface drainage requirements should be an integral part of these regulations.

c. Channel and flood plain encroachment statutes. Encroachment statutes designate areas adjacent to bodies of water that are set aside for the passage of flood flows. Obstructions such as structures or trees should be held to a minimum in these areas. These statutes, together with applicable zoning ordinances, constitute the means for preserving a permanent floodway by permitting only such improvements as playgrounds, which offer a minimum resistance to flood flows and can withstand inundation with little damage.

d. Building codes. Building codes for flood plain development should specify (1) minimum elevation of footings, (2) minimum first floor elevations, (3) require such reinforcement to withstand high velocity flow and water pressure, (4) designate minimum requirements of flood proofing, and (5) control construction of basements.

e. Other controls. Government and private lending agencies can exercise an indirect control over flood plain development by refusing to finance improvements to be located in an existing or potential flood hazard area. Also, land fill or dumping operations should be controlled in the area designated to carry off the flood waters. The acquisition of the flood plain area by easement or in fee simple title by local or state governments for recreation or open space use would put it to uses compatible with the flood hazard. Finally, major drainage and flood channels should be established as the areas are subdivided or developed.

## 18. METHODS TO PROTECT EXISTING IMPROVEMENTS

Control of the flood waters in the Poipu area by constructing diversion channels and building levees would be a solution of the flood problem. Since direct flood control for any of the areas seems unlikely at the present time, two methods may give partial protection to the existing improvements in the flood plains.

a. Flood proofing. Flood proofing could be used for the present structures subject to flooding and incorporated into the basic design for any future buildings planned. This involves raising vulnerable

equipment such as generators, motors, and machinery above the high water profile for a given flood and emergency installation consisting of water-tight doors, windows, walls and ground level air vent coverings. These methods would be effective only for flooding from surface water flow. They would offer no protection from tsunami because of the tremendous forces associated with them. The University of Chicago, Department of Geography, Research Paper No. 65, "Flood Proofing: An Element in a Flood Damage Reduction Program," 1960, by John Richard Sheaffer is a comprehensive discussion of some of the flood proofing techniques that can be employed.

b. Evacuation. Temporary evacuation of movable property is effective only if coupled with an adequate flood warning system. The Kauai Civil Defense Agency has a network system to warn of any impending tsunami. Presently there is no system to predict rain storm floods in the Poipu area except the U.S. Weather Bureau's forecasts of probable heavy rains and possible flooding. Once alerted, residents can either remove their personal property to higher ground or raise it to a safe level and evacuate the area.

## V. CONCLUSION

This report has presented a history and problems of flooding in the Koloa-Poipu area and guidelines for reducing flood damages. Guidelines for the future control of damages resulting from these conditions have also been presented. Recognition of the danger from flooding to low areas and possible flood losses that may result is imperative at this time. Now is the time to act before extensive development and new construction is undertaken.

The information and suggestions in this report are presented to help the State, County of Kauai, and other interested agencies and individuals to plan and regulate land use in the Koloa-Poipu area.

WILLIAM F. ROOS  
Colonel, Corps of Engineers  
District Engineer

## GLOSSARY OF SELECTED TERMS

### A. HYDROLOGIC TERMS

Channel - A natural or artificial watercourse with definite bed and banks to confine and conduct flowing water.

Flood - A temporary overflow of lands not normally covered by water, which lands are used or usable by man when not inundated.

Flood plain - The relatively flat lowlands adjoining a watercourse or other body of water subject to overflow therefrom.

Flood profile - The longitudinal profile assumed by the surface of a stream of water flowing in an open channel.

Flood frequency - The average interval of time, based on the period of record, between floods equal to or greater than the specified discharge. Frequency is generally expressed in years.

Rainfall intensity - The amount of rain that falls in a specified time interval, usually expressed as inches per hour.

Recurrence interval - The average interval of time within which a particular flow will be exceeded once.

Standard project flood - A hypothetical flood, estimated by the Corps of Engineers, representing the critical flood runoff and peak flood flow that may be expected from the most severe combination of meteorological and hydrologic conditions that are considered reasonably characteristics of the geographical region involved, excluding extremely rare combinations.

Tsunami - A sea wave produced by submarine earth movement or volcanic eruption.

Watershed - The area drained by a stream or stream system.

### B. REGULATORY TERMS

Flood plain regulations - A general term applied to the full range of codes, ordinances, and other regulations relating to the use of land and construction within flood plain areas.

Subdivision regulations - Regulations and standards established by a local public authority, generally the local planning agency, with authority from a state enabling law, for the subdivision of land in order to secure coordinated land development, including adequate building sites and land for vital community services and facilities such as streets, utilities, schools and parks.





Figure 1  
Drainage basin - View looking south  
from the intersection of Weliweli Road  
and flume.



Figure 2  
Drainage basin - View looking south-  
west from eastern hills. Note  
harvested sugar cane land.

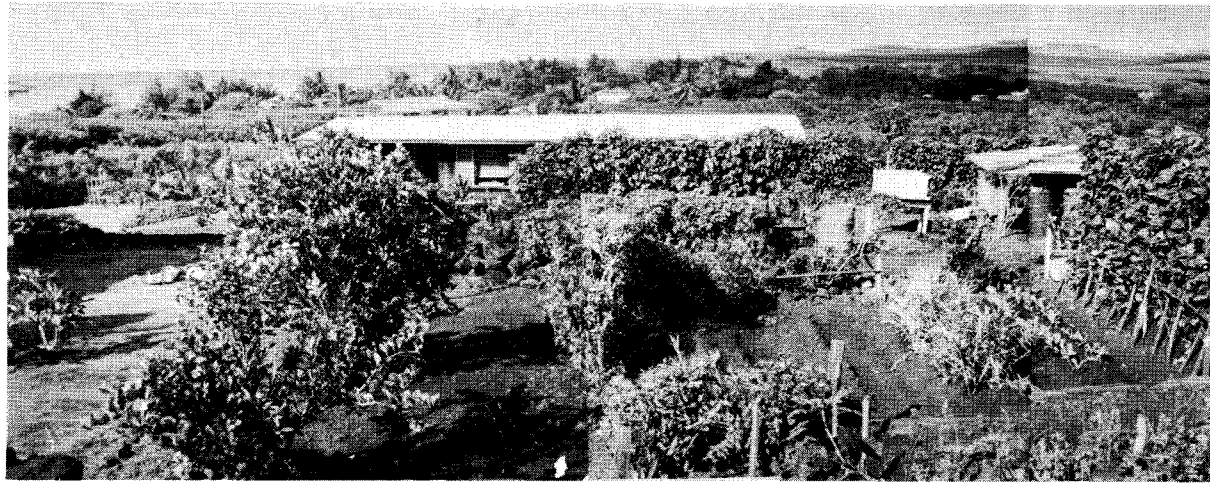


Figure 3

Drainage basin - View looking southwest from Pihakekua on the east side.

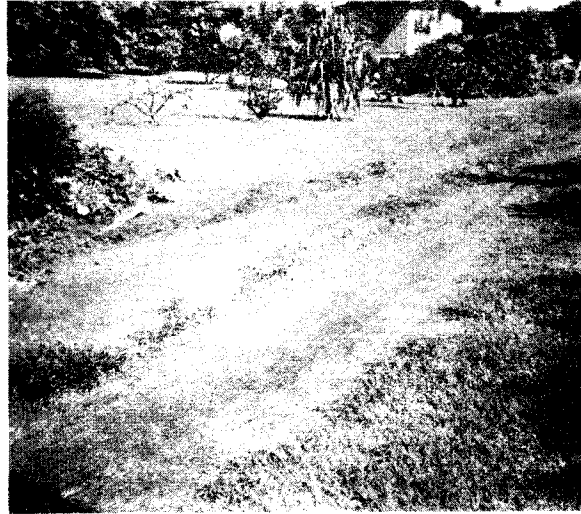


Figure 4  
West side of study area - view looking  
north into residence from old Poipu Road

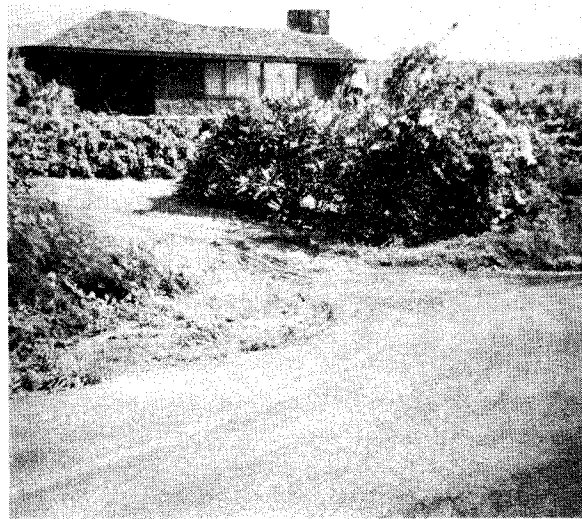


Figure 5  
West side of study area - View looking  
northeast into residence from old Poipu Road



Figure 6

Study area - View of Pau-A-Laka Gardens



Figure 7  
Study area - View of pond near YMCA



Figure 8  
Study area - View looking north on Kuai Road



Figure 9  
Study area - View looking south on  
no-name road towards old Poipu Road



Figure 10  
Study area - View looking east from  
no-name road. House located in area.



Figure 11  
Waikomo Stream - View looking down-  
stream from a point about 1200 feet  
upstream of the new Poipu Road culvert.



Figure 12  
Waikomo Stream - View looking upstream  
from the new Poipu Road culvert.

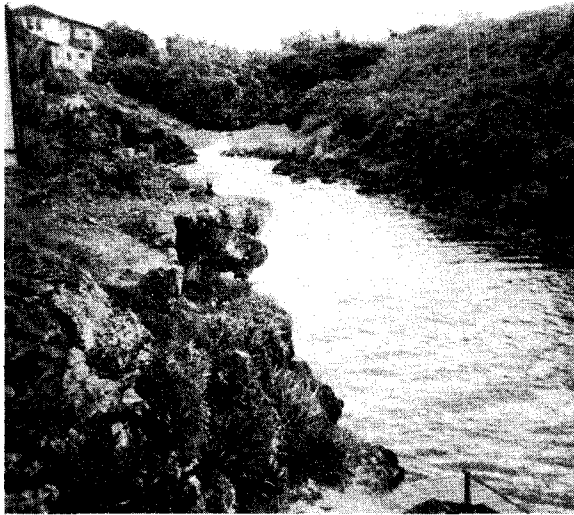


Figure 13  
Waikomo Stream - View looking  
upstream from mouth.



Figure 14  
Waita Reservoir - View looking  
northeast over spillway and into  
reservoir. Note flashboards.



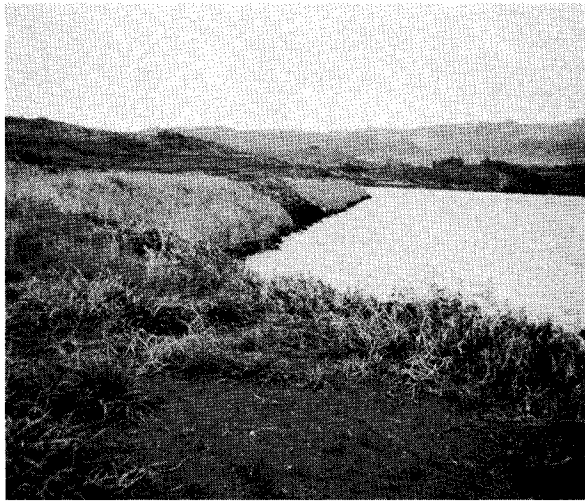
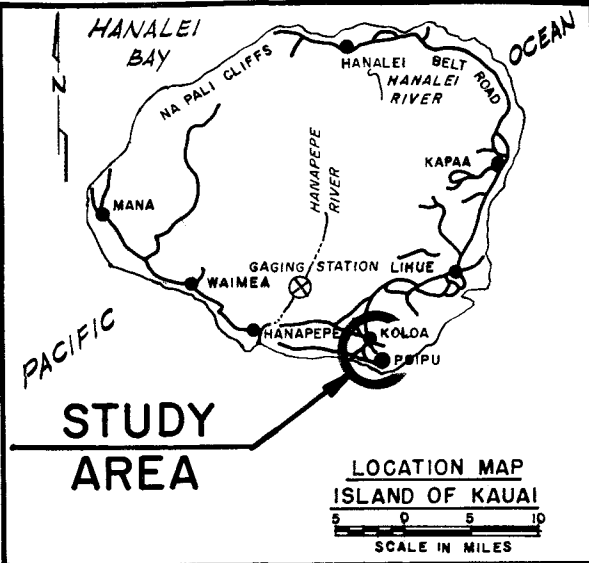
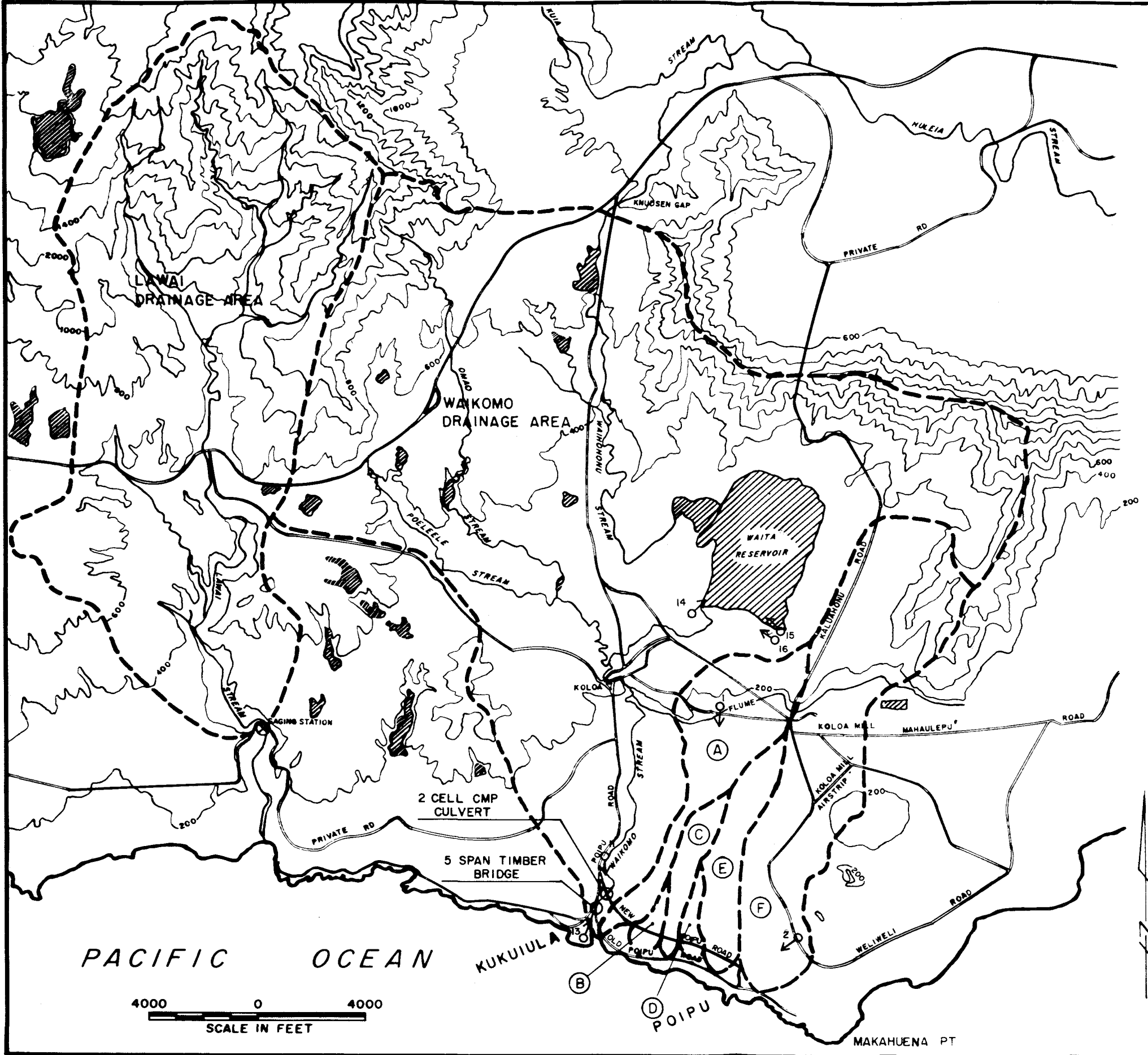


Figure 15  
Waita Reservoir - View looking  
west along dam.



Figure 16  
Waita Reservoir - View looking  
west along backslope of dam.



- LEGEND:
- DRAINAGE AREAS
  - 200 --- CONTOUR LINES
  - (A) KOLOA-POIPU DRAINAGE AREA
  - RESERVOIR
  - ↑ LOCATION AND DIRECTION OF PHOTOGRAPHS(See Figures)

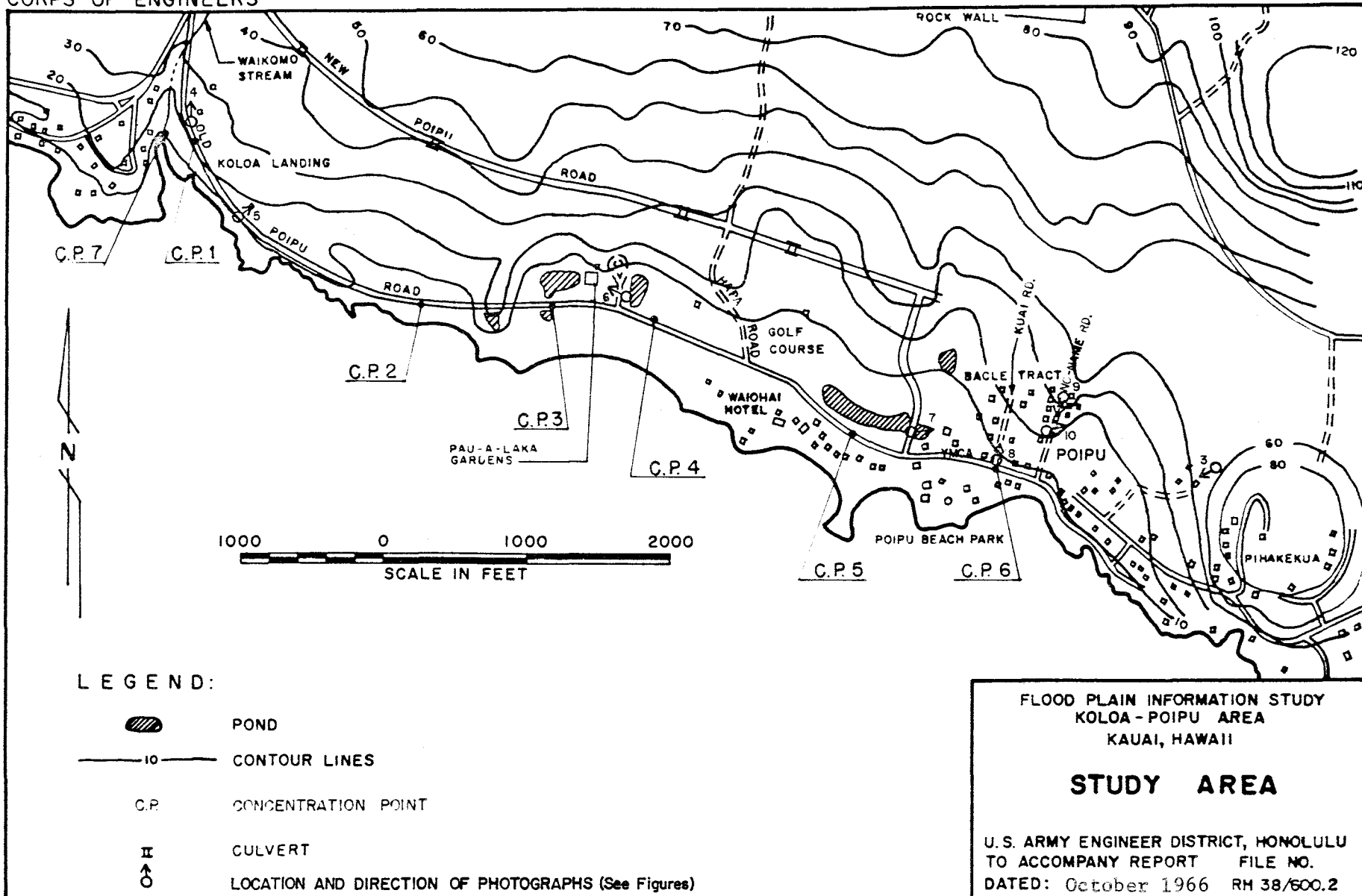
FLOOD PLAIN INFORMATION STUDY  
KOLOA-POIPU AREA  
KAUAI, HAWAII

DRAINAGE AREAS

U.S. ARMY ENGINEER DISTRICT, HONOLULU  
TO ACCOMPANY REPORT FILE NO.  
DATED: OCTOBER 1966 RH 38/600.1

CORPS OF ENGINEERS

U. S. ARMY



**FLOOD PLAIN INFORMATION STUDY**

**KOLOA-POIPU, KAUAI, HAWAII**

**TECHNICAL APPENDIX**

FLOOD PLAIN INFORMATION  
KOLOA-POIPU, KAUAI, HAWAII

TECHNICAL APPENDIX

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A-9	Flood Flow Frequency
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## Exhibits

<u>Exhibits</u>	<u>Description</u>
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A-2	State of Hawaii Letter of Application for Koloa-Poipu Flood Plain Study

FLOOD PLAIN INFORMATION  
KOLOA-POIPU, KAUAI, HAWAII

TECHNICAL APPENDIX

1. PURPOSE

This technical appendix contains detailed information and data to supplement the main report. Additional details for these investigations are available for inspection in the Honolulu District office of the Corps of Engineers.

2. AUTHORIZATION

The authority for the flood plain information report was granted under the provisions of Section 206, Public Law 86-645 (Flood Control Act of 1960). Section 206 reads as follows:

"Sec. 206 (a) That, in recognition of the increasing use and development of the flood plains of the rivers of the United States and of the need for information on flood hazards to serve as a guide to such development, and as a basis for avoiding future flood hazards by regulation of use by states and municipalities, the Secretary of the Army, through the Chief of Engineers, Department of the Army, is hereby authorized to compile and disseminate information on floods and flood damages, including identification of areas subject to inundation by floods of various magnitudes and frequencies, and general criteria for guidance in the use of flood plain areas; and to provide engineering advice to local interests for their use in planning to ameliorate the flood hazard; Provided, That the necessary surveys and studies will be made and such information and advice will provide for specific localities only upon the request of a State or a responsible local governmental agency and upon approval by the Chief of Engineers.

"(b) The Secretary of the Army is hereby authorized to allot, from any appropriations hereafter made for flood control, sums not to exceed \$1,000,000 in any one fiscal year for the compilation and dissemination of such information."

3. COORDINATING AGENCY FOR LOCAL INTERESTS

The Hawaii State Department of Land and Natural Resources was named the coordinating agency for local interests by Act 148, Session Laws of Hawaii 1963. Exhibit A-1 is a copy of Act 148 and Exhibit A-2 is a copy of the letter requesting the Koloa-Poipu Flood Plain Study.

#### 4. PHYSIOGRAPHIC CHARACTERISTICS

The study area lies about 8 miles southwest of Lihue, the county seat. The coastal study area and location of concentration points are shown on plate A-1. Boundaries of contributing drainage areas and the location of one stream gaging station in a nearby area are shown on plate A-2. Rainfall stations in the vicinity of the study area are shown on plate A-3. The total area of the six drainage units is 3.47 square miles and is rectangular in shape, about 3.5 miles long and 1 mile in width. Total relief varies from sea level to elevation 800 feet, m.s.l. in the northeast corner of the drainage basin. The study area is about 1.5 miles wide along the coast and contains 105 acres below the 20-foot contour. Practically all the present residential and commercial development is below the 20-foot contour. The land below the 120-foot contour has a uniform slope of 130 feet per mile and above the 120-foot contour the land slope is about 300 feet per mile. There are no well defined stream courses in the study area.

#### 5. HYDROMETEOROLOGICAL CHARACTERISTICS

The climate of the Koloa-Poipu area is semi-tropical and consists of two seasons. The summer season extends from May through September and is the warmer and drier part of the year with the northeast trade-winds predominating. The winter season, October through April, has lower temperatures and more frequent rains, with the tradewinds less prevalent. A climatological summary of temperatures and precipitation at the Koloa rain gaging station is presented in table A-1.

Table A-1  
Climatological Data for Koloa, Kauai, Hawaii<sup>1/</sup>

Month	Temperature-Degrees F.			Rainfall - Inches		
	Maximum	Minimum	Mean	Maximum	Minimum	Normal
January	86	48	69.5	35.89	0.40	6.91
February	88	46	70.0	16.85	0.55	6.24
March	88	46	70.6	19.40	0.69	6.63
April	86	51	71.8	14.63	0.93	4.73
May	87	54	73.5	14.02	0.63	4.35
June	88	59	75.5	8.65	0.94	3.69
July	89	63	76.2	10.02	1.40	5.06
August	89	61	76.8	16.06	0.80	6.52
September	89	59	76.6	18.70	1.22	4.38
October	89	53	75.7	11.93	0.95	5.31
November	87	50	73.0	21.15	0.80	6.07
December	85	50	71.1	21.42	0.63	7.62
Annual - Period of Record	89	46	73.4	97.92	35.10	67.51

<sup>1/</sup> Station number 936 in accordance with State key number system.

Note: Above data from U.S. Weather Bureau Climatological Data Summaries. Temperature values are based on 33 years of record. Rainfall values are based on 79 years of record.



The three types of meteorological conditions that produce heavy rainfall are the cold front storms and "Kona" storms, which occur during the winter season (October-April), and the tropical storm or hurricane, which usually occurs during the last half of the year, July through December.

a. Cold front storm. Passage of a vigorous cold front brings intense local rain over a small area while a few miles away there is little or no rain. Winds are gusty, sometimes becoming quite strong and damaging.

b. Kona storm. The "Kona" storm is one coming from the west or leeward direction as opposed to the normal east to west tradewind direction. Rain is caused by a slow moving or stationary high level low pressure trough into which moisture is fed from surface winds coming from either side. These rains cover a large area and may continue for several days. The steady, moderate intensity rains are interrupted by periods of torrential downpours.

c. Tropical storm or hurricane. Only four hurricanes, which are tropical storms with sustained high winds exceeding 74 miles per hour, have been recorded in Hawaii since 1904. The island of Kauai suffered damages by hurricanes, once in December 1957 (NINA) and again in August 1959 (DOT).

Mean annual rainfall over the Koloa-Poipu area varies from 35 inches along the coast to 80 inches at the higher elevations. See plate A-3.

## 6. RUNOFF CHARACTERISTICS

The area has no stream channels into which flood runoff can be diverted and led into the ocean. Whenever heavy rain occurs, the ground cannot absorb all of the water. The resulting excess water flows overland causing damage to residences and business establishments. Depressions in the ground are filled with water and soon ponds form and cause flooding in the immediate vicinity. These localized flood areas are scattered along the Old Poipu Road.

## 7. EXISTING FLOOD CONTROL STRUCTURES

There are no existing Federal flood control structures located within or adjacent to the flood plain area. In the lower reach of Waikomo Stream, discharges greater than a 5-year frequency would cause water to back up and overtop the banks at the New Poipu Road culvert. This culvert, consisting of two 10-foot radius, semicircular, corrugated metal pipes, has a capacity of about 7000 c.f.s. Water overtopping the left bank at this juncture would flow southward to the Old Poipu Road and into the Koloa Landing area. The Old Poipu Road bridge, constructed of timber, is also deficient in capacity. Culvert and bridge sections are shown on plate A-4.

## 8. RAINFALL RECORDS

There are 16 rainfall stations in the vicinity of the Koloa-Poipu area. See table A-2 and plate A-3. Two recording rain gages are in operation at the present time. These are the East Lawai gage (No. 934) established in 1960 about 3 miles west of the center of the study area, and M & M (No. 1001) with recorder installed in February 1966. Another recording gage, at Koloa (No. 936) was in operation from 1955 to 1960.

The monthly and annual (minimum, mean and maximum) rainfall recorded at Koloa, Station 936, with over 70 years of record are shown in table A-1. The greatest 24-hour rainfall ever recorded at station 936 is 10.30 inches on January 16, 1921. The greatest 24-hour rainfall observed for the island of Kauai and the State of Hawaii is 40 inches in January 1956.

Plate A-5 shows the rainfall intensity-duration-frequency relationship for the Koloa-Poipu drainage basin.

## 9. RUNOFF RECORDS

There is only one stream gage near the Koloa-Poipu study area. The gage (No. 525) is a recording stream gage 0.9 mile upstream from the mouth of Lawai Stream which has a drainage area of 6.6 square miles above the stream gage. The recording gage has been in operation since August 1963 and is about 3 miles west of the study area. A crest gage recorded peak gage heights of floods that occurred from April 24, 1962 up to the installation of the recorder on August 14, 1963.

The maximum flow of record at the Lawai Stream gage was 3,540 cubic feet per second on March 14, 1963 when a gage height of 9.56 feet was reached. The location of the gage is shown on plate A-2.

The Hanapepe stream gage, No. 490, is a recording gage, 5 miles upstream from the mouth of Hanapepe River, which has a drainage area of 18.8 square miles above the stream gage. The recorder has been in operation since December 1926. Prior to that time a staff gage was used to measure runoff. The highest discharge recorded at Hanapepe was 39,000 c.f.s. in April 1963. The location of the gage is shown on plate A-2. Station descriptions for Lawai Stream and Hanapepe River are shown in table A-3.

Table A-2

## Rainfall Stations In and Near Koloa-Poipu Flood Plain

<u>Number</u> <sup>1/</sup>	<u>Name</u> <sup>2/</sup>	<u>Elevation</u> feet above mean sea level	<u>Geographic Coordinates</u>		<u>Period</u> of <u>Record</u>	<u>Frequency</u> of <u>Observation</u>	<u>Maintained by</u>
			<u>Latitude</u> Degrees & Minutes	<u>Longitude</u> Degrees & Minutes			
933	Paanau	450	21-54.1	159-29.1	1938-date	Daily except weekends	Kauai Pineapple Co.
934	East Lawai	440	21-54.5	159-29.8	1960-date	Recorder	McBryde Sugar Co.
935	Kukuiula	105	21-53.5	159-29.5	1903-date	Daily except weekends	" " "
935.1	Paanau (McBryde)	135	21-53.7	159-28.5	1951-date	" " "	" " "
936	Koloa	240	21-54.6	159-27.9	1887-date	" " " <sup>3/</sup>	Grove Farm
936.1	Field K-43	240	21-54.4	159-28.9	1950-date	" " "	" "
936.2	Koloa Field O	275	21-54.7	159-28.5	1951-date	" " "	Kauai Pineapple Co.
937	Koloa Mill	155	21-53.8	159-26.8	1923-date	" " "	Grove Farm
940	Puuhii	80	21-52.8	159-26.3	1907-date	" " "	" "
940.1	Makahuena Pt.	50	21-52.2	159-26.9	1956-date	Twice daily	U. S. Coast Guard
941	Mahaulepu	100	21-54.7	159-25.4	1904-date	Daily except weekends	Grove Farm
941.1	Field K-21	80	21-54.0	159-25.4	1951-date	" " "	" "
1001	M & M	300	21-55.3	159-27.5	1924-date	" " " <sup>4/</sup>	" "
1002	Waita	250	21-54.5	159-27.2	1926-date	" " "	" "
1003	Kaala	400	21-55.0	159-28.0	1924-date	" " "	" "
1005	Kaluahonu	330	21-55.0	159-26.5	1923-date	" " "	" "

<sup>1/</sup> Stations numbered in accordance with State key number system.

<sup>2/</sup> See plate A-3 for locations.

<sup>3/</sup> Recorder in operation 1955-1960.

<sup>4/</sup> Recorder in operation since February 1966.

Table A-3

## Stream Gaging Stations

Number <sup>1/</sup>	Name	Elevation of Gage	Geographic Coordinates		Drainage Area	Period of Record
		Datum mean sea level	Latitude Degrees Minutes Seconds	Longitude Degrees Minutes Seconds	Square Miles	
525	Lawai	37 ft.	21-54-30	159-30-19	6.6	1962 to present
490	Hanapepe River	222 ft.	21-57-29	159-33-13	18.8	1918 to present (intermittent)

<sup>1/</sup> Stations numbered in accordance with U.S. Geological Survey numbering system.

## 10. FLOOD HISTORY

Newspaper records and climatological records of the U.S. Weather Bureau were used to obtain historical data on flooding and rainfall amounts in or near the study area.

In the past 12 years 6 floods of significance have been reported in the Poipu area. Of these, two floods which are considered to be the most severe are listed below:

a. Storm and flood of January 17-18, 1957. Kona weather blanketed Kauai with clouds throughout the week and brought extremely heavy rainfall to many parts of the island. The highest one day totals were recorded at Mahaulepu gage and Makahuena Point Station which had 11.97 and 11.23 inches, respectively. The 24-hour rainfall at Koloa Mill (Sta. 937) in the drainage area was 10.04 inches. The intersection of Kuai and Old Poipu Roads was flooded to a depth of 4 feet and the Bacle Tract area was flooded.

b. Storm and flood of November 19, 1965. A weather formation on the west side of the island and described as a "disturbance" brought heavy rains to Kauai. Flooding at Poipu developed at about 5 a.m. in the area around Waiohai Hotel and Bacle Tract causing damages to yard and property. Residents of the area stated that this flood was the highest they have ever seen. Most of the Koloa area received 3.5 inches or more of rain overnight. The 24-hour rainfall at Koloa Mill as reported by the U.S. Weather Bureau was 3.9 inches. This flood was probably facilitated to some degree by the November 14 flood which had kept the ground moist.

## 11. RELATIVE MAGNITUDE OF STORMS

The relative magnitude of storms that have occurred in the region is difficult to determine because of the scarcity of detailed rainfall, runoff and damage data. The most severe storms in the vicinity of Koloa-Poipu were those discussed in paragraph 10.

## 12. UNIT HYDROGRAPHS

The unit hydrographs used for the six drainage areas and Waikomo Stream were developed using a unit hydrograph derived for Lawai Stream gage as a guide. The peak flow in cubic feet per second per square mile for the Lawai Stream unit graph was plotted against the drainage area in square miles and a line through this point was drawn generally parallel to a line for the Palolo area on Oahu and then adjusted for difference in drainage area characteristics. The peak flows corresponding to each of the drainage areas were used to construct the 15-minute unit graphs, using the recession and peak timing of Lawai Stream unit hydrograph as a guide.

## 13. STANDARD PROJECT FLOOD

The standard project flood is one which would be exceeded in magnitude only on rare occasions. It establishes a standard for design of structures that would provide a high degree of flood protection without regard to economic or other practical limitations. The standard project flood is substantially less than the probable maximum flood. Standard project floods were developed for the six drainage areas and Waikomo Stream. These areas are shown on plate A-2. The standard project flood hydrographs for Areas A, E, F, and Waikomo are shown on plates A-6 and A-7.

## 14. STANDARD PROJECT STORM

Rainfall data used in computing peak discharges were based on criteria presented in a memorandum by the Office of the U.S. Army Chief of Engineers, dated September 19, 1962, subject, "Standard Project Storm Determinations, Hawaiian Islands." On the basis of this rainfall, the standard project storm for Areas A through F have a maximum 6-hour intensity of 14.4 inches over the Koloa-Poipu area with 24-hour total storm rainfall equal to 24 inches over the area. Similarly, Waikomo Stream would have a maximum 8-hour rainfall intensity of 15.5 inches with 24-hour total storm rainfall equal to 24 inches. Based on an inspection of the area and a comparison with the Palolo, Kalihi and Kuliouou areas on Oahu, an initial rate of 0.8 inch per hour, decreasing to a minimum of 0.4 inch per hour, was chosen as a reasonable infiltration rate for the Koloa-Poipu area. Rainfall data for the critical 6-hour period of heaviest rainfall over the study area are given in table A-4.

Table A-4

## Standard Project Storm Rainfall Data

Areas A to F Inclusive

Incremental time in minutes	T I M E I N H O U R S								
	0	1	2	3	4	5	6	7	8
0	0	0.3	0.5	1.7	0.6	0.4	0.2	-	-
15	0.2	0.4	0.5	2.6	0.5	0.3	-	-	-
30	0.2	0.4	0.7	1.2	0.5	0.3	-	-	-
45	0.3	0.4	0.9	0.7	0.4	0.2	-	-	-

Waikomo Stream

0	0	0.2	0.3	0.4	1.6	0.5	0.4	0.3	0.2
15	0.2	0.3	0.3	0.5	2.5	0.4	0.3	0.3	-
30	0.2	0.3	0.4	0.6	1.0	0.4	0.3	0.2	-
45	0.2	0.3	0.4	0.9	0.7	0.4	0.3	0.2	-

## 15. FLOOD FLOW FREQUENCIES

Peak discharge frequencies for Waikomo Stream and the flood plain were based on the frequency curve for Hanapepe River. Flow data used to compute the frequency at gaging station 490 are published by the U.S. Geological Survey. This basic curve was adjusted for Waikomo Stream and drainage Areas A, E and F according to differences in basin characteristics and 1 hour duration rainfall. See table A-5.

Table A-5

## Drainage Basin Characteristics

Drainage Basin	Area Sq. Mi.	L Miles	$L_{ca}$ Miles	$(LL_{ca})^{.3}$	1-hour Duration Rainfall-inches		
					100 yr.	10 yr.	2 yr.
Hanapepe River	18.80	8.9	4.6	3.05	4.5	3.1	3.3
Waikomo Stream	10.40	7.4	3.5	2.65	4.2	2.9	2.1
Area A	0.45	2.3	1.5	1.45	3.5	2.5	1.9
Area B	0.11	0.7	0.2	0.55	3.2	2.3	1.7
Area C	0.22	1.4	0.7	0.99	3.3	2.4	1.8
Area D	0.08	0.8	0.3	0.61	3.2	2.3	1.7
Area E	0.74	2.6	1.4	1.47	3.5	2.5	1.9
Area F	1.87	3.3	1.8	1.71	3.6	2.6	2.0

Adjustment of discharge frequencies was determined from the relationship:

$$q_1 = q \times \frac{R_1}{R} \times \frac{(LL_{ca})^3}{(LL_{ca1})^3}$$

where  $q$  = discharge in c.f.s. per square mile

$R$  = rainfall in inches

$L$  = length of basin or waterway

$L_{ca}$  = distance upstream to the center of area of the drainage basin

Subscript "1" in the equation is ascribed to the basin without runoff data. Terms without subscript refer to Hanapepe River.

The above method does not give reasonable results for areas less than 0.4 square mile. Therefore, frequency curves for drainage areas B, C, and D were derived by extending the peak discharge versus drainage area curve of Waikomo Stream and areas A, E and F for the various recurrence periods shown on plate A-10. Frequency curves are shown on plates A-9 and A-8.

Lawai Stream has a recording gage but the 4 years of record were considered too short to obtain reliable frequency curves.

## 16. RESERVOIR

Waita Reservoir, located to the north of the Poipu drainage basin as shown on plate A-2, is 0.61 square miles in area. Its physical features include a dam spanning the southern shore, a spillway at the southeastern corner and 3 outlets. Plate A-11 show cross sections of the dam and spillway.

The main source of storage water is surface runoff from the 3.5 square mile drainage area. This supply is supplemented by water drawn from adjacent basins and nearby reservoirs through a system of tunnels and ditches. The maximum capacity of the reservoir is 2.3 billion gallons at a depth of 22.6 feet. Normal depth in the reservoir is 21 to 22 feet. In a 56-year (1910-1966) period, a minimum depth of 1.5 feet was recorded during a drought in 1933. The maximum depth of 23 feet occurred in 1917. Plate A-11 shows gage heights and elevation of the spillway and dam. The data included in the report on sizes and frequencies of future floods are based on the assumption that the dam will not fail or be overtopped.

## 17. TSUNAMI IN HAWAII

The frequency of tsunami in the Pacific Ocean is exemplified by the record of 43 damaging occurrences in Hawaii over the past 146 years. Pertinent information is given in table A-6, which does not include those tsunami producing only slight variations in water surface. The dearth of data recorded by instrumentation and the marked variation in activity even within extremely short distances along a coast preclude the

Table A-6

## Tsunami Affecting Hawaii

<u>Date</u>	<u>Source</u>	<u>Wave period (minutes)</u>	<u>Damage</u>
Apr 12, 1819	Chile	11	Slight
Feb 20, 1835	Chile	-	Severe
Nov 7, 1837	Chile	28	Very severe
May 17, 1841	Kamchatka	40	Moderate
Apr 2, 1868	Hawaii	-	Very severe
Aug 13, 1868	Peru and Bolivia	-	Very severe
Jul 25, 1869	South America	-	Severe
Aug 23, 1872	Hawaii	6	Moderate
May 10, 1877	Chile	20	Very severe
Jan 20, 1878	-	-	Slight
Aug 27, 1883	-	-	Moderate
Jun 15, 1896	Japan	-	Slight
Aug 9, 1901	Japan	-	Slight
Jan 31, 1906	Colombia	-	Slight
Aug 16, 1906	Chile	-	Moderate
Oct 11, 1913	New Guinea	-	Slight
May 26, 1914	New Guinea	-	Slight
May 1, 1917	Kermadea Islands	-	Slight
Jun 25, 1917	Samoan Islands	-	Slight
Aug 15, 1918	Philippine Islands	-	Slight
Sep 7, 1918	Kurile Islands	-	Moderate
Apr 30, 1919	Tonga Islands	90	Slight
Nov 11, 1922	Chile	-	Slight
Feb 3, 1923	Kamchatka	15	Very severe
Apr 13, 1923	Kamchatka	-	Slight
Nov 4, 1927	California	-	Slight
Dec 28, 1927	Kamchatka	-	Slight
Jun 16, 1928	Mexico	-	Slight
Mar 6, 1929	Aleutian Islands	-	Slight
Oct 3, 1931	Solomon Islands	15	Slight
Jun 3, 1932	Mexico	-	Slight
Mar 2, 1933	Japan	-	Moderate
Nov 10, 1938	Alaska	-	Slight
Apr 6, 1943	Chile	-	Slight
Dec 7, 1944	Japan	-	Slight
Apr 1, 1946	Aleutian Islands	15	Very severe
Dec 20, 1946	Japan	-	Slight
Aug 21, 1951	Hawaii	-	Slight
Nov 4, 1952	Kamchatka	38	Moderate
Mar 9, 1957	Aleutian Islands	18	Moderate
May 23, 1960	Chile	33	Very severe
Oct 19, 1963	Japan	-	Slight
Mar 27, 1964	Alaska	22	Slight



assignment of height to the largest wave in each phenomenon. Then, too, eye witness accounts and data provided by post-tsunami examination of areas subjected to violent attack can be misleading, since it is difficult to differentiate between a solid mass of water and runup or spray. In the case of water marks on objects, runup, which varies with the shape of the obstruction and environmental factors, contributes immensely to distortion of the true picture. Wave height determination by refraction analysis was considered, but wave characteristics, such as length, and other factors preclude determination by this procedure. Besides, much data relative to deep water characteristics are lacking.

#### 18. TSUNAMI DAMAGE

Since no correlation of occurrences by wave height could be made, comparison was effected on the basis of severity of damage. Each event was classified into one of four categories, namely, very severe, severe, moderate, and slight. Difficulty was encountered even in this relatively simple approach to the problem because data pertaining to early occurrences is limited. Of the 43 listings, 7 were designated very severe, 2 severe, 8 moderate and 26 slight. There is no record of a tsunami affecting the Poipu area, but it is a potential threat to the southern coast of the island and people in the Koloa-Poipu area should be aware of the possibility of tsunami damage as well as overland flood damage.

#### 19. FLOOD PLAIN REGULATION

Flood plain land use regulation has been accomplished by other states and municipalities using various combinations of legislative powers available to them. Excerpts of laws and ordinances dealing with flood plain regulation are given in the following paragraphs to demonstrate their importance in a well-planned community development program.

#### 20. EXCERPT FROM ZONING ORDINANCE

From Tehama County, California, Ordinance No. 302, adopted September 5, 1961.

##### SECTION 24-A. "PF" PRIMARY FLOOD PLAIN DISTRICTS

Sec. 24-A.1. This district classification is intended to be applied by the County to properties which lie within a primary floodway, which for the purposes of this ordinance shall be construed to be a stream channel and the portions of the adjacent flood plain as are required to efficiently carry the flood flow of the stream, and on which properties special regulations are necessary for the minimum protection of the public health and safety, and of property and improvements from hazards and damage resulting from flood waters.

The following specific regulations and the general rules set forth in Section 31 shall apply in all "PF" Districts.

Sec. 24-A.2. Uses Permitted:

(a) Crop and tree farming, truck gardening, viticulture, live-stock grazing, and other agricultural uses which are of the same or a closely similar nature.

(b) Public utility wire and pipe lines for transmission and local distribution purposes.

Sec. 24-A.3. Uses Permitted Upon The Issuance of Use Permits:

(a) The following uses, buildings and structures when it is found by the Planning Commission that such buildings and structures will be so constructed or placed, or will be so protected by levees or other flood proofing that they will not be appreciably damaged by flooding, will offer a minimum obstruction to flood flow, and will resist flotation:

1. Buildings and structures accessory to agricultural uses for the storage of goods and equipment and the shelter of animals and fowl, but not including dwellings or buildings for human occupancy.

2. Public utility buildings and structures other than wire and pipe lines.

3. Public parks and recreation areas and facilities, including boat ramps, docks, parking areas, picnic tables and fireplaces, private and commercial recreation developments and facilities, camp grounds and trailer parks, provided that rest room facilities shall be located and constructed in accordance with Health Department requirements.

(b) Commercial excavation of natural materials, filling of land areas; construction of levees, dikes or other structures designed to divert or obstruct the flow of flood waters.

(c) Single family residence and multiple family residences when it is found by the Planning Commission that such buildings and structures will be so constructed or placed, or will be so protected by levees or other flood proofing that they will not be damaged by flooding or constitute obstructions to flood flow or hazards to life or property.

(d) By the addition thereto of a new Section to be designated Section 24-B, and to read as follows:

SECTION 24-B, "SF" SECONDARY FLOOD PLAIN DISTRICTS

Sec. 24-B.1. This district classification is intended to be applied to properties which lie within areas inundated by overflow

waters during the historical flood of 1958 of the Sacramento River and its tributaries, excluding areas within established "PF" Districts, which properties are subject to occasional flooding of inundation by overflow flood waters, and so require special regulations for the protection of such properties and their improvements from hazards and damage which may result from flood waters.

The following regulations and the general rules set forth in Section 31 shall apply to all "SF" Districts.

Sec. 24-B-2. Uses Permitted:

(a) Uses as permitted in "PF" Districts, (Sec. 24-A.2 and Sec. 24-A.3).

(b) Single-family dwellings and accessory residential and agricultural structures located on agricultural properties of three or more acres, provided that the ground floor level of such dwellings shall be above the level of the 1958 flood waters upon the particular property.

(c) Residential subdivision improvements and dwellings, as defined herein, within subdivisions approved and recorded in Tehama County after the fourth day of March, 1957, and subject to conditions to such approval and to ground floor level as specified in Sec. 24-B.2 (b) above.

Sec. 24-B.3. Uses Permitted Upon the Granting of Use Permits:

(a) Improvements, buildings and structures listed in Sec. 24-B.2 (a) and (b) above which may not meet the ground floor level specified, but which will otherwise be adequately protected by levees or other acceptable flood proofing.

(b) Single family dwellings, motels, multiple family dwelling.

(c) Local service commercial uses and structures.

(d) Uses and structures for the storage, distribution and processing of agricultural products, supplies and equipment.

(e) Public and private schools, churches, libraries, organization meeting halls and other similar places of public assembly.

\* \* \*

21. EXCERPTS FROM SUBDIVISION REGULATIONS

Clinton

(From Clinton, Tennessee, Subdivision Regulations, adopted Dec. 1957)

Land which the planning commission has found to be unsuitable for subdivision due to flooding, bad drainage, steep slopes, rock formation, or other features likely to be harmful to the safety, health, and general welfare of the future residents shall not be subdivided unless adequate methods approved by the city engineer are formulated by the developer for meeting the problems created by the subdivision of such land.

Land within the Floodway shall not be platted for residential occupancy or building sites. Other land subject to flooding may be platted for residential occupancy or for such other uses which will not increase the danger to health, life, and property. Fill may not be used to raise land in the Floodway areas. In other areas subject to flood, fill may be used providing the proposed fill does not restrict the flow of water and unduly increase flood heights.

In applying this provision, land below the elevation of the 50,000 c.f.s. flood shall be considered subject to flood. The elevation of the 50,000 c.f.s. flood shall be determined from the chart "High Water Profiles, Clinch River, Vicinity of Clinton, Tennessee" (Tennessee Valley Authority, November 1957), which chart is made a part of these regulations. Areas included in the Floodway are as shown on the Zoning Map of Clinton, Tennessee.

\* \* \*

No street shall be approved unless it is at an elevation within two feet of the elevation of the 50,000 c.f.s. flood. The planning commission may require where necessary profiles and elevations of streets for areas subject to flood. Fill may be used for streets provided such fill does not unduly increase flood heights. Drainage openings shall be so designed as to not restrict the flow of water and unduly increase flood heights.

\* \* \*

For each lot in a subdivision that does not contain a flood-free building site as defined by these regulations, the subdivider must fill to the required elevation and meet other requirements concerning fills as specified in the introduction to Article II or include in the deed the restriction that the lower floor of any structure be built at an elevation not lower than that of the 50,000 c.f.s. flood referred to in the introduction to Article II.

\* \* \*

If any portion of the land being subdivided is subject to flood, as defined in the introduction to Article II, the limits of such land shall be shown on the final plat as recorded.

## 22. EXCERPTS FROM BUILDING CODES

### Los Angeles County

(The Los Angeles County, California, Uniform Building Code of 1956 contains the following statement concerning construction in flood areas.)

\* \* \*

A permit shall not be issued for a group A, B, C, D, H or I occupancy in an area which is subject to flood hazards by reason of inundation, overflow, or erosion, and is so determined to be by the County Engineer unless such hazard is eliminated to the satisfaction of the County Engineer by providing adequate drainage facilities, by protective wall, by suitable fill, by raising floor level of the building, by a combination of these methods, or by other means.

\* \* \*

### National Building Code

(From National Building Code, Recommended by the National Board of Fire Underwriters, New York: 1955.)

\* \* \*

Sills shall be anchored to the foundation walls at intervals not exceeding 6 feet by anchors equivalent to bolts not less than one-half inch in diameter with proper washers, embedded at least 7 inches in the foundation.

\* \* \*

### Basic Building Code

(From Basic Building Code, 1955 Edition-Chicago: Building Officials Conference of America, Inc., 1955.)

\* \* \*

Section 874.3 Foundation. Exterior walls below grade and the cellar floors of all buildings for institutional and residential uses (use groups H and L) enclosing habitable or occupiable rooms or spaces below grade shall be made watertight, and when necessary shall be reinforced to withstand water pressure as prescribed in sections 710 and 871. The basement walls of buildings in the residential use groups and the walls of all habitable and occupiable rooms and spaces below grade shall be protected with not less than a one-coat application of approved waterproofing paint, or a one-half (1/2) inch pargeting coat of portland cement mortar or other approved damp-proof covering.

## 23. SELECTED BIBLIOGRAPHY

The following list is a sampling of the papers and publications dealing with floods and flood plain information:

Corps of Engineers, U.S. Army Engineer District, Sacramento, California, Statistical Methods in Hydrology, 1962.

Corps of Engineers, U.S. Army Engineering and Design Manual EM 1110-2-1405, Flood Hydrograph Analysis and Computations, 1959.

Corps of Engineers, U. S. Army Engineering and Design Manual EM 1110-2-1408, Routing of Floods Through River Channels, 1960.

Corps of Engineers, U. S. Army Engineering and Design Manual EM 1110-2-1409, Backwater Curves in River Channels, 1959.

Corps of Engineers, U. S. Army Engineering and Design Manual EM 1165-2-111, Flood Plain Information Studies, 1961.

Corps of Engineers, Honolulu District, Final Post Flood Report, The Tsunami of 23 May 1960 in Hawaii, 1962.

Hawaii Department of Land and Natural Resources, Flood Control and Flood Water Conservation in Hawaii, Volumes I and II.

Tennessee Valley Authority, Flood Damage Prevention, An Indexed Bibliography, Knoxville: 1963.<sup>1/</sup>

University of Hawaii, Hawaii Institute of Geophysics Report No. 14, Potential Tsunami Inundation Areas in Hawaii, Doak C. Cox, undated.

U. S. Coast and Geodetic Survey Preliminary Report, The Tsunami of May 22, 1960 as Recorded at Tide Stations, J. M. Symons and B. D. Zetler, undated.

U. S. Geological Survey Progress Report No. 5, An Investigation of Floods in Hawaii, 1963.

U. S. Geological Survey, Flood Plain Mapping Activities of the United States Geological Survey, Tate Dalrymple, 1963.

U. S. Department of Commerce, Weather Bureau Technical Paper No. 43, Rainfall Frequency Atlas of the Hawaiian Islands, 1962.

Gilbert F. White and Howard L. Cook, Making Wise Use of Flood Plains, 1964.

<sup>1/</sup> Contains 238 listings of references pertaining to flood damage prevention and flood plain regulation, with only selected items concerned with flood control.

CORPS OF ENGINEERS

U. S. ARMY

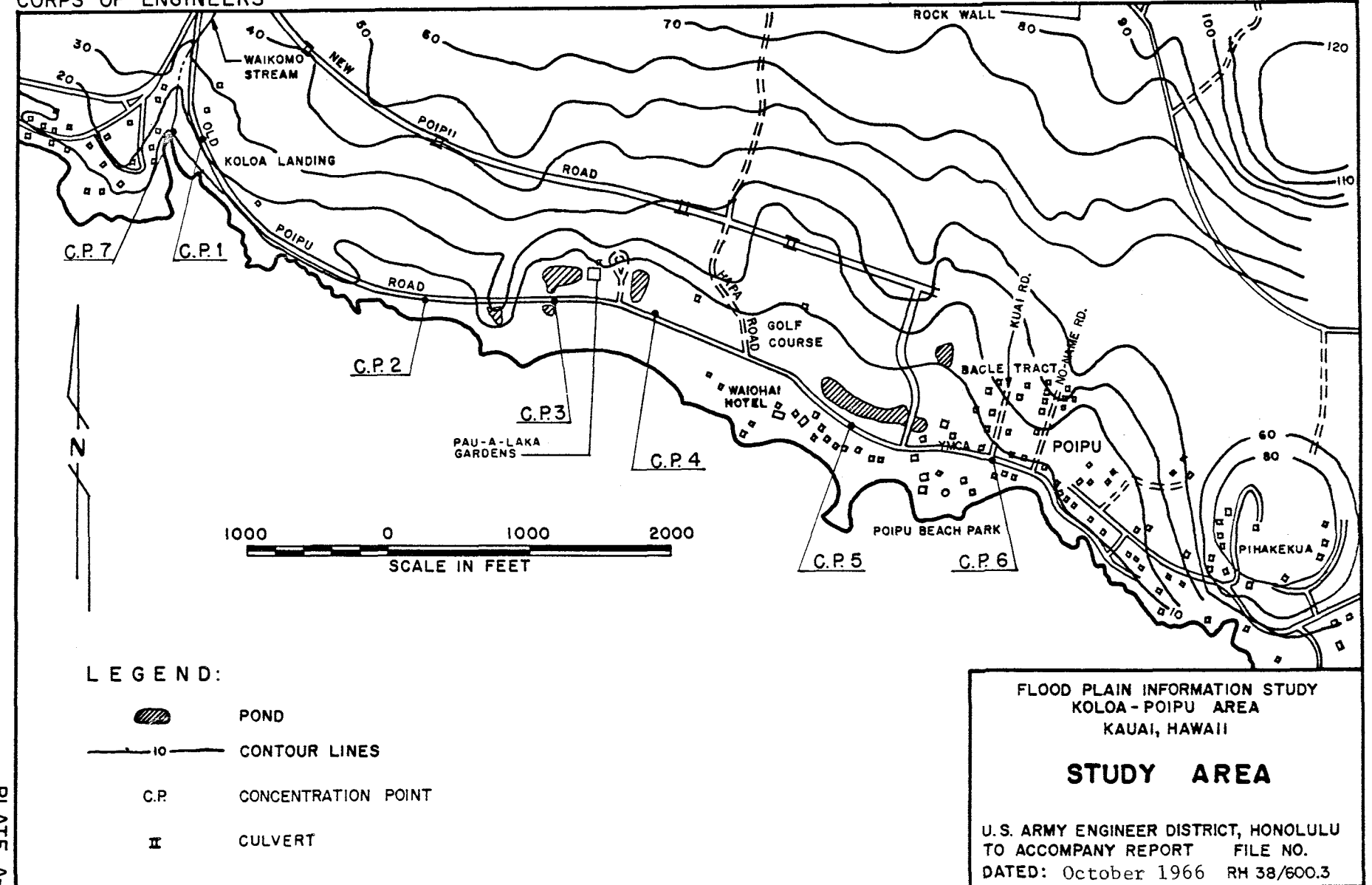
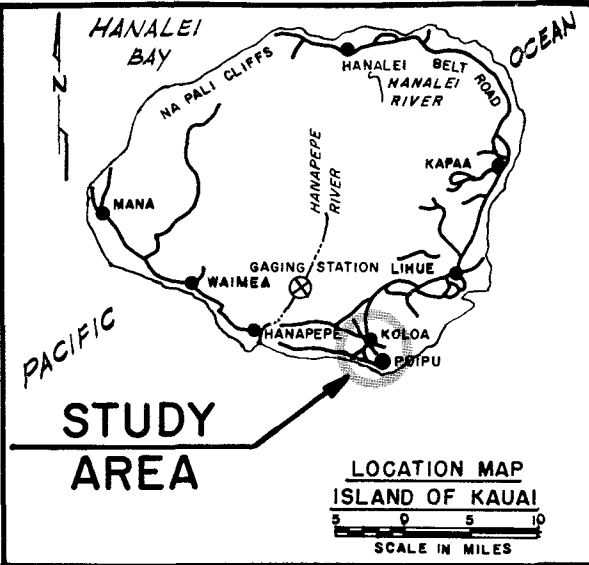
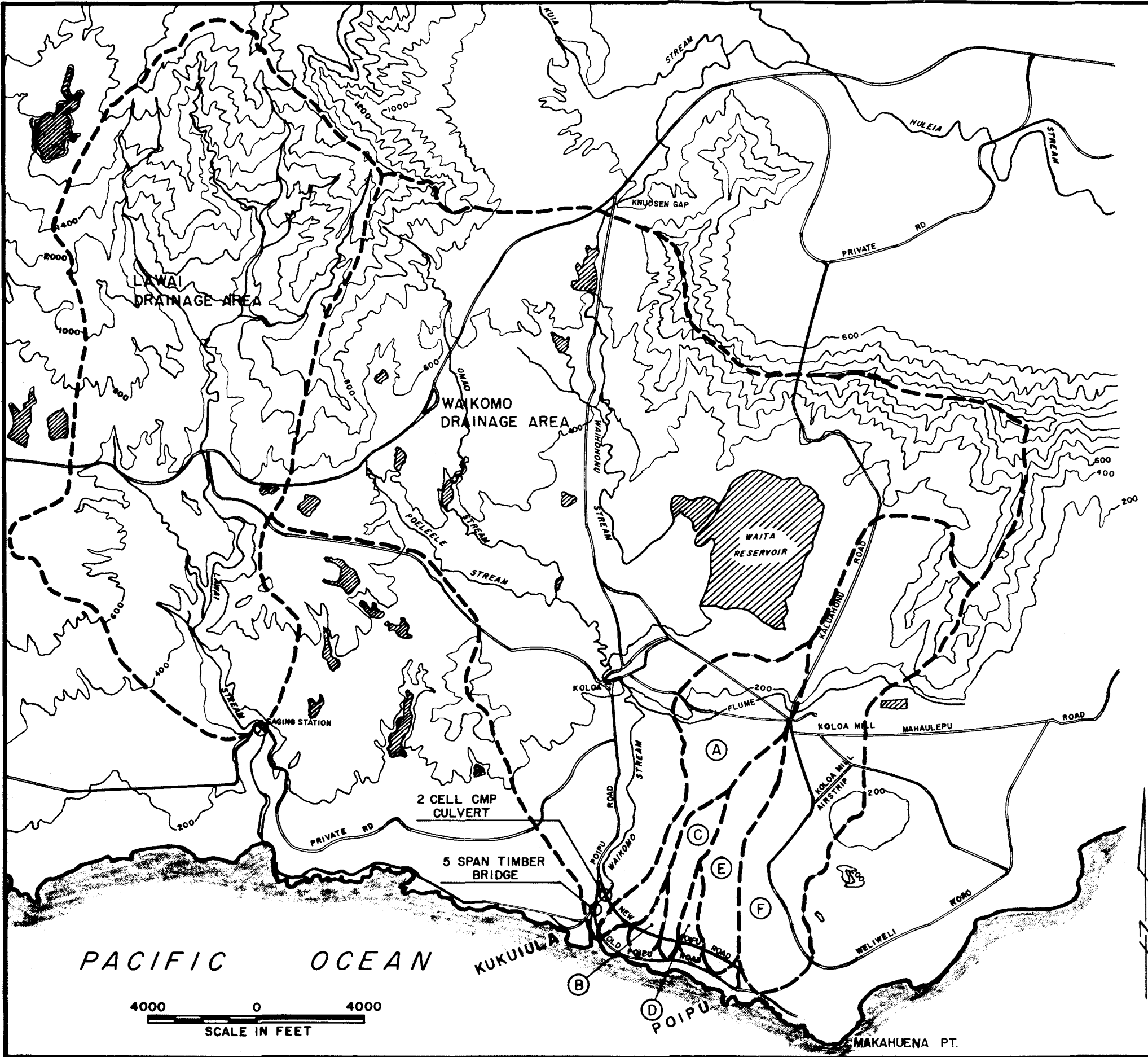


PLATE A-1



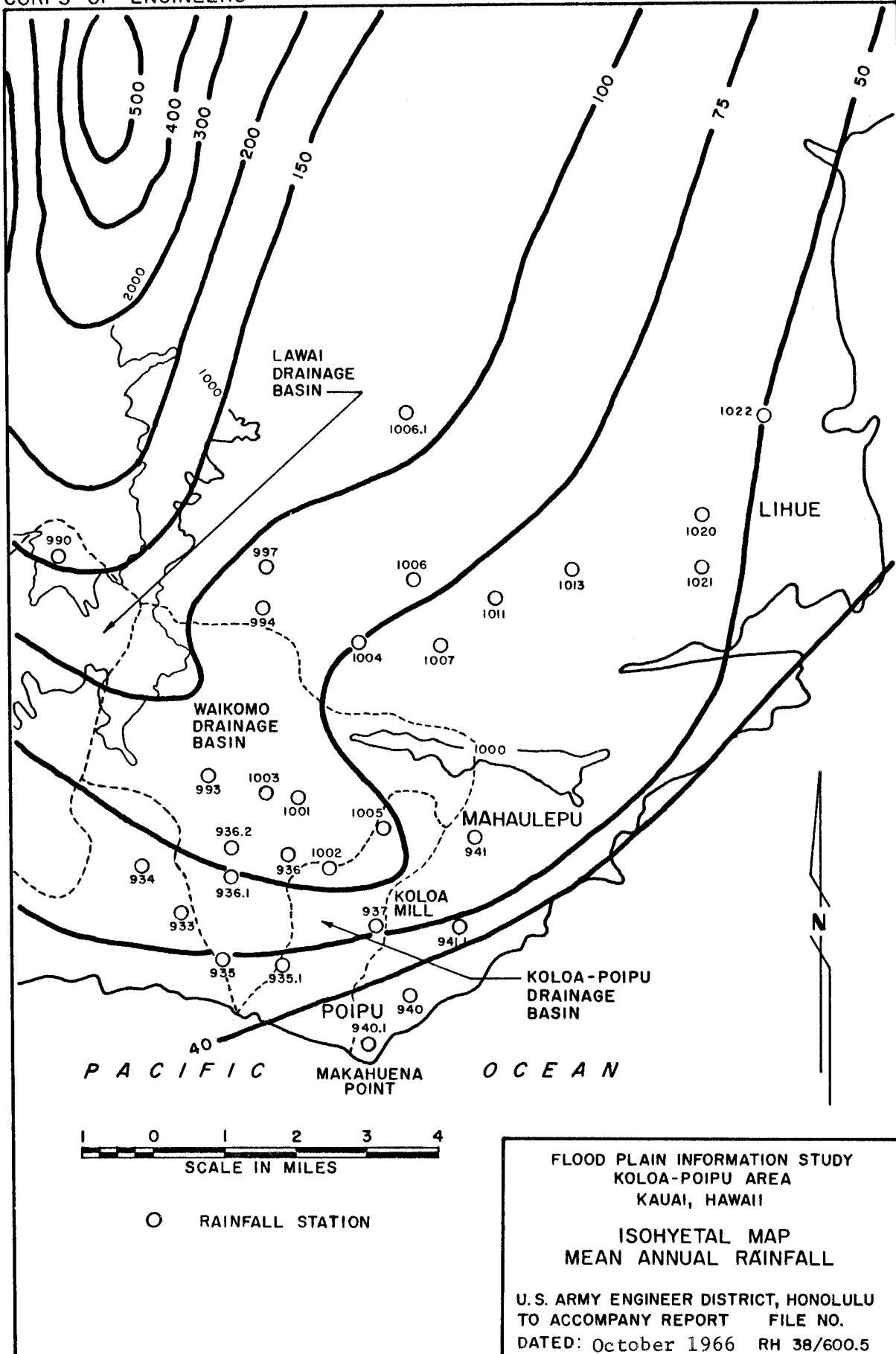
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- DRAINAGE AREAS
  - 200 — CONTOUR LINES
  - (A) KOLOA-POIPU DRAINAGE AREA
  - ◼ RESERVOIR

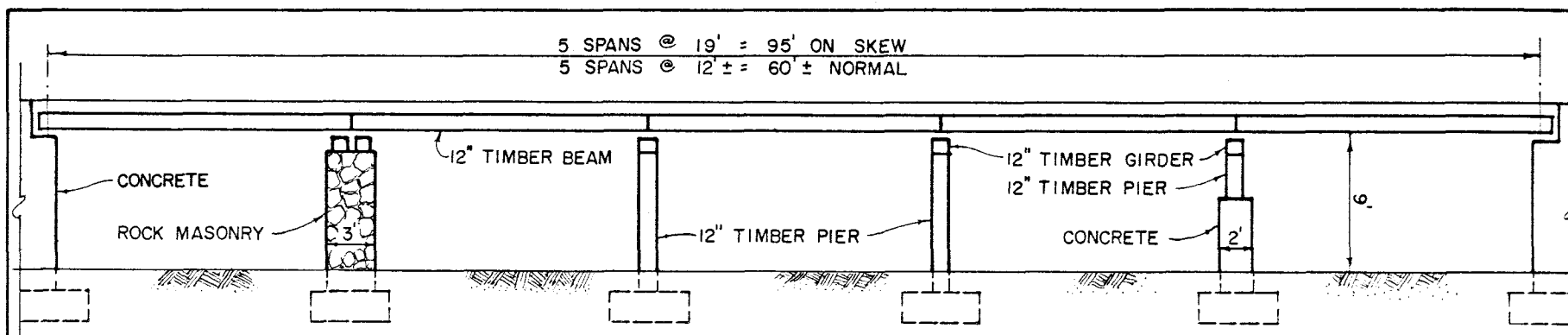
FLOOD PLAIN INFORMATION STUDY  
KOLOA-POIPU AREA  
KAUAI, HAWAII

DRAINAGE AREAS

U.S. ARMY ENGINEER DISTRICT, HONOLULU  
TO ACCOMPANY REPORT FILE NO.  
DATED: OCTOBER 1966 RH 38/600.4

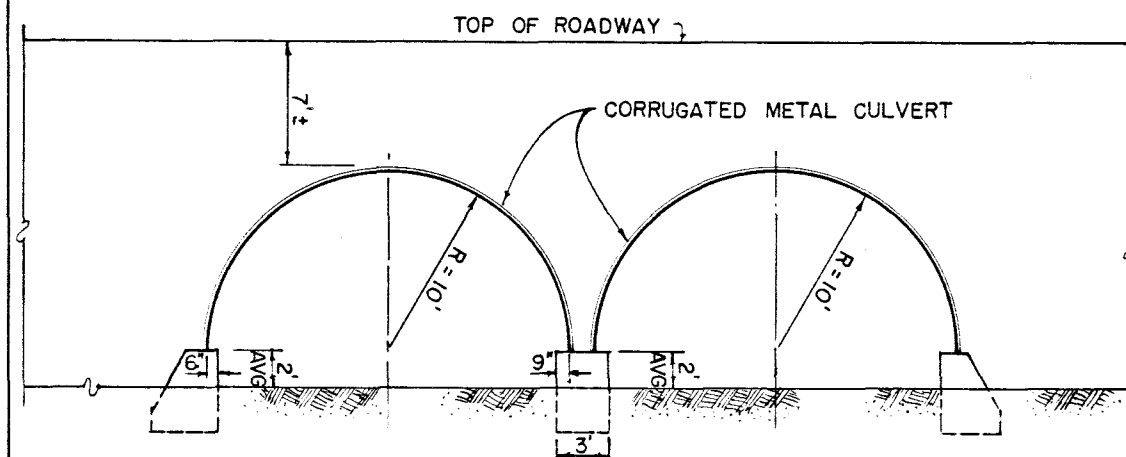






LONGITUDINAL SECTION  
OLD POIPU ROAD BRIDGE

SCALE:  $\frac{3}{32}" = 1' - 0"$



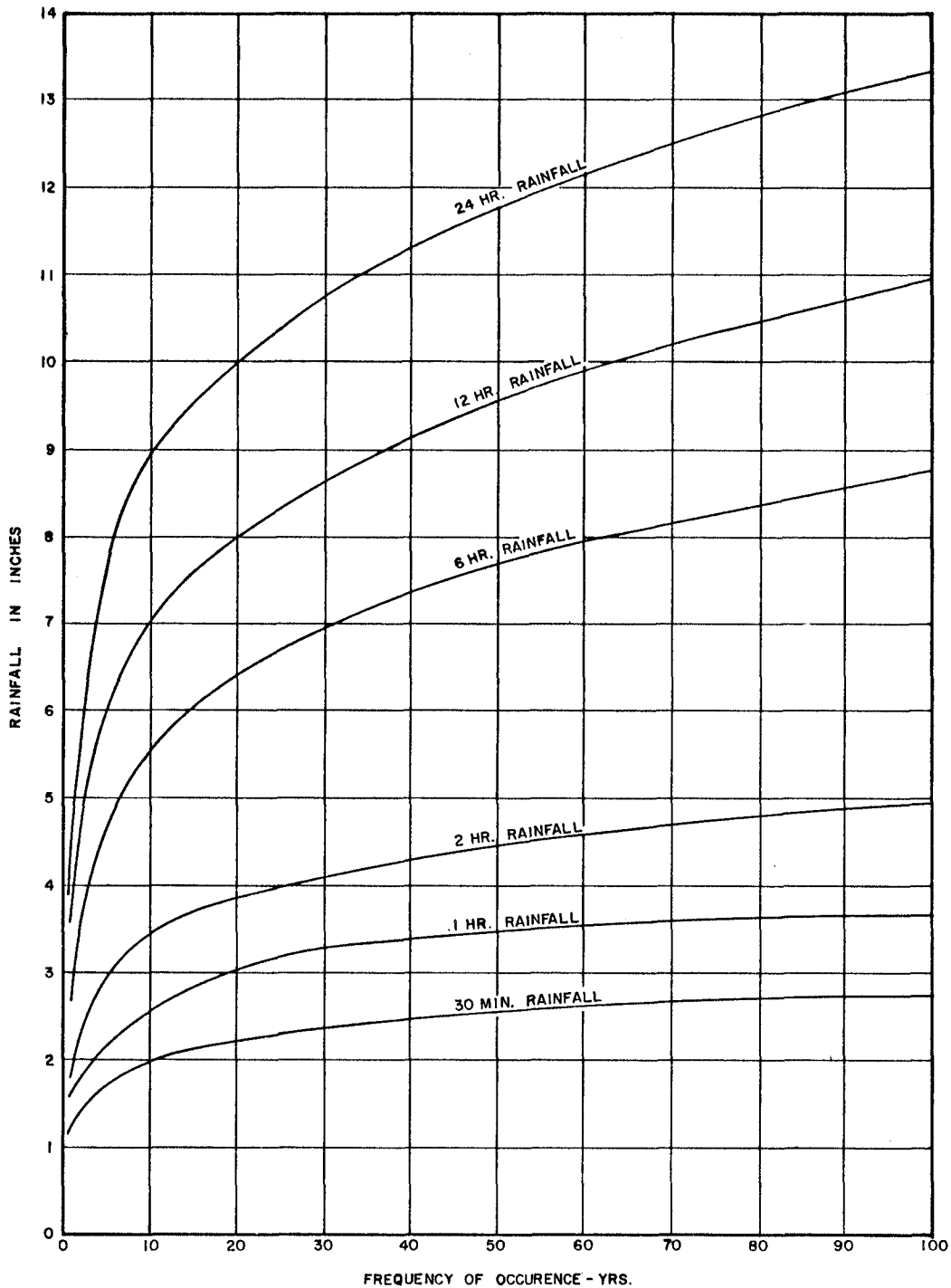
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NEW POIPU ROAD BRIDGE

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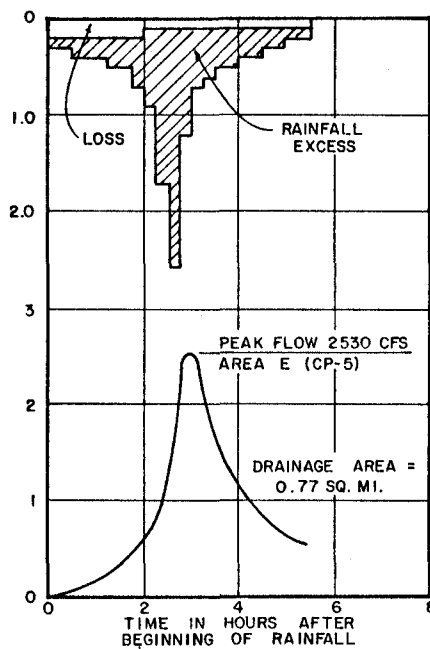
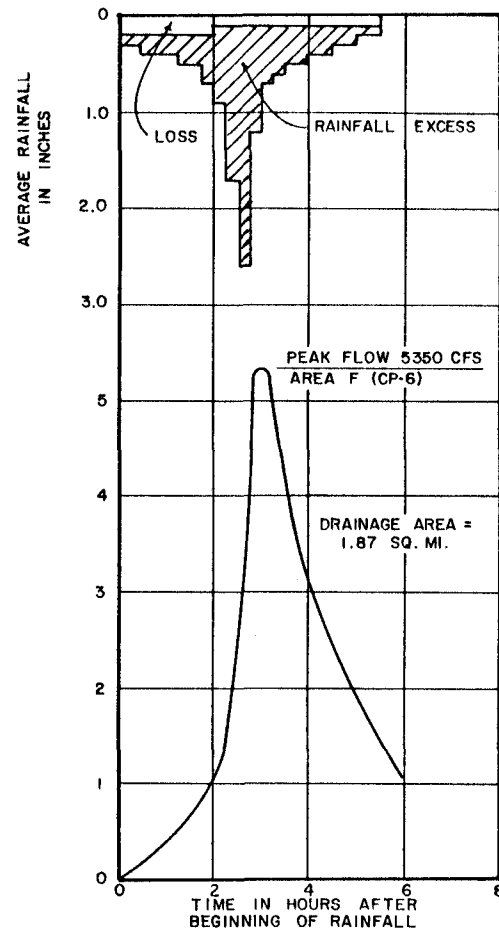
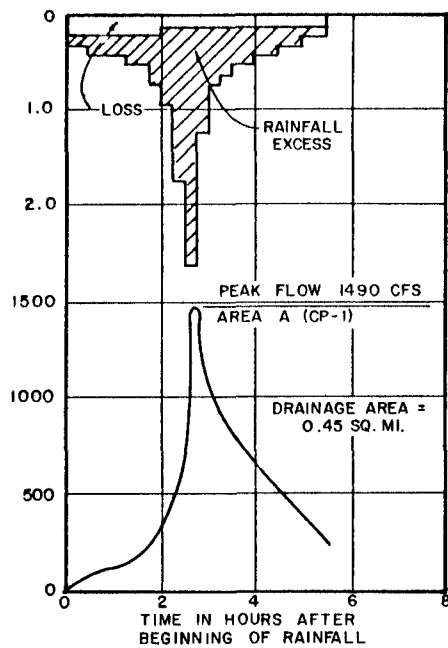
FLOOD PLAIN INFORMATION STUDY  
KOLOA-POIPU AREA  
KAUAI, HAWAII

BRIDGE & CULVERT SECTIONS  
WAIKOMO STREAM

U.S. ARMY ENGINEER DISTRICT, HONOLULU  
TO ACCOMPANY REPORT FILE NO.  
DATED October 1966 RH 38/600.6



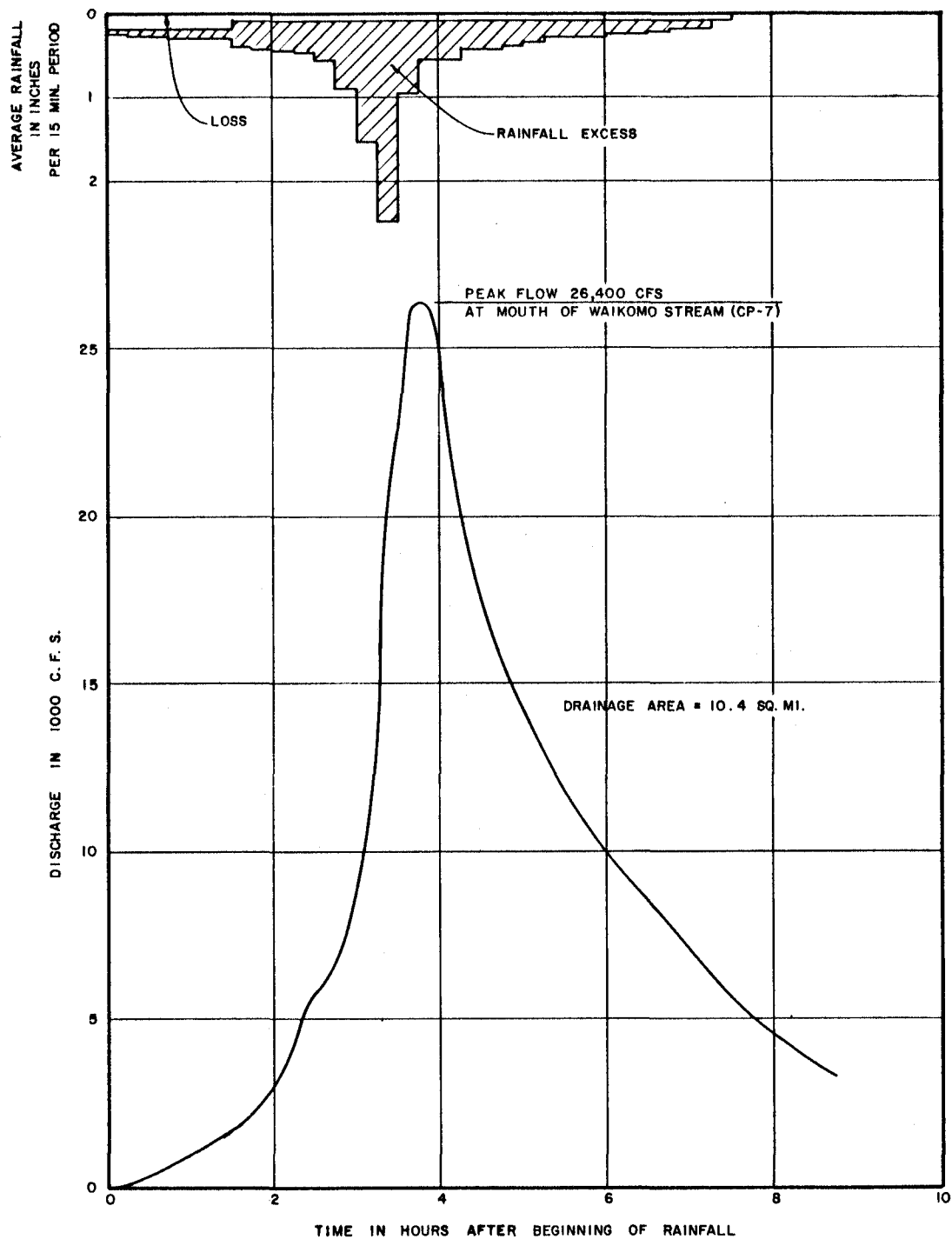
FLOOD PLAIN INFORMATION STUDY  
KOLOA-POIPU AREA  
KAUAI, HAWAII  
RAINFALL INTENSITY-DURATION-  
FREQUENCY CURVE  
DRAINAGE AREAS A TO F INCL.  
U.S. ARMY ENGINEER DISTRICT, HONOLULU  
TO ACCOMPANY REPORT FILE NO.  
DATED: October 1966 RH 38/600.7



FLOOD PLAIN INFORMATION STUDY  
KOLOA-POIPU AREA  
KAUAI, HAWAII

STANDARD PROJECT FLOOD  
HYDROGRAPHS

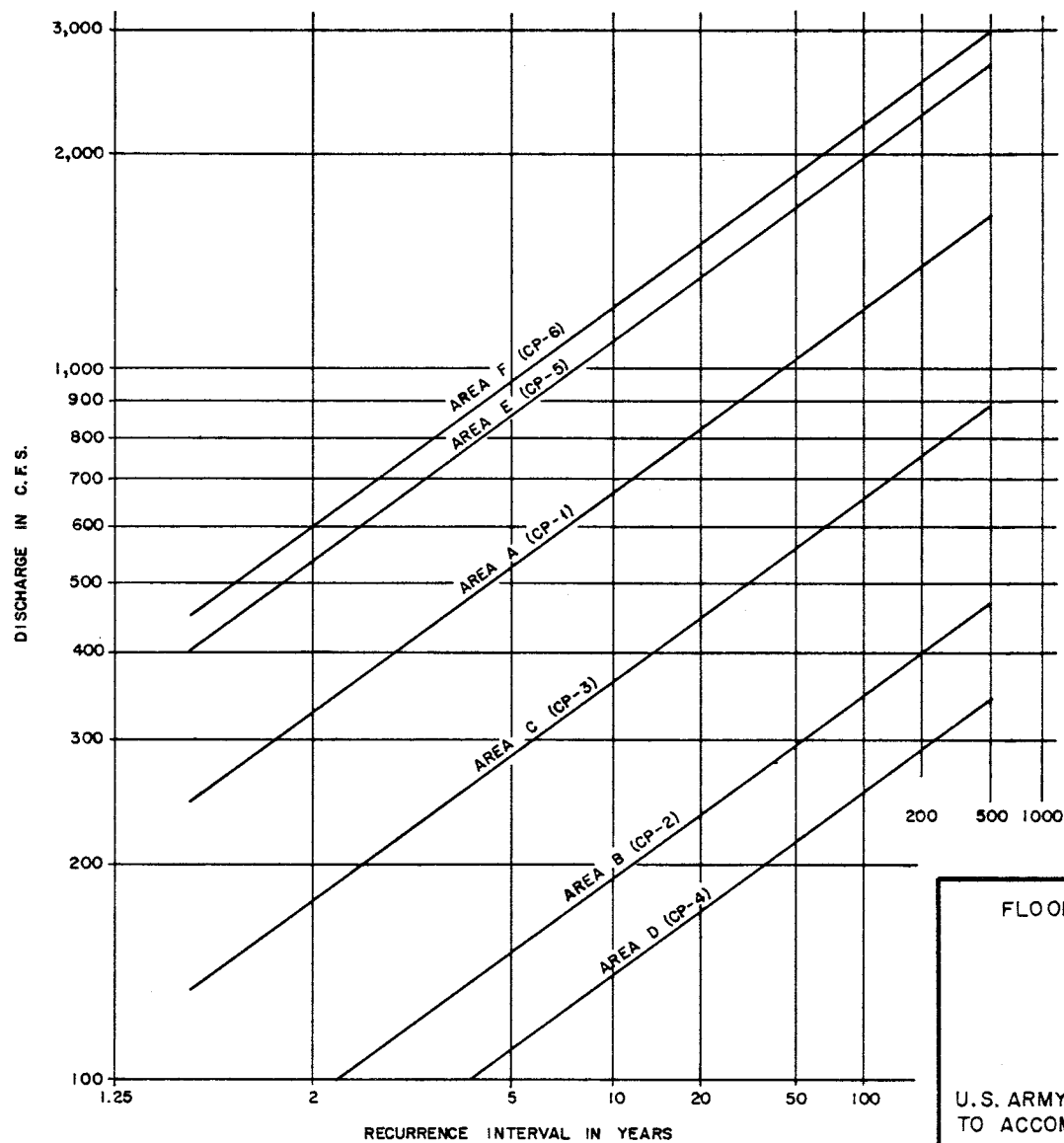
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TO ACCOMPANY REPORT FILE NO.  
DATED: October 1966 RH 38/600.8



FLOOD PLAIN INFORMATION STUDY  
KOLOA-POIPU AREA  
KAUAI, HAWAII

STANDARD PROJECT FLOOD  
HYDROGRAPH

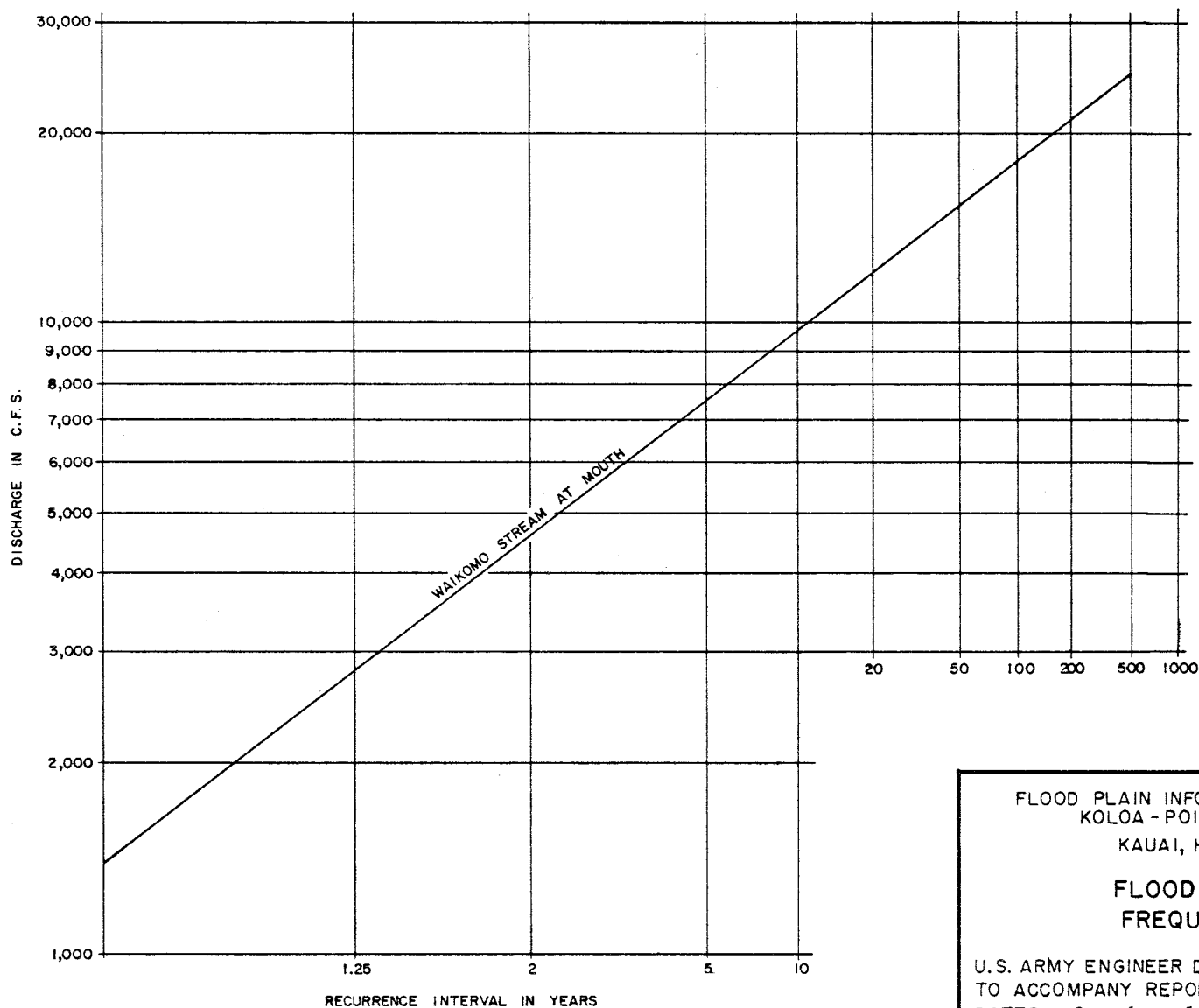
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TO ACCOMPANY REPORT FILE NO.  
DATED October 1966 RH 38/600.9



FLOOD PLAIN INFORMATION STUDY  
KOLOA-POIPU AREA  
KAUAI, HAWAII

### FLOOD FLOW FREQUENCIES

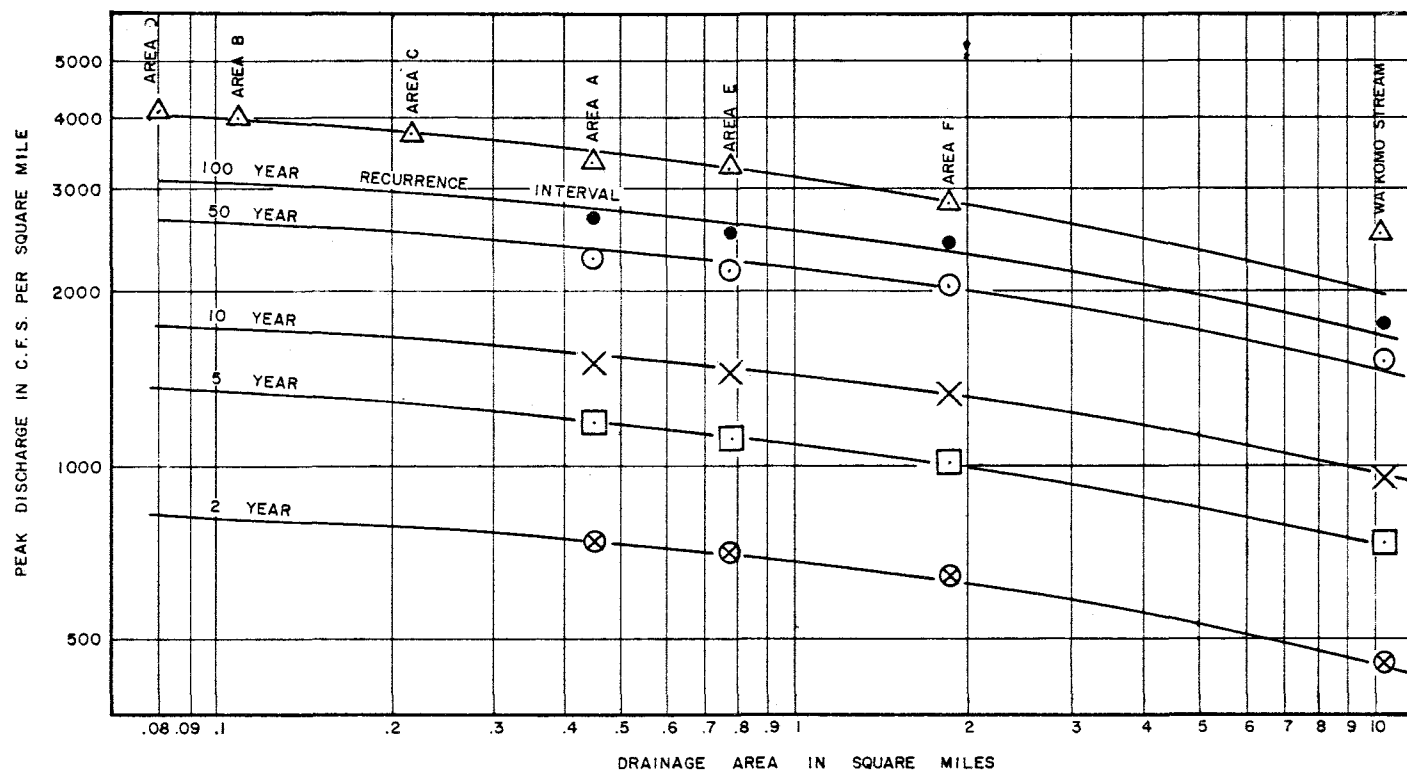
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TO ACCOMPANY REPORT FILE NO.  
DATED: October 1966 RH 38/600.10



FLOOD PLAIN INFORMATION STUDY  
KOLOA-POIPU AREA  
KAUAI, HAWAII

FLOOD FLOW  
FREQUENCY

U.S. ARMY ENGINEER DISTRICT, HONOLULU  
TO ACCOMPANY REPORT FILE NO.  
DATED: October 1966 RH 38/600.11



### LEGEND

- △ STANDARD PROJECT FLOOD PEAK DISCHARGE AT CONCENTRATION POINTS 1 THRU 7, SEE PLATE A-1
- 100 YEAR RECURRENCE INTERVAL
- 50 YEAR RECURRENCE INTERVAL
- × 10 YEAR RECURRENCE INTERVAL
- 5 YEAR RECURRENCE INTERVAL
- ⊗ 2 YEAR RECURRENCE INTERVAL

FLOOD PLAIN INFORMATION STUDY  
KOLOA-POIPU AREA  
KAUAI, HAWAII

### PEAK DISCHARGE-DRAINAGE AREA RELATIONSHIP

U.S. ARMY ENGINEER DISTRICT, HONOLULU  
TO ACCOMPANY REPORT FILE NO.  
DATED October 1966 RH 38/600.12



TOP OF DAM  
EL. 248 (G.H. = 28 FT.)

G.H. = 21.1 FT.

MAX. 1.5' REMOVABLE  
FLASHBOARDS

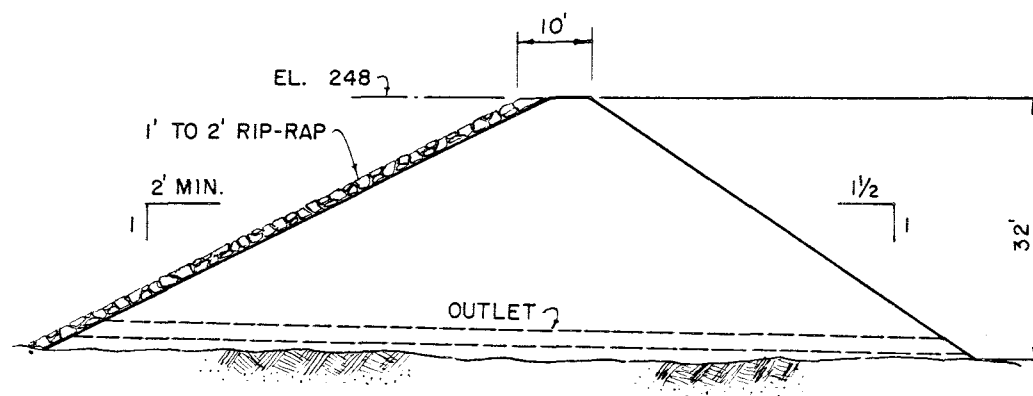
60'

40'

CONCRETE STRIPS

### SECTION AT SPILLWAY

NO SCALE



### TYPICAL CROSS SECTION

EARTH DAM

NO SCALE

FLOOD PLAIN INFORMATION STUDY  
KOLOA-POIPU AREA  
KAUAI, HAWAII

DAM & SPILLWAY SECTIONS  
WAITA RESERVOIR

U. S. ARMY ENGINEER DISTRICT, HONOLULU  
TO ACCOMPANY REPORT FILE NO.  
DATED October 1966 RH 38/600.13

## A B I L L F O R A N A C T

RELATING TO FLOOD CONTROL AND AMENDING CHAPTER 87C, REVISED LAWS OF HAWAII 1955, AS AMENDED.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF HAWAII:

SECTION 1. Chapter 87C, Revised Laws of Hawaii 1955, as amended, is hereby further amended to read as follows:

"Sec. 87C-1. Declaration of Purpose. It is hereby declared:

- (a) That floods caused by heavy rainstorms and abnormal tidal action are detrimental to the health, safety, and general welfare of the people of the state, resulting in jeopardy to and the loss of life and property, disruption of commerce, and interruption of transportation and communications; that the reduction of flood damage is therefore of primary importance to the people of the state; and the conservation and beneficial use of flood water is an essential adjunct to rainfall drainage and flood control.
- (b) It is the purpose of this Act to provide for the coordination by the state of all federal and state flood control projects undertaken in Hawaii and for such technical and/or financial assistance to its political subdivisions as may be desirable or necessary to assure maximum benefits to the people of the state from the expenditure of state funds for flood control purposes.
- (c) Nothing in this chapter shall prevent any political subdivision through its proper officials from requesting federal aid on its own initiative and at its own expense without having to secure State approval.

Sec. 87C-2. Definitions. The following terms, whenever used and referred to in this Act, shall have the following respective meanings, unless a different meaning clearly appears in the context:

'Abnormal tidal action' shall include high seas or surf, hurricane floods, and tsunamis or seismic waves.

'Board' shall mean the board of land and natural resources.

'Department' shall mean the department of land and natural resources.

'Drainage' shall mean the collection and conveyance of surface or sub-surface water, storm runoff, or any other water to a disposal area, or into a watercourse or standing body of water to reduce damage to lands which are not necessarily adjacent to such watercourse or standing body of water, or to reclaim lands for beneficial use.

'Drainage facilities' shall mean any man-made construction undertaken for drainage purposes and shall include conduits, ditches, canals, dikes, embankments, dams, reservoirs, and other appropriate facilities.

'Drainage measures' shall include drainage facilities, land treatment, statutory and building code requirements relating to drainage, and any other measures intended to accomplish drainage purposes.

'Flood' shall mean the temporary inundation of usable lands caused by the overflow of an adjacent natural watercourse or standing body of water.

'Flood control,' 'flood water control,' and 'flood prevention,' shall mean the minimizing of flood damage by appropriate protective, preventive, and corrective measures.

'Flood control measures' shall include flood control works, land treatment, master planning and zoning to establish encroachment zones along watercourses and adjacent to standing bodies of water, training of flood fighting units, flood disaster plans and operations, and any other measures relating to flood control, flood water conservation, and flood damage.

'Flood Control Plan,' 'General Flood Control Plan,' and 'Plan' shall mean the report entitled General Flood Control Plan for Hawaii (Volume II of Flood Control and Flood Water Conservation in Hawaii), published by the Board in January 1963.

'Flood control program' when referring to a specific watershed or sub-watershed, shall mean all existing or planned flood control measures relating to such area; when referring to the statewide flood control program shall mean the General Flood Control Plan and all activities of the Board and Department pursuant to the provisions of this Act.

'Flood control project,' 'federal flood control project,' and 'state flood control project' shall mean, respectively: (1) specific flood control works which comprise all or a portion of the works needed to complete a specific flood control program; (2) a flood control project authorized and implemented pursuant to the Federal Flood Control Act of 1936 or the Watershed Protection and Flood Prevention Act of 1958, as amended or supplemented, and (3) a flood control project sponsored and financed by the State and authorized and implemented pursuant to Section C-4(c) of this Act.

'Flood control works,' 'works of improvement,' 'works,' or 'flood control facilities' shall mean any man-made construction undertaken to confine storm runoff within a natural watercourse, conserve such runoff, or lessen the energy and effect of abnormal tidal action, and shall include conduits, ditches, canals, levees, dikes, embankments, dams, reservoirs, breakwaters, groins, seawalls, and other appropriate facilities.

'Flood water conservation' shall mean the confinement, storage and beneficial utilization of storm runoff by the construction, operation, maintenance, and supervision of drainage and flood control facilities.

'Political subdivision' shall mean any of the several counties under existence in the state by virtue of the laws of Hawaii or any legally organized district or political incorporation thereof.

'Watercourse' or 'natural watercourse' shall mean any river, stream, gulch, gully, valley floor, or any other naturally formed channel having a bed and sides or banks in which water flows either perennially or intermittently. 'Natural watercourse' shall also include a drainage ditch in existence after seven years from installation but shall not include

a ravine, swale, or similar depression within which water flows only during rainfall.

'Standing body of water' shall mean a fresh water pond, lake, or reservoir, or the Pacific Ocean along an extended shoreline or a tidal inlet such as a bay, harbor, pond, or estuary.

'United States' shall mean the United States of America, including the agencies, instrumentalities, officers, agents, or employees thereof.

Sec. 87C-3. Statewide Flood Control Agency and Program.

- (a) The board of land and natural resources, whose functions include under the existing laws of Hawaii, the management and administration of water resources of the state, is hereby designated as the state agency responsible for the accomplishment of the purposes of this act.
- (b) All flood control and flood water conservation and related activities, and any attendant powers and duties, heretofore assigned to other state departments or agencies, but not including flood disaster operations, shall be transferred to the Board upon the enactment of this law.
- (c) It is declared that the General Flood Control Plan is to be regarded as a general guide for the orderly and coordinated implementation of a statewide flood control program and the specific existing and planned flood control programs and the specific existing and planned flood control programs comprising the Plan to be financed by State funds. This declaration is not to be construed so as to constitute approval of the specific flood control programs included in the Plan. Nor shall this declaration be construed so as to prohibit the development of lands bordering water-courses or standing bodies of water. The Board may, from time to time, modify the Plan to the extent that it finds such to be necessary or desirable.

Sec. 87C-4. Powers, Duties and Jurisdiction of the Board. In addition to those powers and responsibilities of the Board established by existing law, the Board is authorized to implement the declared purposes of this act with regard to flood control and flood water conservation in the following manner:

- (a) Coordinate the programs and activities of all agencies of the state, in conformance with the objectives of the statewide flood control program.
- (b) Compile, evaluate, interpret, and disseminate information for technical use and for the general information and education of the people of the state.
- (c) Render technical assistance to the political subdivisions and other agencies of the state only upon request of the affected agencies in matters of master planning, zoning, qualifying for and constructing federal and state flood control projects, the training of flood fighting units, and related flood control activities.
- (d) With regard to federal flood control projects:
  - (1) review plans submitted by federal agencies for state approval and make appropriate recommendations to the Governor; (2) formulate and recommend to the Legislature of a general policy for state participation with the political subdivisions in the assurances of local cooperation required by federal flood control acts; (3) review requests from political subdivisions for financial assistance in meeting local participation requirements and make appropriate recommendations to the Legislature; and (4) execute and administer agreements with political subdivision to implement state assurances of participation in federal flood control projects.
- (e) For meritorious proposed projects which do not meet feasibility standards for federal flood control projects: (1) formulate state feasibility criteria and project funding procedures; (2) study, evaluate, and determine the feasibility of proposed projects in accordance with established criteria and make recommendations to the Legislature; (3) execute and administer agreements with political subdivisions to assure compliance with the conditions of state projects; and (4) design, prepare plans and specifications, obtain bids, let contracts, and supervise the construction of state flood control works.
- (f) With regard to projects initiated and financed entirely by political subdivisions, render coordination and aid only if requested by the respective agencies."

SECTION 2. Existing Laws and Severability. All laws or parts of laws which are held to be inconsistent with this Act are hereby amended to conform with the provisions of this Act. The provisions of this Act are declared to be severable, and if any portion of this Act or the application thereof to any person, circumstance, or property is held to be invalid for any reason, the validity of the remainder of this Act or the application of such portion to other persons, circumstances or property shall not be affected thereby.

SECTION 3. This Act shall take effect upon its approval.

APPROVED this 3rd day of June, 1963

/s/ John A. Burns

GOVERNOR OF THE STATE OF HAWAII



STATE OF HAWAII  
DEPARTMENT OF LAND AND NATURAL RESOURCES

P. O. BOX 621  
HONOLULU, HAWAII 96809

February 5, 1965

Lt. Col. Glenn P. Ingwersen  
District Engineer  
U.S. Army Engineer District, Honolulu  
Corps of Engineers  
Building 96, Ft. Armstrong  
Honolulu, Hawaii 96813

Dear Col. Ingwersen:

Koloa-Poipu Flood Plain Information Study

The Department of Land and Natural Resources, which was designated by Act 148, Session Laws of Hawaii 1963 (copy attached), as the State agency to cooperate in the flood plain information studies authorized by Section 206 of Public Law 86-645, hereby applies for Federal study of the Koloa-Poipu area on the island of Kauai, Hawaii.

The problem area, with a drainage area of about two square miles, is shown on the attached map. No defined stream channels exist but sheet flow over much of the area with accompanying ponding in many depressions behind the highway occurs about once a year. Outlets from these low areas to the sea are lacking.

The area along the existing highway is partially used for a public park, private residences and resort hotels. Upon opening of the recently completed highway about 1,200 feet inland, much more of the desirable shore front property will be available for resort development with supporting facilities. Data on the flood potential will be needed as soon as practicable to adequately plan for further developments which are already in process.

The State can provide without cost an aerial map with 10-foot contours of the area; plan and profile of the new highway with design data on culverts; and some sparse data on past flooding.

As it is obviously impracticable to compute the elevation and area coverage of flood flows because of the lack of stream channels, detailed topographic maps,



February 5, 1965

and any reliable stage and discharge of past floods, it is requested that the scope of the study be limited to estimating the flood flows and frequencies related to the approximate individual sub-drainage areas included in the problem area. A determination of areas flooded frequently under present conditions is also requested.


The State of Hawaii will be responsible for providing the following local cooperation:

1. The State of Hawaii and the County of Kauai will publicize this report throughout the island of Kauai and will make copies available to all interested parties and individuals.
2. Zoning and other regulatory, development, and planning agencies and public information media will be provided with the flood plain information for their guidance and appropriate action.
3. Survey markers, monuments, etc., established in any Federal survey in the area concerned will be preserved and safeguarded.

We wish this study to have priority over the one recently requested for the Anahola area on Kauai, and its prompt approval and initiation will be greatly appreciated.

Very truly yours,

BOARD OF LAND AND NATURAL RESOURCES

  
JIM P. FERRY  
Chairman and Member

enc.

cc: Mr. Masao Kutaka

EXHIBIT A-2