DRAFT

ENVIRONMENTAL IMPACT STATEMENT

PUUKAPU FLOOD CONTROL PROJECT

WAIMEA, HAWAII

Prepared by

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF WATER AND LAND DEVELOPMENT
HONOLULU, HAWAII

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Environmental Impact Statement for Puukapu Flood Control Project

Summary Sheet

A. Administrative Action for Draft Environmental Statement

B. Brief Description of Flood Control Project

The proposed Puukapu Flood Control Project Job No. 28-FH-6E will be located in the town of Waimea, Kamuela, Hawaii. Tax Map Key: 6-6-03. The channel will be a realignment of the existing Waikoloa Stream. It is 1600 feet in length and concrete and/or concrete rubble masonry lined. The alignment begins at a double box culvert at Lindsey Road, continues southwest, curves westward then southwest and terminates in State of Hawaii owned property.

The proposed project will minimize flood damage to the flood plain.

C. Environmental Impact

The realignment of Waikoloa Stream and the construction of a concrete lined channelwill reduce flooding of the area to a minimum. Economic benefits are the lessening of damages to crops and property and stability of the truck-crop farming industry. Conservation benefits from the project include reduction of soil erosion and minimizing the destruction of trees, shrubs and wildlife. Public health and safety will also be enhanced. Health risk from overflowing cesspools caused by flooding will be minimized.

D. Adverse Environmental Effects

Sixteen hundred feet of natural stream channel will be replaced by a concrete lined channel. The lined channel and its new alignment will travel through a grove of trees. Tree destruction will be minimized by alignment and land usage. Air, water and noise pollution of a temporary nature will occur during construction.

E. Alternatives

Alternatives to the project include following the natural stream alignment with a improved channel, and a realignment of the channel. Also considered was no stream improvement.

Two profiles were also considered. They included a straight line profile with a constant slope and a stepped channel with varying slopes. Various channel cross-sections were also considered in the analysis.

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A. PROJECT DESCRIPTION

1. Location

The proposed Puukapu Flood Control project is located in the town of Waimea, Hawaii. Waimea Town is in the northern portion of the island and lies on the Waimea Plains between the Kohala Mountains and Mauna Kea (Fig. 1).

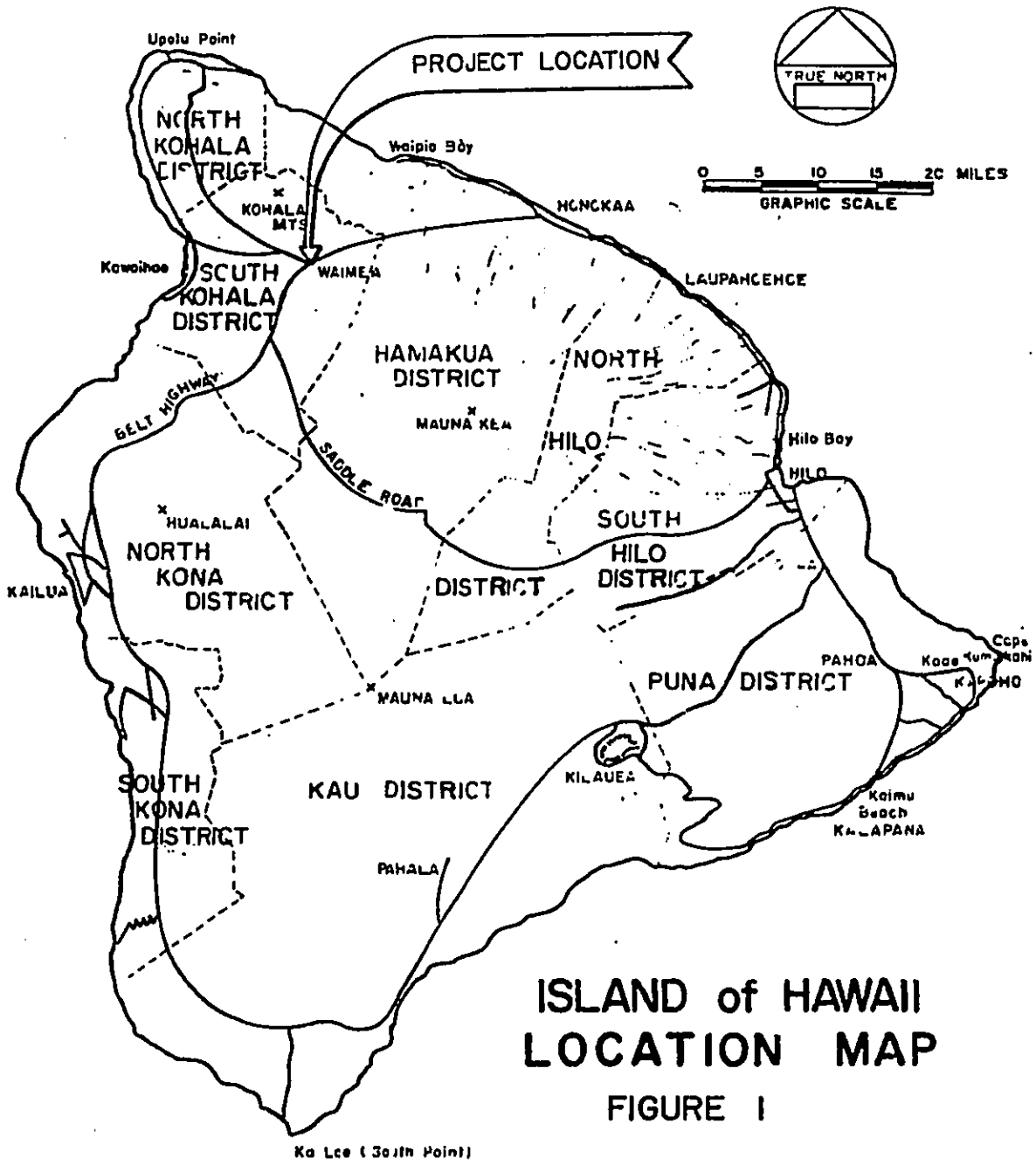
Two major streams traverse Waimea. They are Waikoloa and Lanimaumau Streams (Fig. 2). Both streams, along with a number of unnamed drainageways, are intermittent (Ref. 3). Waikoloa Stream originates in the Kohala Mountains and flows rapidly through Waimea. Ten miles further downstream it exits into the sea. Lanimaumau Stream, which also originates in the Kohala Mountains, has in the past been diverted away from Waimea Town and into a nearby lava tube (Ref. 3).

There is almost no stream flow from Mauna Kea due to the lava's permeable nature.

2. Purpose of Project

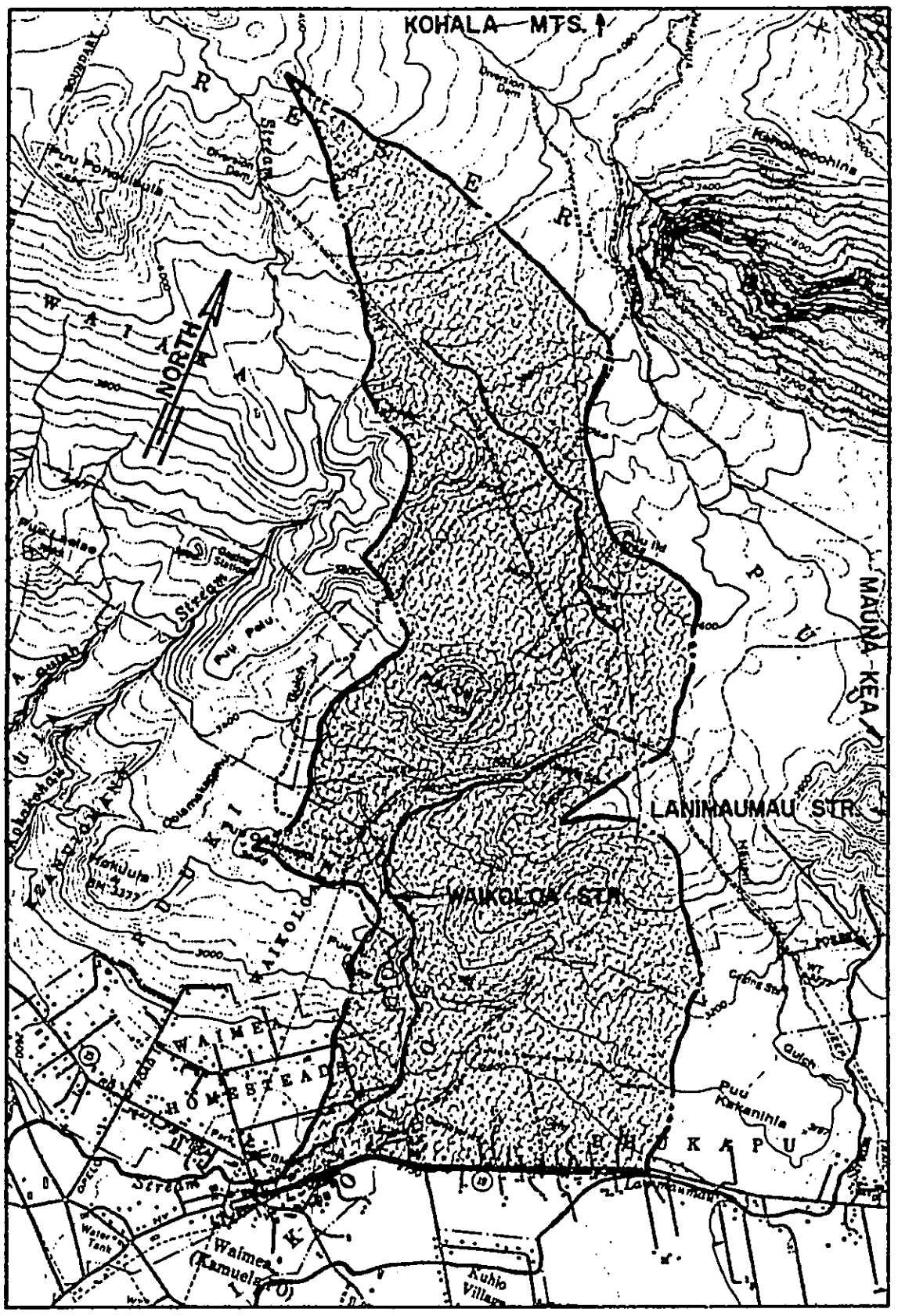
The purpose of the Puukapu Flood Control project (Tax Map Key 6-6-03) is to institute measures that will reduce the frequency of flooding in the towns of Waimea and Kuhio Village. The means of accomplishing this is by the realignment of a small portion of the meandering Waikoloa Stream (Fig. 3), and the utilization of 1600 feet of lined channel. The proposed channel will have a concrete base and side walls of concrete-rubble-masonry (CRM) or perhaps a textured precast slab in an attempt to make the channel as aesthetically pleasing as possible.

The proposed channel realignment originates at the crossing of Waikoloa Stream at Lindsey Road bridge. It traverses through pasture land and terminates in State of Hawaii owned property. This channel alignment is being proposed to aid the passage of water resulting from Waikoloa Stream and proposed upstream flood control projects (Ref. 1). The narrow twisting channel section at Lindsey Road constricts the flow and it is expected to cause localized flooding at property below Lindsey Road and in the upstream areas near the proposed flood control projects.



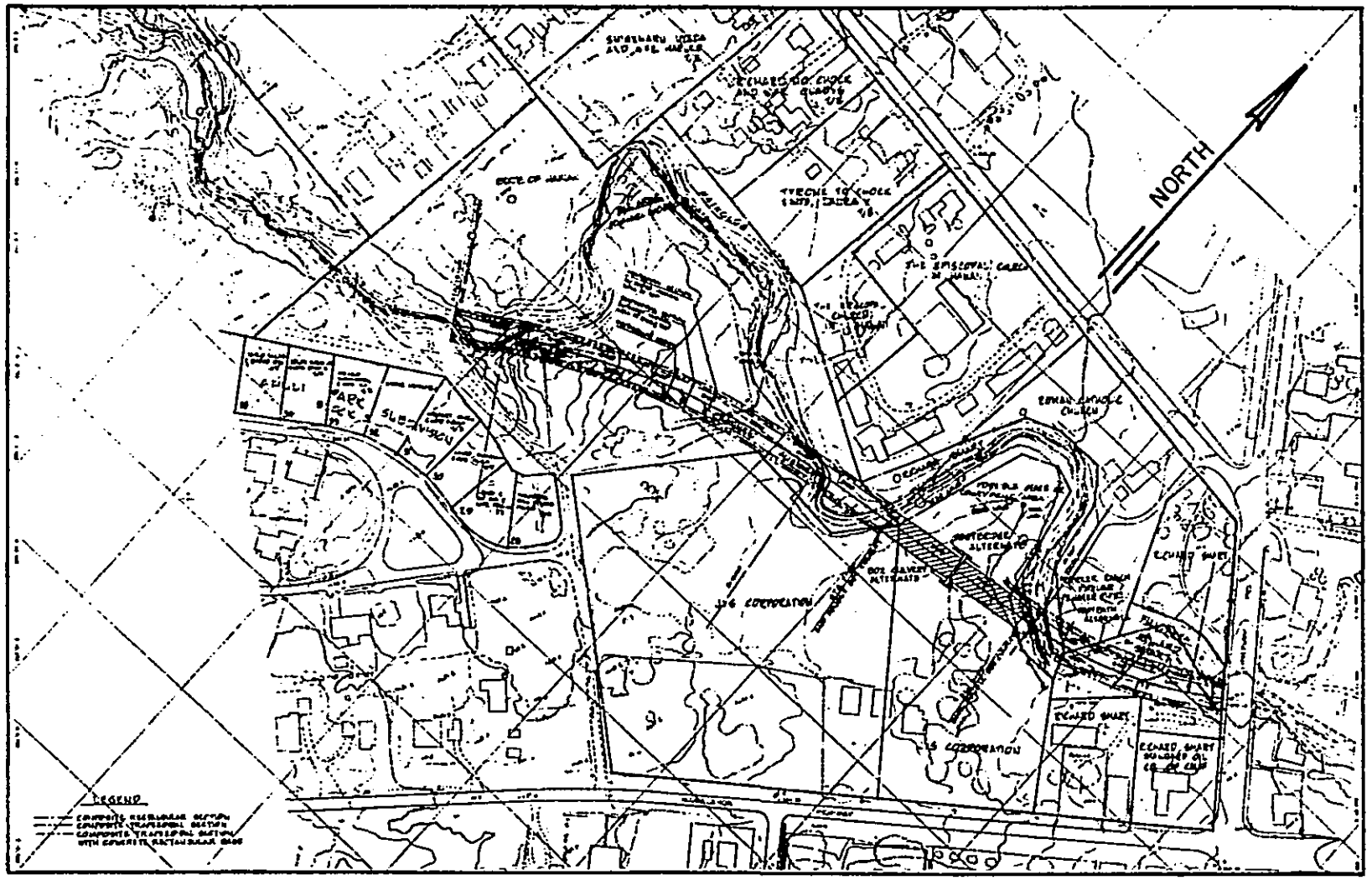
ISLAND of HAWAII
LOCATION MAP

FIGURE 1



WATERSHED LOCATION MAP

FIGURE 2



PUUKAPU FLOOD CONTROL PROJECT
FIGURE 3

3. Recommended Channel Alignment and Profile

a. Alignment

The recommended alignment was selected due to its proximity to the existing conditions and new urban developments now being considered. This alignment is 1590 feet in length and begins at a 17-foot x 10-foot double box culvert at Lindsey Road. It continues in a southwest direction and turns on a radius of 750 feet westward through a grove of Eucalyptus trees. It takes a path which minimizes the destruction of this grove and at the same time provides a minimum encroachment to the properties surrounding the alignment. The alignment turns southwesterly on a 1500 foot radius until it meets the existing stream located in pasture land owned by the State (Fig. 3).

b. Recommended Profile

The recommended channel profile for the Puukapu Flood Control channel is a stepped profile (Fig. 7 Page 24). It begins at the Waikoloa Stream and Lindsey Road bridge and continues for 100 feet at a 1.5 percent slope. The channel floor then drops 2 feet vertically and the profile slope is reduced to 1.0 percent for 200 feet. The channel drops vertically for a second time, 3 feet and continues at a 1.0 percent slope for 450 feet. The third drop is 2.33 feet and the slope is changed to 0.5 percent for 210 feet. The channel bottom drops 3 feet again and continues on a 0.5 percent slope for 210 feet. Finally the channel profile drops 3 more feet and continues on a 0.5 percent slope until it meets the existing stream bed. This alignment profile reduces the average velocity of the design flow such that it meets the allowable standards set by the County of Hawaii's Storm Drainage Standards (Ref. 2).

At the end of the proposed lined channel a transition section will be necessary between the lined and natural channel. This section is necessary to prevent scour to the natural channel section and damage to the lined channel.

To minimize scour and damage to the channel sections, energy dissipators may be included in the design. In an attempt to keep the lined channel as aesthetically pleasing as possible, natural boulders may be utilized as energy dissipators instead of concrete blocks or baffles.

Various channel cross-sections are discussed in Section E.

4. Current Status of the Project Area

a. Existing Improvements

There are no improvements for flood control within the drainage basin. Waikoloa Stream and Lanimaumau Stream are natural unimproved streams.

The Department of Land and Natural Resources State of Hawaii has made a Preliminary Engineering report for the Puukapu Watershed. It has proposed flood control measures upstream of Lindsey Road bridge (Ref. 1). These proposals are also in accordance with the General Plan for the County of Hawaii (Ref. 8).

b. Socio-economics

The major industry in Waimea Town is beef production, and the largest single private owner in the community is Parker Ranch. Most of the town's residents are heavily dependent on the Ranch for economic livelyhood. Second to beef production is commercial truck farming. Other areas of economic livelyhood include small privately owned farms and ranches. Of the estimated 350 to 400 residents living on the plains area, only a few commute from the area to jobs elsewhere (Ref. 3).

c. Flood Problems

Floods in the Puukapu area are usually the result of heavy rainfall over the Watershed. Studies of recent hydraulic history show that flooding has occurred at least eight times during the last twelve years (Ref. 1). Two recent storms (Dec. 1957 and Aug. 1957) caused severe flood water damages in the area (Ref. 1). These storms produced 11.10 inches

and 9.47 inches of rainfall at the Waimea gaging station for the months of December and August respectively (Ref. 10).

There are two areas of flooding in the watershed: (a) At stream sections above Lindsey Road in Waimea, flooding and over-bank flow can be expected every year. Flood waters flow through Waimea Park and sections of the old Hawaii Preparatory Academy. Flood waters eventually re-enter Waikoloa Stream (Ref. 1). (b) Lanimaumau Stream and its tributaries create the second source of flooding. After entering the Waimea Plains, the stream parallels Mamalahoa Highway. The stream banks are at a higher elevation than most of the truck farming areas in the plains and its channels are characterized by narrow sections and sharp bends. Vertical banks are approximately eight feet deep. Due to these conditions over-bank flows occur every other year (Ref. 1). Due to decreasing channel cross section size, overbank flows occur annually in Kuhio Village and surrounding areas (Ref. 3).

A number of unnamed drainage channels drain into Paiakuli Reservoir, a shallow natural depression. In the past the reservoir has been used for stock watering, but with the development of water distribution systems, it no longer serves in that capacity. During periods of large storms and runoff, the reservoir overtops and flows into the truck farming area. The flood waters eventually converge with Lanimaumau Stream (Ref. 3).

Flood waters from numerous small unnamed drainageways above Mamalahoa Highway empty directly onto the road, pasture and truck crop areas before collecting on the highway and flowing into Waimea Town and Waikoloa Stream.

Originally Lanimaumau Stream was a part of Waikoloa Stream. However, a man-made diversion now forces flows into a lava tube for underground disposal. During high flood flows, Lanimaumau and its tributaries converge above Kuhio Village where part of the flow follows the old watercourse through Waimea Town. This portion of flow joins Waikoloa Stream .

During exceptionally high flows, the capacity of the lava tube is exceeded and water overflows onto the highway and into Lanimilo Irrigation Project. Damages due to this flooding have been minimal primarily because of good vegetative cover (Ref. 3).

5. Damages

In the August 1958 storm, approximately 950 acres were flooded. Of this land about 790 acres were truck cropland and pastures. Substantial indirect damages were not measurable, however, much of the farming labor is supplied by family members, and loss of a crop equals a substantial loss of economic opportunity (Ref. 3).

Total flood damages were estimated at $186,380 for the August 1958 storm. 22 percent of the damages were non-agricultural (roads, utilities, residential and commercial property) (Ref. 3).

B. ENVIRONMENTAL SETTING WITHOUT THE PROJECT

1. Description of Area

a. Topography

The Waimea Plains are centrally located in the Puukapu Watershed and range in elevation from 2640 to 2880 feet above sea level. An approximate slope of 1.5 percent prevails over the plains area. The Kohala Mountains, which form one of the watershed's boundaries, rise above 4000 feet in elevation. These mountains are characterized by steep slopes and well defined drainageways. In comparison Mauna Kea, the watershed's southern boundary, is characterized by permeable lava slopes with shallow drainageways. The lower boundary of the watershed is arbitrarily established below Waimea Village (Ref. 3).

The volcanic Island of Hawaii is the youngest of eight major islands in the Hawaiian chain. Soils on the slope of Mauna Kea and on the Waimea Plains have their origins from lava flows, cinder cones and ash beds. There are also small deposits of sedimentary rocks.

Surface relief on the plains is virtually flat with low mounds and knolls. The Kohala Mountains differ considerably. There are many areas of alluvial deposits, while in other areas, soils approach a heavier silty-clay-loam. On the wetter slopes, soils developed from volcanic ash. Bare bedrock outcrops are minimal as soil and moisture of the area support abundant growths of vegetation (Ref. 3).

Soils in the flood plain are characterized as "mellow, deep, darkbrownsoils over a non-uniform lava bedrock. They have a low bulk density, high moisture holding capacity, and are easily worked and ideally suited to truck crop production"(Ref. 3).

The Soil Conservation Services (SCS) has tabulated the acreage subjected to flooding in the Waimea Plains. Approximately 500 acres of Class I (SCS Classification I to VIII Ref. 9) and 650 acres of Class II lands are subject to floods.

100 acres of Class III land above Mamalahoa Highway floods due to runoff from higher elevations. The remaining acreage in the plains is classed as VI, VII and IV (Ref. 3).

b. Hydrology

The Island of Hawaii is situated near the northern limit of the tropics. However unlike the high-humid temperatures of the tropics, the island is cooled by ocean currents and a prevailing northeasterly tradewind. There is also a breeze from the sea toward the leeward slopes of Mauna Kea. This leeward wind blows almost daily and meets the tradewinds in the saddle area between Mauna Kea and Kohala. The stronger of the two then prevails over the Puukapu Watershed (Ref. 3).

Rainfall over the area is the result of mechanical lifting or orographic precipitation. Cyclonic storms, or more commonly referred to as "Kona" storms, occur several times a year and are characterized by high winds and intense precipitation. (Ref. 3).

The annual precipitation over the Puukapu Watershed varies greatly. In the vicinity of the Kamuela Post Office in Waimea Town, annual precipitation is approximately 40 inches. On Mauna Kea and its slopes, precipitation averages even less. However precipitation increases gradually to almost 170 inches/year in the Kohala Mountains (Ref. 3, 10).

Within the watershed temperature variations are great. Averages do not represent conditions over the entire watershed. Lush vegetative cover on the Kohala Mountains is in contrast to the almost desert like atmosphere on the slope of Mauna Kea which is only three 3 miles away (Ref. 3). The maximum recorded temperature in Waimea was 90 degrees fahrenheit in November 1938. The minimum recorded temperature was 34 degrees fahrenheit. Temperature in Waimea Town remains relatively low and is uniform throughout the year (Ref. 3).

Due to the permeable lava within the Waimea area, rainfall percolates through the ground to lower levels. Evidence indicates the presence of high level diked water in the Kohala Mountains below the Waimea Plains. Perched ground water sources have remained unexplored (Ref. 3).

c. Vegetation and Wildlife

Vegetation in the area is typical of that found in similar regions of Hawaii. Good grass cover dominates most of the Waimea Plains while forest coverage exists in the Kohala Mountains.

Wildlife in the watershed is also typical of Hawaii. There are a number of varieties of small birds; doves, sparrows, cardinals, and mynahs, which are found in both populated and unpopulated areas. Small animals such as mongooses, rodents and domesticated animals gone wild are also common throughout the area. Larger domesticated animals are typical of an argricultural-ranching-community.

Based on existing maps, photos and knowledge of the area, there are no known rare species of wildlife or vegetation near or within the projects limits (Ref. 7).

d. Productive Crops

The only arable areas in the watershed are on the Waimea Plains. Soil conditions and the relatively cool dry climate are very conducive to productive truck-farming. Crops normally grown in this area include cabbage, celery, lettuce, corn, cucumber, turnip, rutabagas, and burdock. Exotic flowers are also grown and marketed (Ref. 1).

e. Historical and Archaeological Sites

The Bernice P. Bishop Museum is currently conducting an archaeological survey for a proposed highway corridor from Waimea Town to Kawaihae. The survey has indicated numerous existing and potential archaeological sites along the corridor (Ref. 6). However with the combination of maps, photos and knowledge of the area, it is not expected that any historic or archaeological sites will be encountered or disturbed in the immediate vicinity of the project site (Ref. 6).

2. Socio-Economic Development

a. Present level

The watershed includes Waimea community, Hawaiian Home truck-crop and pasture lands, Kuhio Village, a portion of

Parker Ranch, State owned lands, and the first and part of the second series of the Puukapu Homesteads (Fig. 4) (Ref. 3).

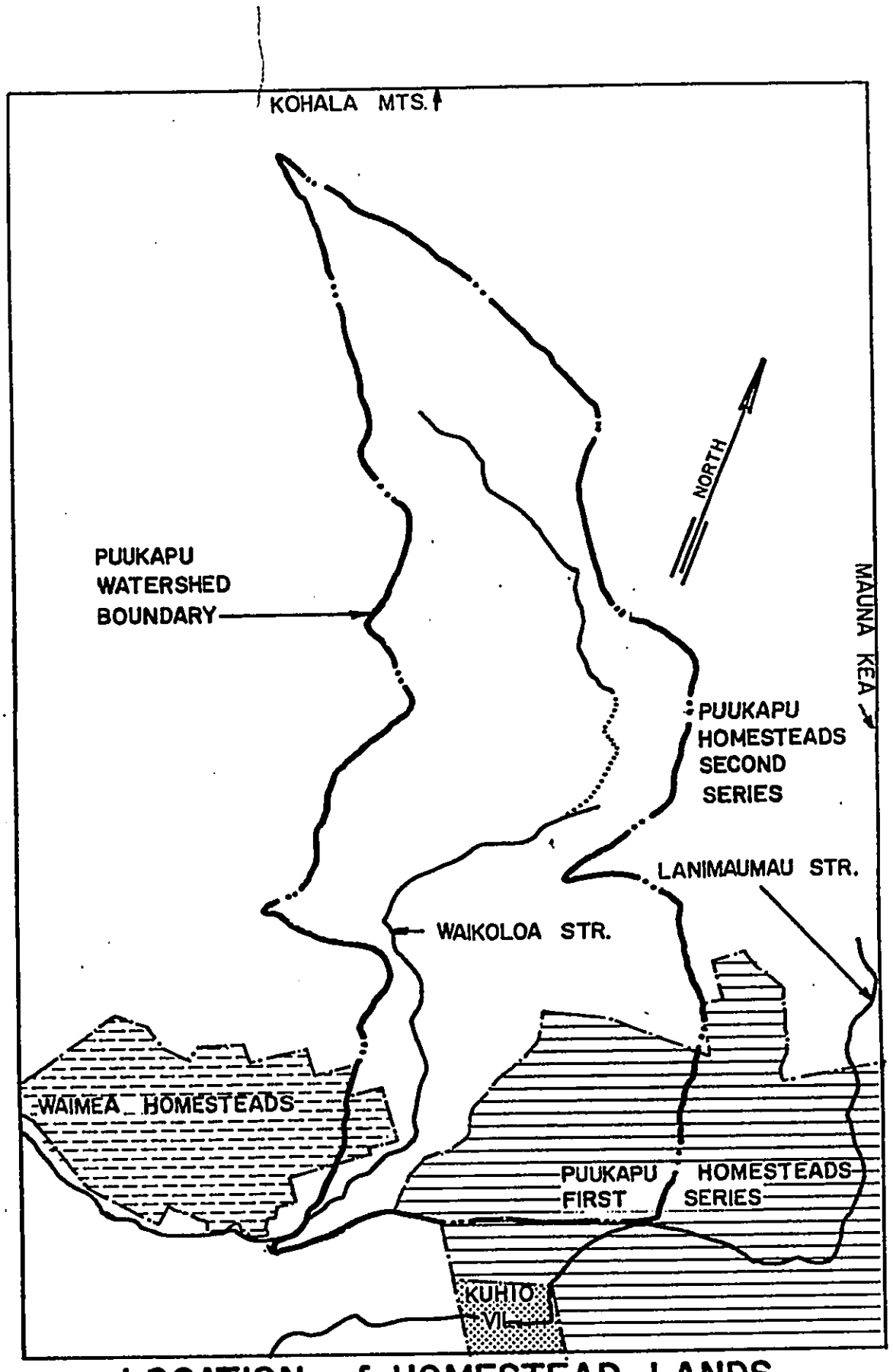
The first series of the Puukapu homestead lands were opened for purchase in 1901. These homestead lands were predominantly truck croplands which were originally owned by Hawaiians and Caucasians. Today the lands are owned and farmed by people of Japanese ancestry. The second series of homestead lands are composed of mostly pasture lands. These lands were opened for purchase in 1913 (Ref. 3).

Hawaiian Home truck-crop and pasture lands are leased to only those of Hawaiian ancestry. The lands are leased with low rentals and long term leases. Kuhio Village is also leased under similar arrangements as the Hawaiian Home truck-crop and pasture lands. The Village is composed of Homesites for the lessees of Hawaiian Home lands (Ref. 3).

The watershed area in the Kohala Mountains is mostly in forest reserve lands. The remaining portion is leased for pasture. Watershed lands in the Mauna Kea area are primarily owned by Parker Ranch (Ref. 3).

The Puukapu homesteads consist of some forty farm units in the flood plain area. These farm units range in size from 5 acres or more to the larger farm units of 16 to 20 acres. The normal growing season for these truck-crop farms is January to June. Crops are dependent on rainfall which may be deficient during any season, or over abundent during storms. The maximum variation in monthly rainfall has been recorded at 26.4 inches (Ref. 10). The dry season normally occurs from June to October when the average monthly rainfall is only 2.4 inches (Ref. 10). Truck-crop farmers now purchase some irrigation water from the County's domestic water system. (Ref. 3).

Two or more crops per year can be grown on the truck-crop farms. Maximum utilization of the land is not employed because of land preparation, fallowing, flood damages and soil building crops. Produce grown is marketed locally and in Honolulu. Orderly marketing in Honolulu is complicated because of the irregular production volume. Costs of marketing



LOCATION of HOMESTEAD LANDS

FIGURE 4

also rise as the volume fluctuates (Ref. 3).

The residents of the Puukapu watershed are serviced by all of the modern utilities and other services. Utilities include electricity, gas, water and telephone. Services include postal, police, fire, court house, schools, service and shopping centers.

The watershed is connected by hard surface roads from Hilo, Kona, Honokaa and Kawaihae (Fig. 1). Inter-island air service is provided by two major airlines at the Hilo and Kona airports. There are more than 30 daily passenger flights out of Hilo and Kona by these two airlines. A number of smaller air services also land at Hilo and Kona. Air freight services to Kamuela are also on a scheduled basis. Kawaihae and Hilo are the two main harbors for shipping.

b. Population Trends

Hawaiian Home lands may not be sold, but they are leased to those who qualify. There is room for additional Hawaiian homesite expansion in Kuhio Village.

Extensive urban development has not encroached into the watershed. There is increasing economic pressure on owners to sell at high prices due to some very desirable potential urban development areas nearby (Ref. 3).

c. Argricultural and Industrial Trends

Truck cropland is at a premium in all of Hawaii. It is not anticipated that the Puukapu trucklands will be utilized for urban development as there is no replacement available (Ref. 8). "It is possible that the demand for cropland may lead to conversion of some Hawaiian Home pastureland to truck crops" (Ref. 3).

To date approximately one-half of the capability Class I and Class II (SCS capacity Classes Ref. 9) land in the flood plain is presently used for pasture. Some of this acreage was formally truck cropland, but due to flooding and threats of flooding, the land was turned into less profitable pasture land (Ref. 3).

d. Relationship with Other Projects

Farmers in Puukapu now purchase some irrigation water. Crop losses may be lessened as the Lalamilo irrigation project adjoining the dry side of the watershed is activated. The main water distribution system for the project will traverse Puukapu watershed (Ref. 3).

As mentioned in Section A-2 the Puukapu Flood Control project is being proposed in order to compliment other planned flood control projects within the area. Upstream flood control measures will cause the flooding within the project's area if the channel is not constructed.

C. ENVIRONMENTAL IMPACT

1. General

A flood study was carried out to determine if the existing Waikoloa Stream channel needed improvements. In another study (Ref. #1), the effects of diverting water from the Puukapu Subdivisions to Waikoloa Stream was further investigated. This latter study was first outlined in A Preliminary Engineering Report for the Puukapu Flood Control Project at Kamuela, Hawaii (Ref. #1).

The existing natural channel was found to be adequate to handle discharges of a 2 year recurrence interval for both situations studied. The banks of the stream were not topped for a 5 year storm, but were inundated for a 10 year recurrence interval storm. (Fig. 5,6)

The results of this study indicated (Ref. #2) that the diversion of water from Puukapu Subdivision to Waikoloa Stream increased the stream discharge but more importantly, it indicated that the natural channel as it exists now, is capable of handling a discharge of 1200 cfs, and the banks have a capacity of 2800 cfs.

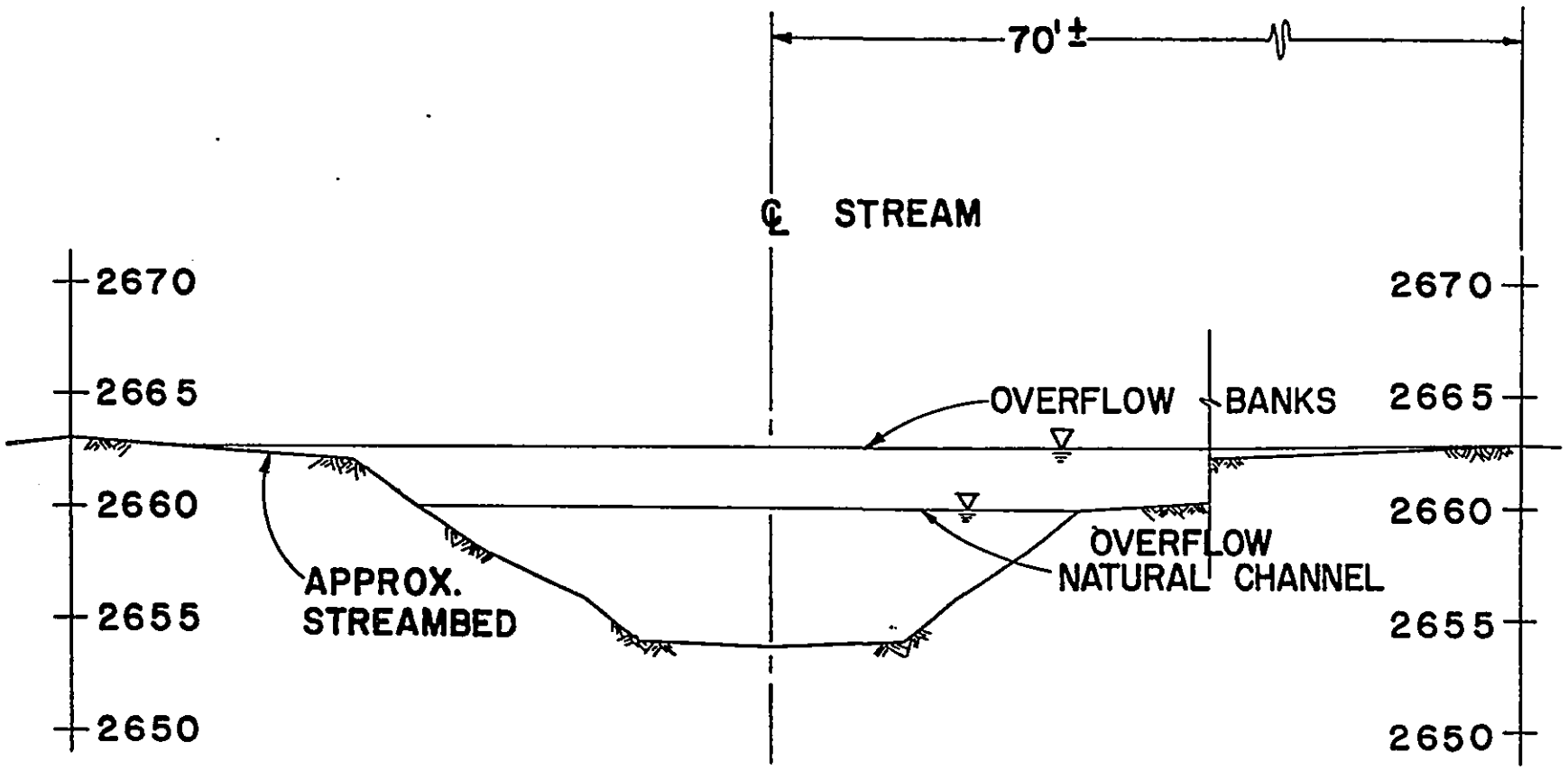
An estimated discharge for a 50 year flood event is 8000 cfs, which would completely inundate the area. The flood control channel will alleviate the flooding in the area for the 50 year flood event, and may be capable of a 100 year flood capacity.

2. Social

a. Urbanization

As previously stated, the Hawaiian Home Land in the flood plains cannot be sold and used for urban development. The proposed Puukapu Flood Control Project will not encourage urbanization of prime agricultural land. Rather the project will aid the agricultural community as truck farming will become a more lucrative operation due to decreasing crop damage and soil erosion.

It is also a stated purpose of the General Plan (Ref. 8) to protect agricultural land from urbanization thru the use of strict zoning. Of 93,721 acres zoned agricultural, 60,573 acres are vacant (Ref. 8). The County will aid agriculture



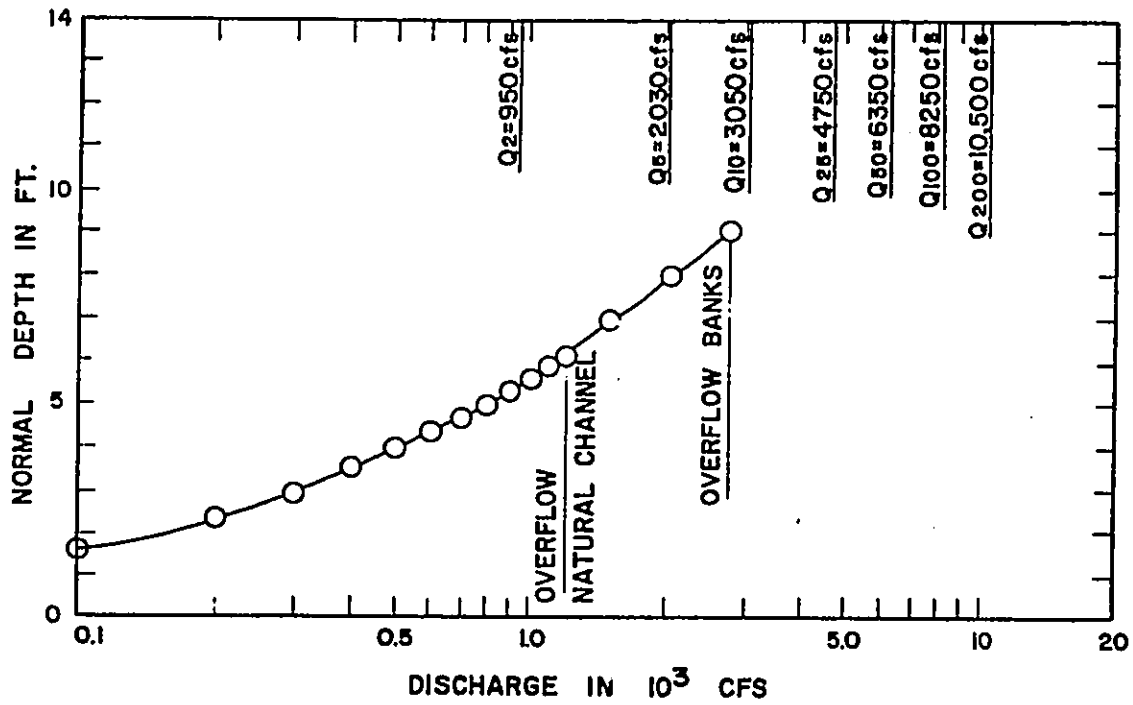
APPROXIMATE EXISTING STREAM

CROSS SECTION

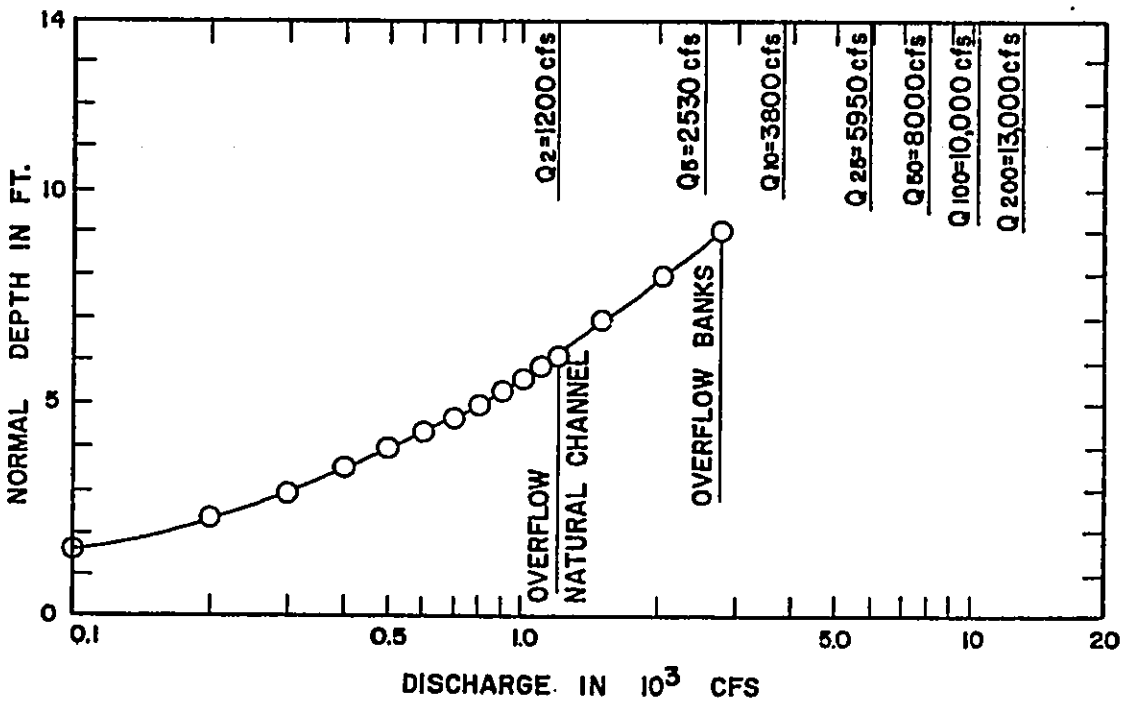
SCALE : 1/8" = 1'-0"

FIGURE 5

FIGURE 6



FLOOD STUDY OF APPROXIMATE SECTION
WITHOUT UPSTREAM IMPROVEMENTS



FLOOD STUDY OF APPROXIMATE SECTION
WITH UPSTREAM IMPROVEMENTS

by providing water systems and encouraging larger farms which employ more mechanized skills.

Residential zoned lands amounts to 567 acres of which 217 acres are undeveloped. Over 63% of the lands in Waimea zoned multi-residential are undeveloped (Ref. 8). Commercial zoned lands amount to 184 acres with 75 acres undeveloped (Ref. 8).

b. Population Displacement

The proposed channel realignment of Waikoloa Stream will not displace any residents in the immediate vicinity of the project area. It is further felt that the flood control project will have a stabilizing effect on the population of the flood plain. This is due to the increased economic benefits to truck crop farmers.

c. Public Health and Safety

Sanitary facilities within the flood plain area consist primarily of cesspools (Ref. 8). The health risks associated with overflowing cesspools are greatly increased in areas inundated by flood waters. The proposed project will minimize flooding and the health risks previously mentioned. Personal safety and loss of life due to flooding conditions will also be minimized.

3. Economics

The economic benefits associated with the proposed project are the lessening of property and crop damages. The truck crop farmers will be in a better economic position due to the minimal crop damages by flooding. Economic benefits are also present in the lessening of damages to structures, utilities, roads and commercial enterprises caused by flooding.

Operation and maintenance of the structural measures will be the responsibility of the County of Hawaii.

4. Environmental Effects

a. Conservation

The proposed project will minimize soil erosion on the flood plain. The project will also take the path of least destruction of the natural surroundings by taking the straightest

path possible. The project will pass through a small grove of Eucalyptus trees, however, a minimum number will be destroyed.

b. Usage of Space or Area

The proposed project will not inhibit the use of the area. The project cuts a piece of property into two segments; however, a footbridge over the channel is proposed. Plans for an adjacent multi-residential development are considering the proposed channel alignment and the areas surrounding it.

c. Waste Management

Temporary air, noise and water pollution will result from the construction of the proposed project. Contractors will adhere to strict requirements for minimizing air, noise and water pollution, as setforth in the Standard Specifications (Ref. 4, 5).

Contractors will adhere to Temporary Project Water Pollution Control (Soil Erosion) (Ref. 4).

d. Public Facilities

The project will protect existing public facilities from frequent flood damages now incurred. It will be suggested to the proper authorities that a small portion of land that will be cut in two by the realignment be bought and converted into a picnic or park site. This small piece of property will be accessible only by a foot bridge or foot path should the proposed project take effect.

f. Downstream Facilities

The proposed flood control project will relieve conditions that will cause flooding near Lindsey Road bridge and in the proposed upstream flood control projects. However by realigning the channel to increase the hydraulic efficiency at that section, downstream areas may be subjected to adverse effects. Only one downstream area is thought to be adversely affected by the proposed channel.

At the junction of Opelo Road and Waikoloa stream, the stream passes through a narrow "Box Culvert" with a wooden

bridge over it. Capacity of the culvert and surrounding stream banks are not known at this time. The surrounding area is pasture land. Flooding at this point is not expected to cause severe damage to property.

D. ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED SHOULD THE PROPOSAL BE IMPLEMENTED

The implementation of the proposed project will necessitate the abandonment of approximately 1,600 feet of natural streambed. A realigned concrete channel will be utilized in its place. The environmental impact of this action is minimal as the stream is intermittent and not an exclusive habitat of any particular vegetation or wildlife. The proposed project will also cut through a small grove of trees. The path taken through this grove has been designed to minimize tree destruction. This small grove of trees is also being considered for use as an aesthetic landscape area for a proposed urban development. The developer is trying to utilize as many natural trees in the area as possible.

During the construction phase of the proposed project, temporary water, air and noise pollution will be anticipated. To minimize this, contractor will adhere to strict requirements set forth in the State of Hawaii Construction Specifications (Ref. 5).

The proposed channel will divide a privately owned piece of property in two. Accessibility to one piece is extremely limited. A foot bridge or foot path is proposed to give the owner access to that portion which is inaccessible.

At the junction of Opelo Road and Waikoloa Stream a constriction in the stream channel occurs. This condition may cause flooding or bank overtopping should the proposed channel be installed. However, surrounding land areas are primarily used for pasture purposes.

E. ALTERNATIVES TO THE PROPOSED ACTION

1. General

Alternatives discussed in this section will fall into three major categories; (1) channel alignment; (2) channel profile, and (3) channel sections. In addition to these categories, a section will discuss no channel improvement.

2. Channel Alignment

a. Following Existing Stream

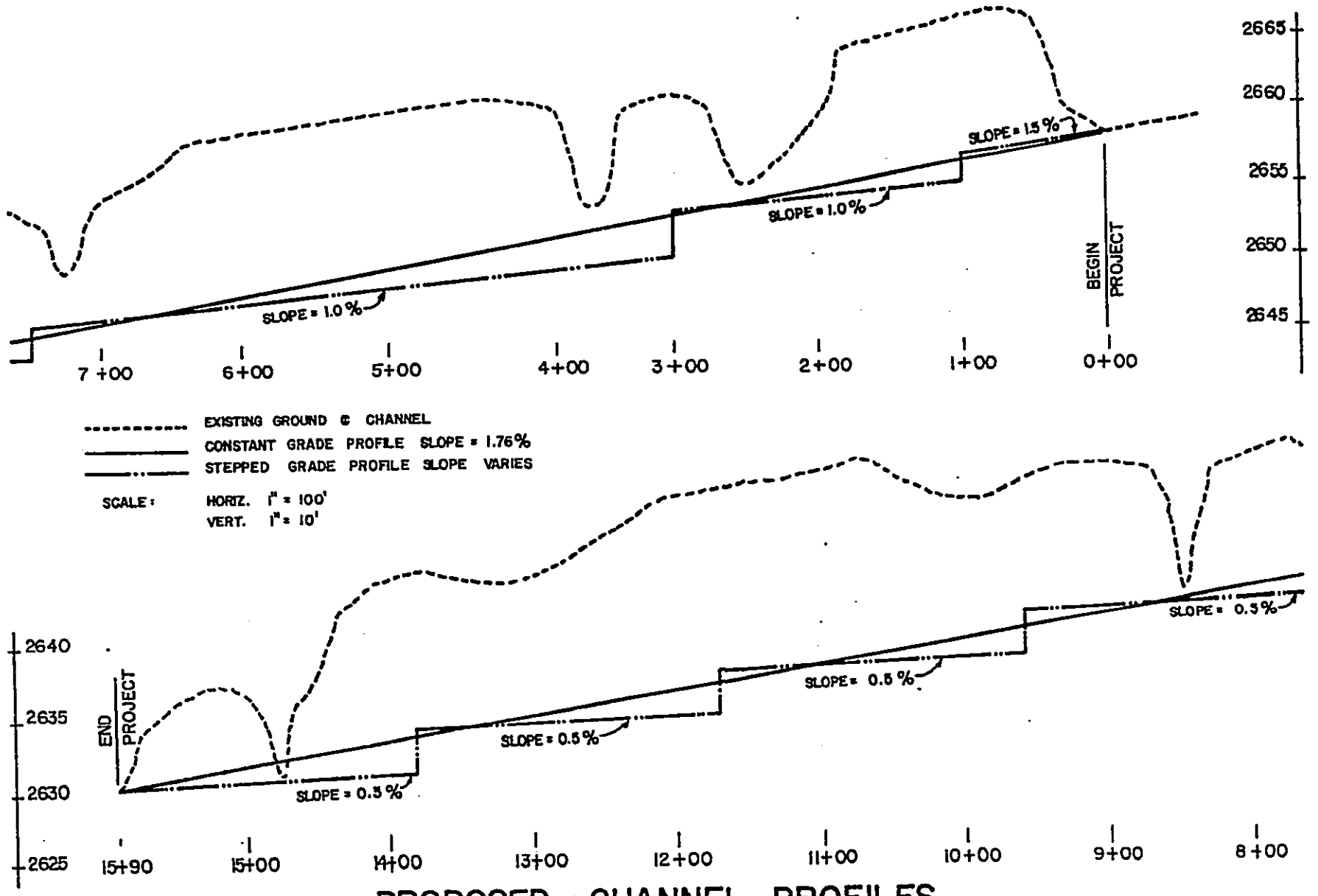
An alignment following the existing stream was investigated as an alternative. However, the meandering condition of the stream produced a channel section that was considered unreasonable. Superelevation at one section with a normal depth of 9 feet was found to be 9 feet. This produced a rectangular channel with a vertical depth of 20 feet.

This alternative was disregarded on a number of reasons. (1) The channel sections were aesthetically poor in many areas. (2) With channel sections reaching 20 feet in depth in places, the hazards involved are great. Personal injury is increased greatly should someone fall in. (3) Sections reaching 20 feet in height were considered uneconomical in view of other alternatives. (4) Structural members for the channel cross section became more difficult with this alignment. (5) Finally, the hydraulic efficiency of the channel would be poor due to the meandering course of the stream.

3. Channel Profile

a. Natural Vertical Profile

A possible profile was considered utilizing the natural average slope of 1.75% between beginning and terminating points of the channel (Fig. 7). Using this information, this slope gave an average velocity at design discharge of 32 feet per second. It is noted that this exceeds the maximum allowable velocity of 20 fps set by the County of Hawaii in their Storm Drainage Standard (Ref. 2). Exceeding the allowable velocity necessitates the use of special energy dissipators at intervals in order to maintain a twenty feet per second average velocity.



PROPOSED CHANNEL PROFILES
FIGURE 7

b. Recommended Profile

An alternative to the aforementioned profile is a stepped alignment which is discussed in Section A-3-b.

4. Channel Sections

An investigation of the various sizes of channel configurations was done and the discharge capacities verses the normal depths plotted.

Reflecting upon these graphs, it was noted that at the point of the design discharge, 8500 cfs, increasing the base of the channel by 10 feet did not reduce the normal depth by a significant amount.

Also keeping in mind that the right-of-way is another limitation, the following sections were selected for investigation:

1. 40' x 10' composite trapezoidal section with a 40' x 3' concrete rectangular section on bottom (See Fig. 8).
2. 50' x 10' composite trapezoidal section with a 50' x 3' concrete rectangular section on bottom (See Fig. 8).
3. 40' x 10' composite rectangular section (See Fig. 9).
4. 50' x 10' composite rectangular section (See Fig. 9).
5. 30' x 10' composite trapezoidal section
6. 40' x 10' composite trapezoidal section with vertical walls at normal depth (See Fig. 10).

A comparative cost analysis was done to determine the economical sections (See Tables 1, 2 & 3). Of these sections, the following are considered for recommendation:

1. 40' x 10' composite rectangular section cost/LF = $1,037.90.
2. 40' x 10' composite trapezoidal section with vertical walls at normal depth. Cost/LF = $957.45.
3. 40' x 10' rectangular concrete channel based trapezoidal section with vertical walls at normal depth. Cost/LF = $913.55.

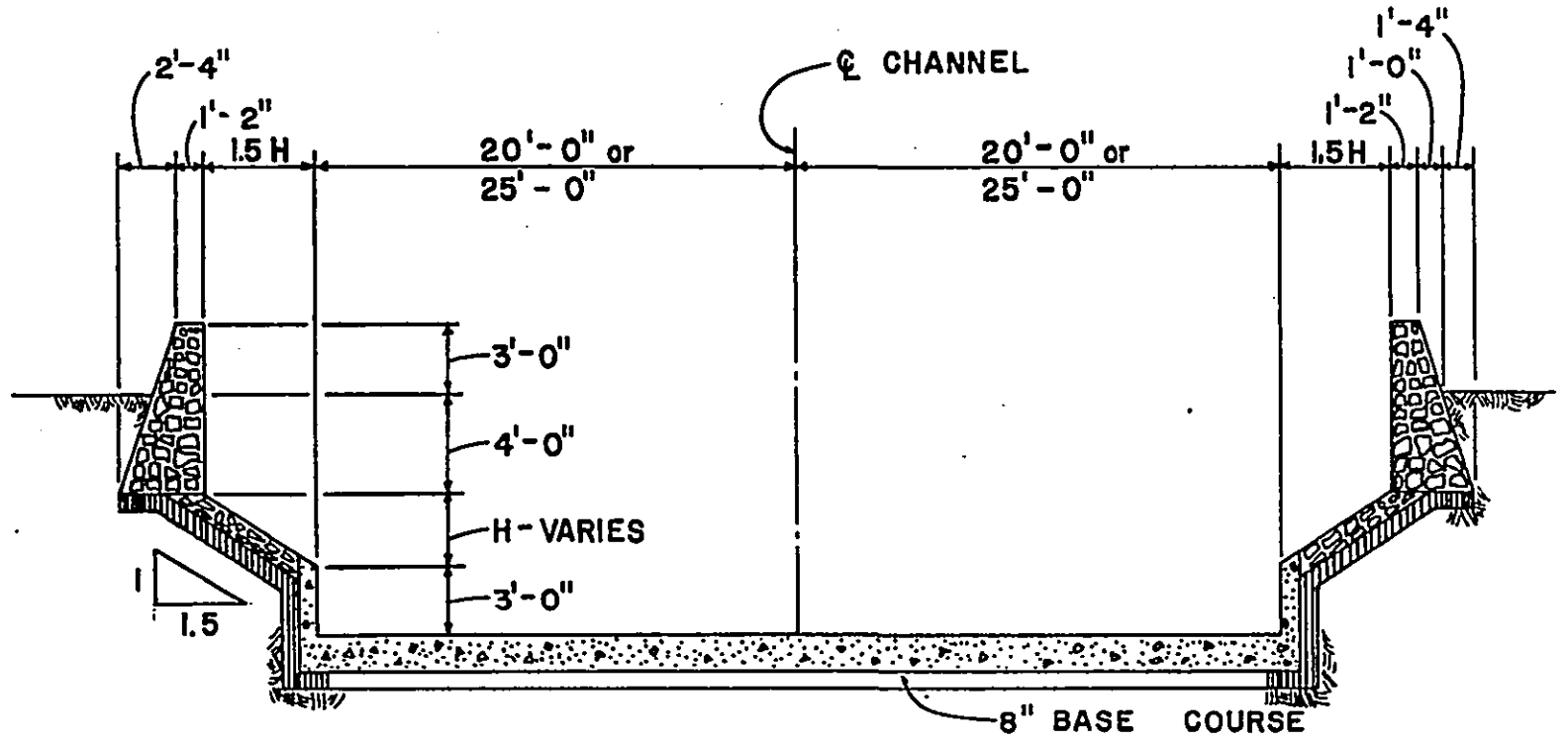
In order to maintain a natural state in the area where the alignment passes through the grove of trees around Stations 4+00 to 7+00, an initial alternative of a covered double box

conduit was considered (See Fig. 11). The size of the openings for the double box were found to be 20-feet x 10-feet each. However since it is a double box conduit, a debris barrier became necessary to ensure that the passages remain clear. One such barrier is a pier extension (See Fig. 11). The extension protrudes into the channel for a length of approximately 16 feet.

In addition to the pier extension, the double box culvert necessitates the use of transition sections since the top widths of the open channel sections are larger than the width of the culvert.

As an alternate to the double box culvert, an investigation was made utilizing the open channel throughout the alignment. The open channel travels through a grove of trees and separates a lot into two pieces. The separated segment could be utilized and made accessible with a foot bridge (See Fig. 12 and 13). Having the open channel throughout the alignment eliminates the need for transition sections and pier extensions. A cost comparison between the double box culvert and the open channel with a foot bridge was prepared and the results are shown in Table 2. It is shown that the open channel with a foot bridge represents a savings of approximately $200,000.

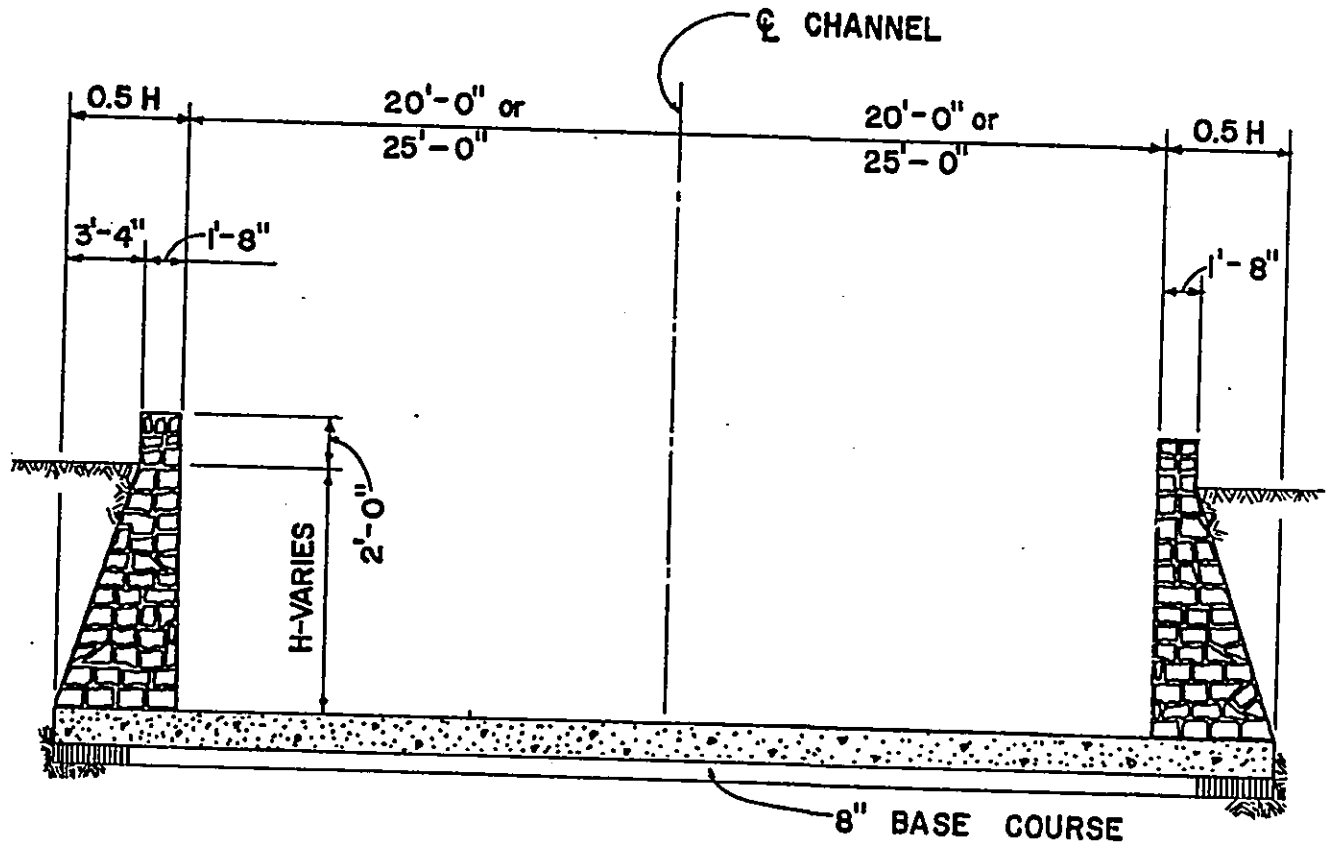
A vegetative lined channel (See Fig. 14) following the recommended alignments was also considered as an alternative. The County of Hawaii's Storm Drainage Standards (Ref. 12) stipulates the maximum velocity for this type of channel to be 5 feet per second (fps). This fact coupled with the roughness coefficient of 0.04 for the basis of sizing the channel, a 40 feet based trapezoidal section with side slopes of 1.5:1 requires a depth of 23 plus 2 feet freeboard. This necessitates a top width of 115 feet which require too much acquisition of surrounding property to justify its existence; therefore, it is eliminated from consideration.



TYPICAL SECTION - SCHEME I

SCALE: 1/8" = 1'-0"

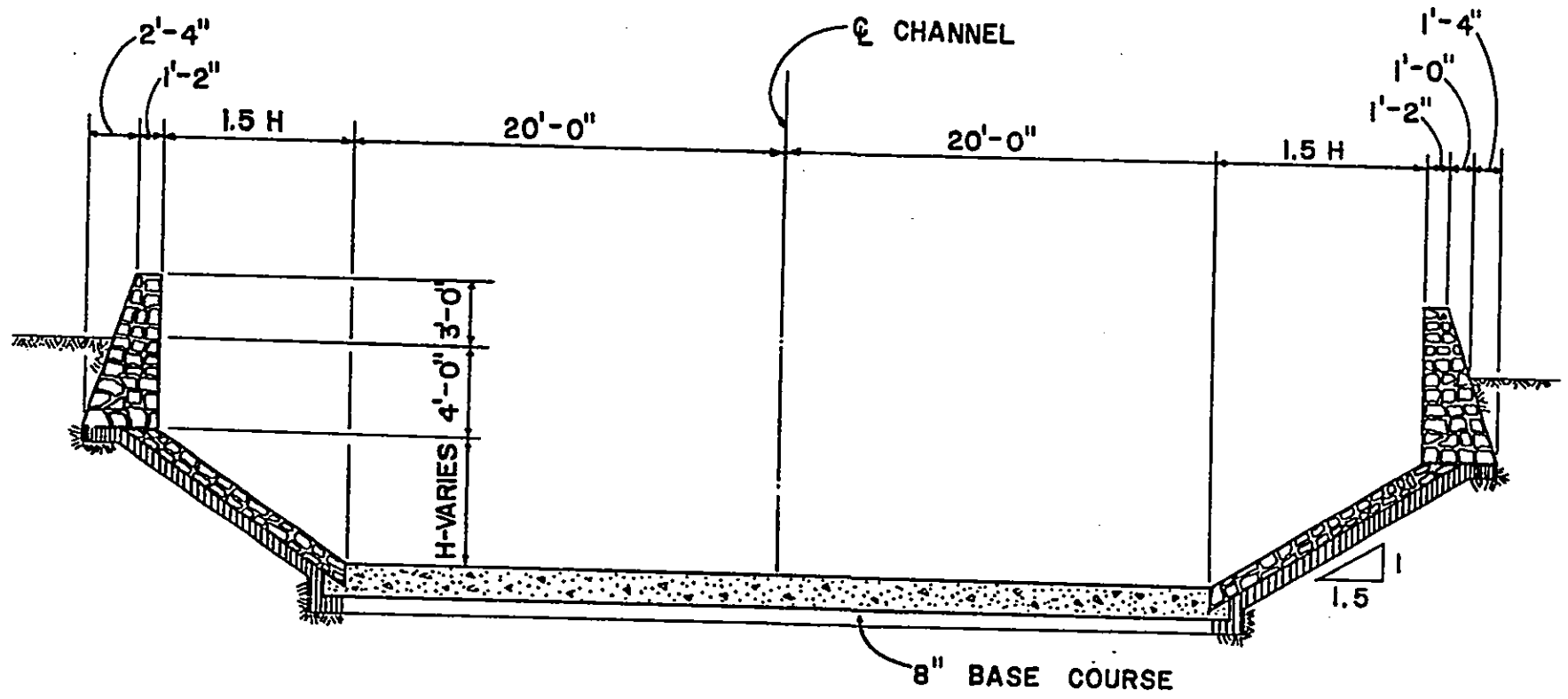
FIGURE 8



TYPICAL SECTION – SCHEME II

SCALE : 1/8" = 1'-0"

FIGURE 9



TYPICAL SECTION - SCHEME III

SCALE : 1/8" = 1'-0"

FIGURE 10

TABLE 1

Items Considered in Cost Estimate

ITEM	UNIT PRICE
Volume of Concrete	$150/cu. yd.
Volume of Concrete Rubble Masonry	$85/cu. yd.
Volume of Excavation	$20/cu. yd.
Area of Right-of-Way	$1.25/ft.^{2}
Foot Bridge	$40/ft.^{2}

TABLE 2

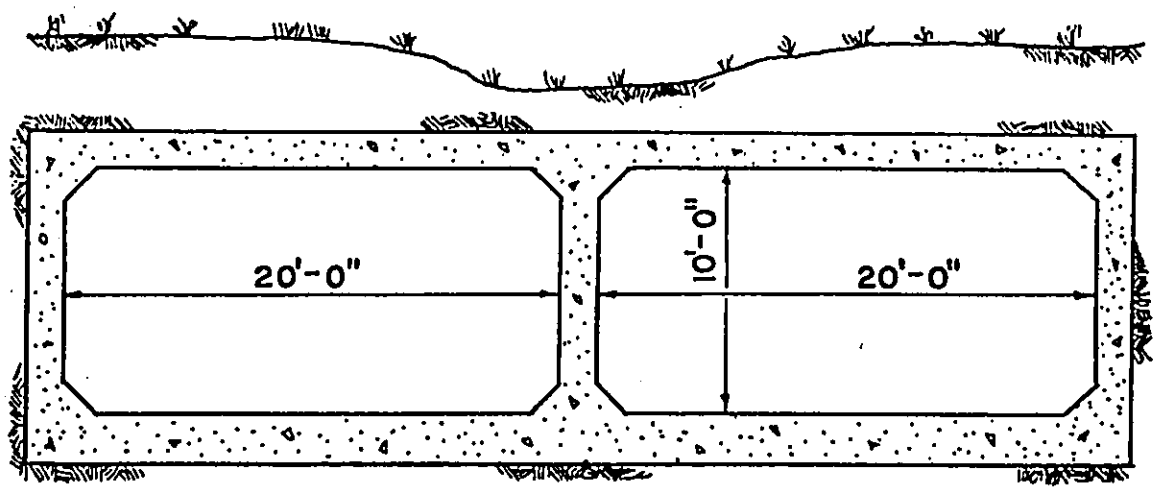
Cost Comparison of Box Culvert vs.
Open Channel with Foot Bridge

Item	Channel Section Scheme I (Fig.)	Scheme II (Fig.)	Scheme III (Fig.)	Double Box Culvert
Conc.	$125,100	$ 99,900	$111,150	$334,800
CRM	$ 61,200	$ 33,660	$ 22,950	N. A.
Exc.	$103,320	$124,800	$114,840	$166,875
R.O.W.	$ 21,750	$ 28,875	$ 25,125	$ 22,314
Foot Bridge	$ 8,000	$ 15,400	$ 13,400	N. A.
TOTAL	$319,370	$302,635	$287,465	$523,989

TABLE 3

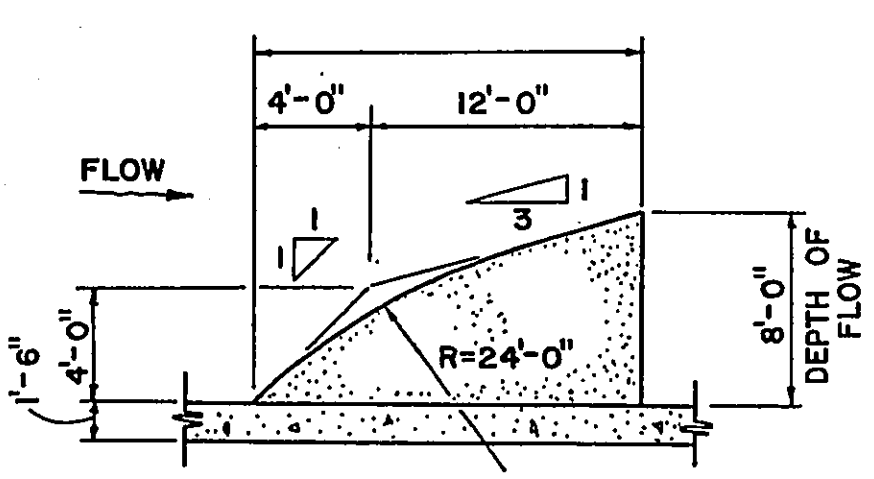
Item	Combined Section 40 x 10	Combined Section 50 x 10	Rectangular Section 40 x 10	Rectangular Section 50 x 10	Trapezoidal Section	Combined Section With Vert. Walls	Trapezoidal Section With Vert. Walls	Double Box Culvert
Conc.	370.50	454.50	417.00	499.50	267.00	370.50	333.00	1,116.00
CRM	79.90	79.90	204.00	204.00	132.60	76.50	112.20	N.A.
Exc.	495.80	581.00	344.40	418.60	407.00	382.80	416.00	556.25
R.O.W.	98.75	111.25	72.50	85.00	95.50	83.75	96.25	74.38
TOTAL	1,044.95	1,226.65	1,037.90	1,207.10	904.10	913.55	957.45	1,746.63

NOTE: ALL COSTS IN DOLLARS/LIN. FT.



TYPICAL BOX SECTION

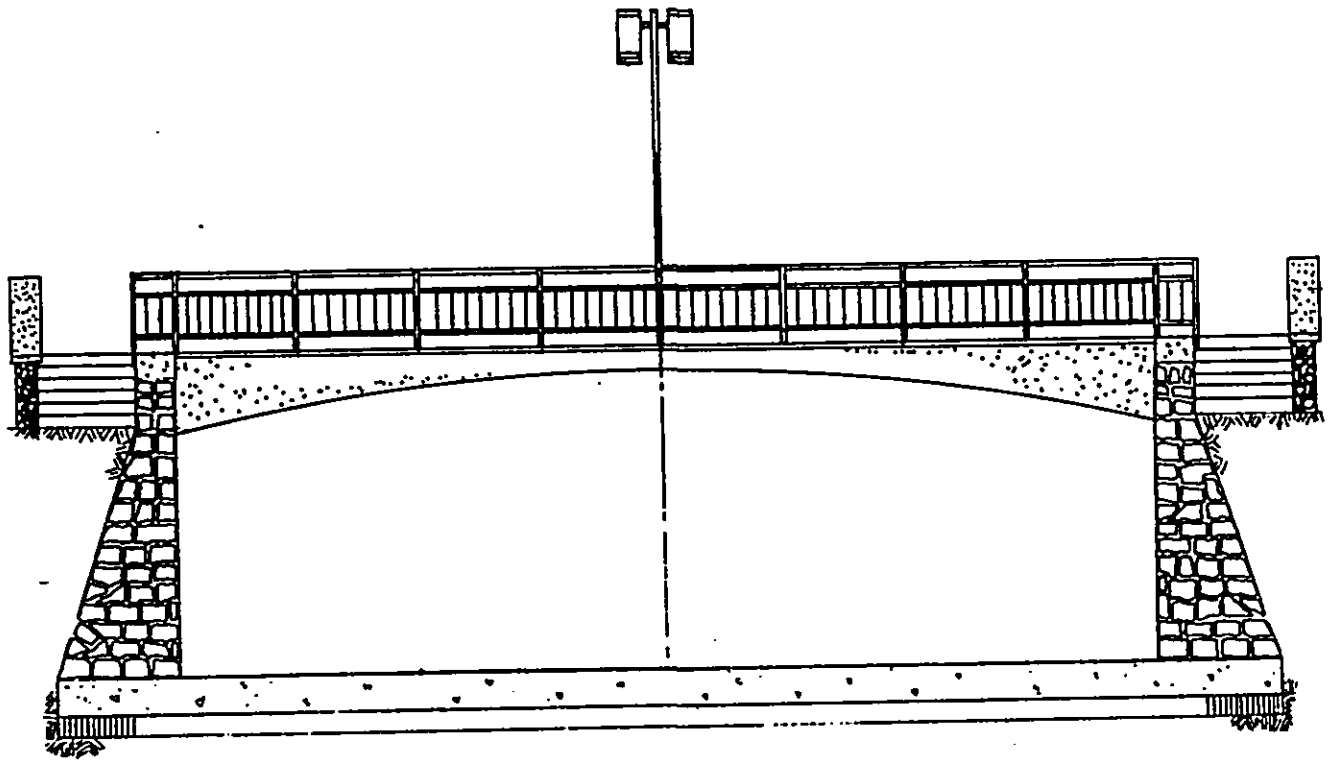
SCALE: 1/8" = 1'-0"



PIER EXTENSION

SCALE: 1/8" = 1'-0"

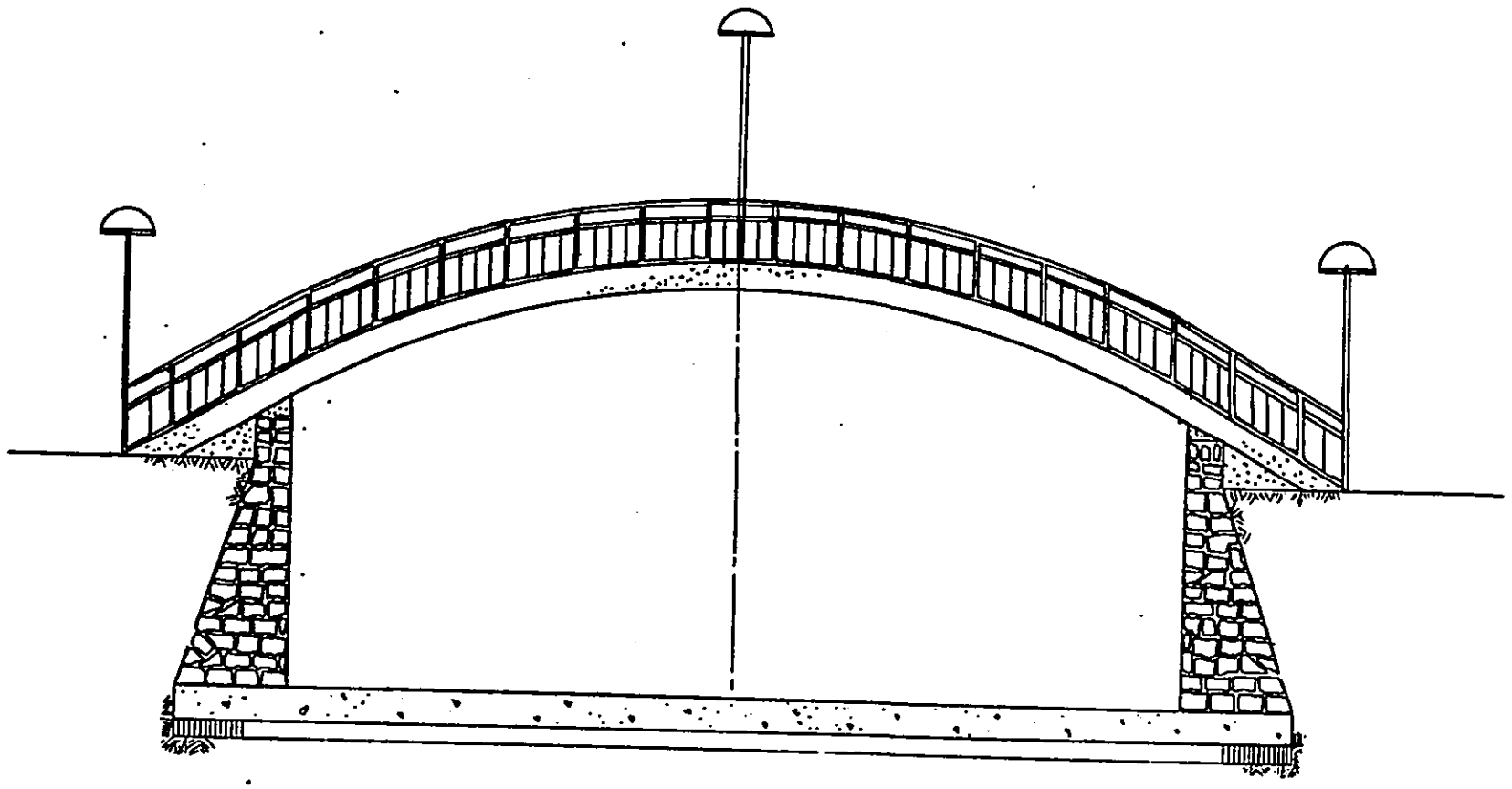
FIGURE II



ELEVATION ALTERNATE 1

SCALE: 1/8 = 1'-0"

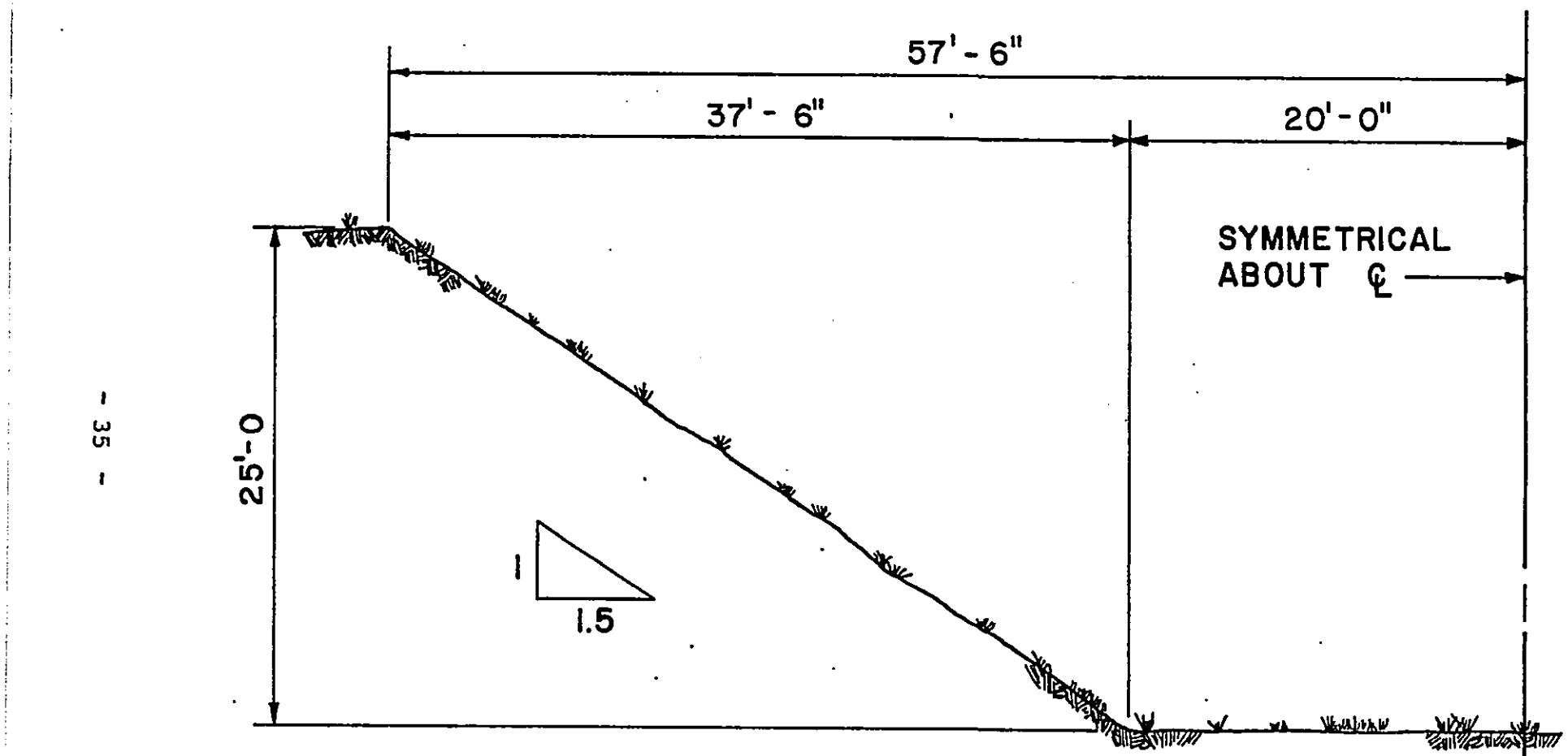
FIGURE 12



ELEVATION - ALTERNATE 2

SCALE : 1/8 = 1'- 0"

FIGURE 13.



TYPICAL HALF SECTION
GRASS LINED CHANNEL

SCALE: 1/8"=1'-0"

FIGURE 14

5. No Channel Improvement

An alternate to the proposed flood control plan in Puukapu is to let existing conditions continue unimproved. With this alternative, the total cost of the project is saved.

This alternative subjects local residents and facilities to continual annual losses due to flooding. Such adverse conditions will lead to a de-emphasis of agriculture.

Restrictions on agricultural usages within the flood plain by zoning could lessen damages caused by flooding. Such a proposal is similar to the alternative of no improvements. Local residents and facilities will still be subject to annual flooding.

The alternate of no channel improvement does not conform to the County of Hawaii's General Plan (Ref. 8). The General Plan calls for channel improvements for effective flood protection. Also a proposed multi-residential development next to the proposed channel will be endangered by flood waters should no improved channel be installed.

F. THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The proposed flood control plan provides an adequate level of protection for the present and projected future use of the benefited land. It will permit efficient use of the land and continued economic return to the land owners. The proposed project will not narrow the range of beneficial uses of the environment or pose long-term risks to health or safety. Rather, the project can lead to an expansion of agricultural usages, and enhance the health and safety of those in the community.

G. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTION SHOULD IT BE IMPLEMENTED

Labor and construction materials are those resources committed in the implementation of this project that are irreversible and irretrievable in nature. Implementation of the project will mean the destruction of a few trees. The path of the proposed channel is routed to minimize this. The commitment of land is not considered irreversible. The original streambed may be reclaimed and used for other purposes.

H. COORDINATION WITH OTHERS

This section will be finalized upon coordination of the draft environmental statement with County, State and Federal government agencies and with local community organizations.

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