HAMAKUA-KOHALA
HHFA 701 PLANNING PROJECT
COUNTY OF HAWAII
STATE OF HAWAII

(D R A F T)

Report

on

WATER SUPPLY, DRAINAGE, AND SEWAGE AND WASTE DISPOSAL

November, 1962

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WATER SUPPLY

NOTE TO THE READER

The reader should be cautioned that this report is a draft only of the final study. In order to meet the required time limitations it was necessary to perform the fact gathering phases of the study some months ago. Since then the region which is the subject of our attention has endured perhaps the most severe phase of a prolonged drought, which may, indeed, prove to be unprecedented in severity. The authors are closely following this phenomenon and will examine up to data records and data before preparing the final report. This may occasion some modifications in the conclusions reached, particularly as to storage requirements. It is not at present believed that changes in the basic premises and conclusions will be affected, however.

I N D E X

WATER SUPPLY

SECTION I

FINDINGS

The following findings are presented as a convenient and condensed version of some of the more important highlights of this report. Like all condensations they suffer from the defect of omission of contingencies and qualifications. For this reason and because other comments and conclusions not included in these findings are thought to be useful though of lesser degree, the reader is urged to study the whole report.

1. The Hamakua area posses ample resources of water, much of it undeveloped.
2. Within this area, the three plantations served by the Lower Hamakua Ditch need more water.
3. It is believed that this additional water can be developed at a cost favorable to its use as required by the plantations.
4. Private enterprise is commencing steps in that direction.
5. The most favorable water source in the Hamakua area for export to South Kohala is Waipio Valley.
6. In quantities of 6.67 mgd this water could be delivered to and stored near Waimea Village for about 25 cents per 1,000 gallons, exclusive of purchase cost of the water itself. In lesser quantities the unit cost would be higher.

7. The North Kohala area is adequately provided with water.

8. There are some prospects for developing additional water, possibly for export, but it is not believed that this warrants further consideration for the planning period and growth projections which form the basis for the present study.

9. Water transmission and distribution facilities in the Hamakua and the North Kohala areas do not, it is believed, present problems of significance to the present study.

10. Surface streams above Waimea Village provide an adequate resource to serve projected development in South Kohala.

11. In order to do this it will be necessary to provide adequate storage to tide over dry spells.

12. This would consist of four reservoirs of 20 MG capacity each by 1980, assuming that population projections are correct.

13. These reservoirs could be built one at a time as need requires.

14. The cost of water in the reservoir, based on 1980 estimated water consumption, would be about 11 cents per thousand gallons.

15. This is less than half the cost of providing water from Waipio.

16. The cost of a transmission line from storage and to serve the Kawaihae-Puako coastal area, which would be required before 1980, would be a little over $1,000,000 at today's prices.

17. Water available from the State's Upper Hamakua Ditch System is adequate for irrigating 1,000 - 1,500 acres.

18. There are no other large sources of low-cost water which can be developed for irrigated farming. Very little, if any, expansion in farm acreage irrigated with domestic water is anticipated.

19. Despite rather poor results of exploration to date, there is reason to suppose that useful quantities of basal water could be developed in the general coastal area -- Kawaihae to Puako.

20. This would require field investigations followed by test drilling.

21. For service to the coastal areas, this basal water would have an economic advantage over water stored above Waimea Village and transported to the coastal areas by a transmission system.

22. It is not possible at this point in time to forecase the geographic location, priority and extent of various segments of the estimated growth.

23. Therefore a master plan and cost estimate for a water transmission system along the coast is impractical.

24. Certain basic suggestions in this regard are included in the text.

SECTION II

RECOMMENDATIONS

Certain major recommendations regarding water supply are presented below. A number of less important but pertinent suggestions are included at various parts in the text material.

1. Surface streams above Waimea Village should be adopted as the basic water resource to serve the projected population increase to 1980.
2. Problems of water rights to these stream flows should be negotiated and settled between the parties on a mutual interest basis.
3. Planning for irrigated agriculture in the general Waimea area should be limited to 1,000 to 1,500 acres of total area.
4. Further effort should be made to develop useful quantities and acceptable quality of water at properly placed sites mauka of the shoreline.
5. A first step would be a thorough investigation of fresh water leakage along the shore, followed by further geological study and then programmed testing.
6. Land development, highway development and water transmission should be coordinated and phased in the shore area.

SECTION III

INTRODUCTION

The region which is the subject of this Planning Project includes all of the Kohala Mountain mass and much of the northerly slopes of Mauna Kea. It therefore includes the summit area of Kohala but not of Mauna Kea. Kohala is the older of the two mountains. Both mountains have long been inactive.

In common with the other sea mountains in the Hawaiian archipelago, Kohala was built up from the ocean floor by countless thinly bedded flows of basaltic lava. Above sea level, these lavas are for the most part highly permeable to water. However, in the last stage of its volcanic activity the mountain produced the andesite and trachyte forms of basalt, which are relatively less permeable than the older flows. Thus, a substantial part (perhaps half) of the dome shaped mass of Mount Kohala is plastered with a shield of material which offers resistance to the penetration of rain water.

During the mountain's active life, magma forced its way up in channels to feed the volcanic activity at the surface. The lava in these channels, upon cooling, formed dikes which are quite impervious to the passage of water. They occur in greatest numbers under the crest area of the mountain where they interconnect in such a way as to form cisterns or reservoirs where entering rain water is effectively stored.

In certain locations, during the process of mountain building, ash was laid down or an area was quiescent long enough for soil to form. Later flows covered these areas and under the forces of nature they became reasonably water tight. Thus, rainfall percolating downward has a tendency to come to rest on these ash and soil beds.

The Northeast (windward) side of Kohala Mountain was subjected to severe forces of erosion so that deep, long canyons were carved into this side of the mountain. Three of these, Waipio, Waimanu and Honokane, encroached upon the crest area of the mountain and cut through dikes containing stored rain water. This results in high level springs.

Mauna Kea was formed in much the same general way as Kohala. Its side slopes are gentler, it is not so deeply eroded on its windward side (no valleys remotely approach the crest area) and it is not plastered near the surface with andesite or trachyte flows in the region under study. Mauna Kea flows antedated the Kohala flows and therefore buried them. At the surface junction of the Mauna Kea flows with the existing Kohala Mountain, a ponding effect occurred and this created what is known as Waimea Plain.

Rainfall distribution in the region is influenced by topography and wind direction. Thus the best rainfall on Kohala Mountain occurs in the region of the crest where just to windward it approaches 200 inches per year. Average rainfall lessens sharply leeward from the crest area and the leeward and northerly coasts are comparatively arid. Rainfall is adequate on the slopes directly to windward of the crest.

The best rainfall on that part of Mauna Kea under study occurs in a band along the windward slopes between, very roughly, 1,000 feet and 3,000 feet elevation. Within this band, rainfall is greater at the southerly end than at the northerly end. The leeward (northwesterly) slopes of Mauna Kea in the region under study are dry.

These phenomena explain the occurrence of developable water in the region. These may be summarized as follows.

KOHALA MOUNTAIN

Perched Water: Water in limited quantity is perched on ash and soil beds lying on the northerly slopes above and within the sugar cane fields. This resource has been exploited. There remains the possibility of developing perched water elsewhere on Kohala.

High-Level Water: Abundant water is stored by dikes under the crest area. In part it flows naturally out from springs near the heads of large canyons. A considerable amount of this water has been exploited but much of this resource remains to be put to use. The remainder of this dike-confined high-level water could be exploited by tunneling.

Surface Water: A considerable amount of the rain that falls on the crest area does not penetrate the surface due to the resistant trachyte, andesite shield. It runs off in streams. This resource is being exploited but can be further developed.

Ground Water: Much of this rainfall does, however, penetrate the surface and makes its way downward, acted upon by gravity. The andesite, trachyte shield no doubt prevents direct downward percolation and forces this water to move downward along the shield. It finally comes in contact with and floats on the sea water which penetrates the mountain mass and then slowly makes its way to sea. Attempts to exploit this water resource near the leeward coast have only been partly successful.

MAUNA KEA

Ground Water: The rainfall on the leeward slopes of Mauna Kea is insufficient to contribute major quantities of ground water which could be developed near the leeward coastal area of this region. However, there is, along the Hamakua Coast, a good supply of ground water which has only been exploited in part.

(The reader wishing a more detailed study of the general geologic and hydrologic features of the region is referred to Bulletin 9, Hawaii Division of Hydrography, 1946, "Geology and Ground-Water Resources of the Island of Hawaii," H. T. Stearns and G. A. MacDonald. The present authors have drawn freely upon this work in preparing the above and, for convenience, will refer to it as "Stearns" in the material hereinafter.)

The region as a whole, therefore, has excellent resources of water, much of it not in use. Unfortunately, these resources are not well dispersed and, in fact, are to some extent unfavorably located with respect to those areas where population and economic growth are foreseen.

In other studies of this Planning Project, population estimates for the years 1970 and 1980 are developed. By areas within the region, these projections are summarized as follows:

	Population Estimates		
Area	1960	1970	1980
Hamakua	8,364	7,800	7,280
North Kohala	3,386	3,480	4,420
South Kohala*	1,538	4,500	9,300
TOTAL	13,288	15,780	21,000

*Includes an adjacent segment of North Kohala.

These estimates are used to form the basis for the future regional water requirements developed hereinafter. They show that the population of the Hamakua area will probably decline, that the population of the North Kohala area will increase somewhat but not substantially and that the growth potential for the region will likely occur mostly in the South Kohala area. Thus, the present study must consider developable sources in the South Kohala area in economic comparison with any sources in the other two areas which may be available and developable for transmission to the growth areas in South Kohala. It is not thought to be either useful or advisable to attempt to project water requirements beyond 1980 although the material and studies herein should provide a useful background for anyone interested in the relatively distant future.

By far the largest exploiters, transporters and users of water in the region are the several sugar plantations along the windward and northerly coasts. They use water for sugar cane irrigation and, as adjuncts to their sugar activity, for industrial and domestic uses. As to the last named, a number of plantations are gradually phasing out of this service and turning their systems over to the public.

Apart from the above and one or two other private water systems of small size, the agency which provides water service in the region is the Board of Water Supply of the County of Hawaii. For geographic and demographic reasons, this agency's service is made up of many small and isolated systems. As might be expected, there are some problems within each system but in general the solutions to these problems (insofar as present service is concerned) appear to be recognized and within the financing arrangements and management capability of the organization and need not be further considered in a broad Planning Project such as the present study. The major problem facing the Board of Water Supply is service to programmed and anticipated population and resort development in the South Kohala area. Water for farming use is treated in some detail later.

The study which follows is aimed at a determination of the best solution of this problem in the light of present knowledge. Available water sources are identified, analyzed and compared as to feasibility for the purpose. Additional investigations are recommended where indicated. Growth limitations due to water problems are pointed out, where necessary, and finally, recommendations are developed. The various water resources are taken up by areas.

One cautionary thought should be expressed at this point. It is obvious (as seen elsewhere in this Planning Project) that much of the growth potential of the region is in scattered but attractive sites up and down the leeward coasts -- at unfavorable locations from the stand point of water service. Even assuming a satisfactory solution of the water resource question, very large sums are required for water transmission. It seems obvious that, in order to be financially feasible, development should proceed from site to site in an orderly manner and in correlation with a program of transmission facilities extension.

SECTION IV

HAMAKUA AREA

Commencing at the southerly end of this area, the first water resource of significance is the basal water supply in Mauna Kea lavas. Stearns finds that "Basal ground water underlies the entire lower slope of Mauna Kea from Hilo to Kukuihaele. Along the coast it is generally brackish but half a mile inland it is of good quality ..." and again "...basal ground water can be secured in large amounts at low levels on eastern and northeastern slopes of Mauna Kea by the construction of Maui-type wells. Even in the area between Paauilo and Honokaa where rainfall is comparatively low, large amounts of basal water can be developed ..."

Two basal water wells in the Hamakua area exploit this ground water. The 1937 Ookala well furnishes one of the Laupahoehoe Sugar Company mills with industrial water and domestic water for the adjacent village. It is adequate for the purpose. Its portal is on the side of Kaula Gulch at an elevation of 300 feet. Hamakua Mill Company operates a similar type of well at Paauilo. This well was developed in 1944 with a portal elevation of 273 feet. The portal is on the southeast side of Paauilo Gulch. This installation is performing satisfactorily.

There is every reason to believe that other similar installations could be satisfactorily operated further up the coast.

However, they are not needed for population growth in the Hamakua area and water produced would be too costly for sugar irrigation. Since the water source is near sea level the pumping lift and the very long transmission line seems to rule out this source as a solution to the growth problem in South Kohala.

In the southern part of the Hamakua area, where the rainfall is favorable, there is a substantial amount of surface water. These sources are fed by springs as well as by surface runoff. They are exploited for industrial and domestic use, but a substantial surplus remains. The transmission distance to the growth areas is so great, however, that this resource is not believed to be of interest in the solution of the South Kohala water problem. The northern part of the Hamakua coast is relatively drier and only one perennial stream is of interest in our present study. This is the Lalakea Stream situated just south of Waipio Valley. A study of flow characteristics of this stream indicates that its use for transmission to the growth areas is economically unfavorable.

The next water resource to be considered is Waipio Valley. This is a long, deep, flat bottomed valley which produces large amounts of water from high level springs fed by abundant rainfall. The rain gage at the most northerly valley branch has recorded a median annual rainfall (to 1960) of 187.5 inches.

Early in this century a major water development project was constructed to take advantage of the spring water production above elevation 1,000 feet. It consists of intake works in each of the valley branches, connected by a tunnel constructed in the side walls of the valley. At the discharge end of this tunnel, a long ditch transports this water for use by Honokaa Sugar Company, Paauhau Sugar Plantation Company and Hamakua Mill Company. The entire system consists of 9.9 miles of open ditch, 1.1 miles of flumes and 10.8 miles of tunnel. It terminates near Paauilo Town at elevation 810 feet. The system is called the Lower Hamakua Ditch and is operated by the Hawaiian Irrigation Company, Ltd., a wholly owned subsidiary of Honokaa Sugar Company. The water itself, the intake structures and most of the tunnel within the valley belongs to the Trustees of the Bernice P. Bishop Museum and is subject to a newly negotiated 25-year lease in favor of the Hawaiian Irrigation Company, Ltd.

Figure 1 is a duration-discharge curve of the flow of this system as measured by a weir just outside the valley and at the intake to the open ditch. This curve shows that this is a remarkably large and reliable water source. The discharge averages 36 mgd and for 99.2 percent of the time measures 20 mgd or more. During the unprecedented drought of the past two years the unimpeded flow over the weir did not fall below 22 mgd.

The ditch system does not meet the full demands of the plantations which it serves. A careful study of demand shows

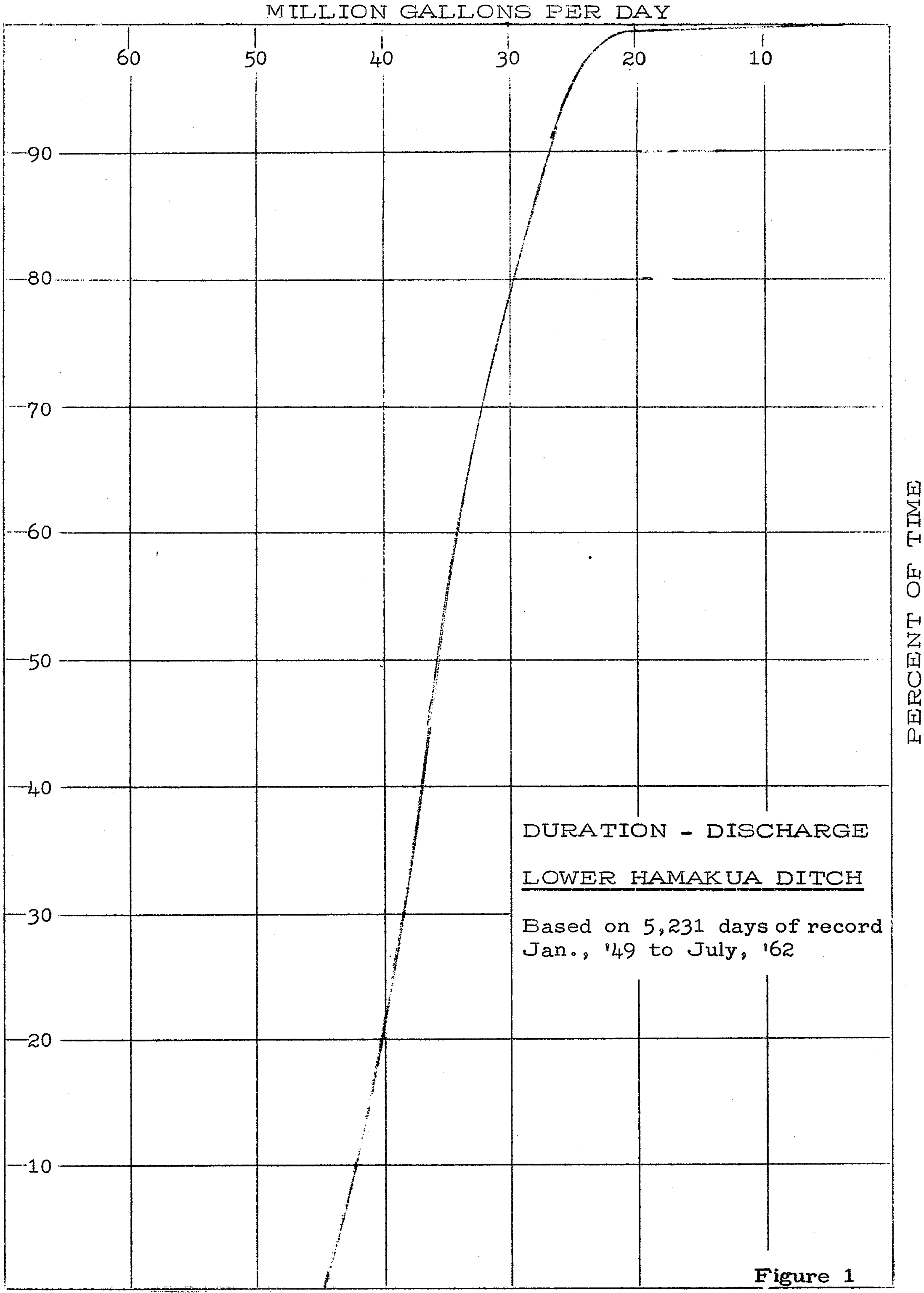
MILLION GALLONS PER DAY
60
50
40
30
20
10
90
80
70
60
50
40
30
20
10
PERCENT OF TIME
DURATION - DISCHARGE
LOWER HAMAKUA DITCH
Based on 5,231 days of record
Jan., '49 to July, '62

Figure 1

that the ditch flow falls short of plantation requirements 65 percent of the time during the "on season". Furthermore, the plantations are at present expanding their overhead irrigation system. Although this system reduces the quantity of water required per acre, the expansion will doubtless offset this saving so that the plantations feel the need to have available to them during the "on season" 10 to 15 mgd more water than the present ditch flow. In order to accomplish this, consideration might be given to additional storage, short tunnels to capture water which would otherwise emerge below the ditch, pumping up into the ditch from below, and perhaps others. Since the beneficiary of such a development would be the several plantation users of this additional development, it seems reasonable to suppose that the Hawaiian Irrigation Company should undertake the necessary study and project.

An almost equal amount of water emerges below the 1,000 foot level and is not at present captured by the ditch. Stearns and others have estimated that about 30 mgd flows from springs above 500 feet elevation but below the ditch. There is little or no use of water on the valley floor but the ownership of the water is to some extent questionable since, according to a study by Collin G. Lenox for the Museum Trustees dated October, 1954, about 300 acres of the valley floor consists of a patch work of old kuleanas with various ownerships. So far as is known the proportion of water attributable by ancient appurtenant right to these kuleanas has not been adjudicated.

Since the most downstream intake to the Lower Hamakua Ditch is situated less than six miles from Waimea Village, this water source in Waipio Valley is worth considering for use in South Kohala. There are two disadvantages. First, it would be necessary to pump water up 2,000 feet in order to deliver it into a service and storage reservoir and second, the plantations now need all the water and more delivered by the Lower Hamakua Ditch during times of maximum demand. The second point can easily be overcome by pumping from the stream at elevation approximately 500 feet where 30 mgd additional is available. In such a case the pumping head would be 2,500 feet. Since lesser quantities of water can be made available from streams just north of Waimea Village (as described later) an estimate has been made of water costs from this resource delivered to Waimea Village in average quantities of 6.67 mgd. This corresponds to maximum use of 10 mgd. This estimate is shown in Table 1.

The Table 1 calculation which arrives at a cost of 27 cents per 1,000 gallons assumes fairly steady pumping. Since such a large proportion of the cost is attributable to power charges, a similar study has also been made on the assumption that "off peak" hours and rates could be used. This naturally would require larger mechanical equipment, transmission lines

TABLE 1

ESTIMATED COST
WAIPIO WATER DELIVERED TO
WAIMEA VILLAGE

CAPITAL COSTS:

Pipeline, 30,700 LF	$ 751,000
2 MG Concrete Reservoir	175,000
Pump Station Buildings, etc.	100,000
Access Road	120,000
Electrical and Mechanical Equipment	381,000
Engineering and Incidentals @ 15%	229,000
TOTAL	$1,756,000

ANNUAL COSTS:

Amortization	
Mechanical and Electrical - 20 yrs. at 6%	$ 33,200
Other - 50 yrs. @ 6%	83,600
Operation and Maintenance	12,500
Power	517,000
TOTAL	$ 646,300

UNIT COST:

6.67 mgd equals per year	2,435MG
At a cost of	$ 646,300
Cost per Million Gallons	$ 268
Cost per Thousand Gallons	$ 0.27

and additional storage. It appears possible to save about 20 percent by this method but it might introduce operating problems.

As stated above these cost estimates are based on an average delivery at Waimea Village of 6.67 mgd. Naturally a lesser quantity could be delivered by means of smaller (and therefore less costly) facilities. This would result in higher unit costs, however; that is to say, the cost per thousand gallons for water delivered in quantities averaging less than 6.67 mgd would run to more than the estimated 27 cents per thousand gallons stated above.

Naturally it might be possible to pump out of the Lower Hamakua Ditch System during off hours and thus effect a saving due to the lesser lift. However, this introduces problems of conflict with the Hawaiian Irrigation Company and is not further considered here. If at some date in the future Waipio water is to be used in South Kohala, this thought would be worthy of further exploration.

It seems reasonable, therefore, to use as rough estimate for comparison purposes a figure of 25 cents per 1,000 gallons as the cost of pumping water from Waipio Valley to Waimea Village. This figure, of course, does not include the cost of water itself which would be a matter of negotiation with the owner and its lessee, nor the cost of transmission and distribution within South Kohala.

A neighboring water resource is that of Waimanu Valley. Springs in this valley issue from behind dikes which, according to Stearns, are at an altitude of about 425 feet. The same authority estimated the flow of two observed springs at 17 mgd at about this elevation, and the flow at the mouth of Waimanu Stream at about 30 mgd. Despite prospects for development of substantial water in Waimanu Valley by tunneling at about 400 feet elevation, this site is unfavorably located compared with Waipio Valley with respect to the South Kohala area.

It may therefore be said about the Hamakua area that (1) the area has ample water resources to serve its needs; (2) there are no serious water service problems in the area from the transmission and distribution viewpoint; (3) the Board of Water Supply is expanding its facilities in the gradual transition from private to public water service; (4) the Board of Water Supply faces no major difficulties in this process; (5) the area has water resources of major proportions available for export to growth areas in South Kohala; and (6) the most favorable of these is Waipio Valley.

SECTION V

NORTH KOHALA AREA

Within the North Kohala area, water sources falling in each of the catagories described in the Introduction are exploited. Surface water in the crest area is captured by the Kehena Ditch System. Surface water fed by runoff and by high level springs in the locality between Waimanu Valley and Honokane Valley is diverted into the Awini Ditch. High level springs in Honokane Valley feed into the Kohala Ditch. Tunnels into ash and soil beds in the upper reaches of Kohala Plantation contribute to the Kohala Ditch and in some instances are used for domestic water service to plantation villages. Two basal water pump installations are in operation near the coast at Kohala Sugar Company.

The major water development in the area is the Awini Ditch-Kohala Ditch System operated by Kohala Sugar Company through its subsidiary Kohala Ditch Company. The system originates about five miles northwest of Waipio Valley. In this locality it runs along at about the 2,000 foot level and collects surface waters. This ditch ends at and forms a waterfall on the side of Honokane Valley and, on the valley floor, Awini water is collected and merged with the spring water in Honokane Valley. This combined water is diverted into the upper end of the Kohala Ditch.

Honokane Valley, one of the three major erosion valleys in the windward slopes of Kohala Mountain, produces water from dike compartment springs, water perched on tuff beds and a high level tunnel. The Kohala Ditch transports the Awini water and the Honokane water for about 11 miles through the cane fields of Kohala Sugar Company. There are numerous intakes along the way by means of which surface water and water from soil and ash bed tunnels is captured. This ditch system is used for sugar cane irrigation and to a much lesser extent for domestic and ranch use.

Ditch flow is measured near the point of entry into the plantation as well as at several points upstream. A careful study has been made of these various measurements from which the conclusion is drawn that, exclusive of surface and tunnel water within the plantation area, the ditch discharges an average of nearly 27 mgd of which not less than 15 mgd is discharged 96 percent of the time. The surface water coming from the Awini portion of the system is relatively flashy and the majority of the reliable ditch flows are made up of water from Honokane Valley. A statistical study shows that when the ditch flow is at about 25 mgd, about 60 percent of the flow comes from Honokane Valley. When the ditch flow falls to 15 mgd, Honokane Valley produces 80 percent of the total.

The high-level tunnel mentioned above was constructed between the years 1942 and 1946. Portal elevation is 1,900 feet.

Plantation people have expressed themselves as disappointed with the results. A close analysis of discharge records, show, however, that the tunnel and its dike compartment sources have resulted in a significant improvement in the low flow characteristics of the ditch system.

Studies by Doak Cox (March 7, 1957) and Chester K. Wentworth (August 21, 1957) indicate that further tunneling at Honokane might develop additional water but both authorities are cautious in their predictions.

The downstream intakes to the ditch system mentioned above average about 5.6 mgd (5-year average) according to a study by George M. Collins dated March 1, 1960.

The Kehena Ditch is operated by the Plantation. It originates near the crest area of the Kohala Mountain at elevation approximately 4,250 feet. The ditch follows along the uplands above Honokane Valley and then takes a downward course to a terminal reservoir at elevation 1,800 feet in the vicinity of the Kohala-Waimea Road near Puuokumau. At a U.S.G.S. measuring station near the upper end of Honokane Valley at elevation approximately 3,850 feet, the 34-year average discharge of the ditch was established at 7.69 mgd. However, the Collins study gives a ten-year average ditch discharge available to the plantation (presumably measured at a lower level by the plantation) as 1.1 mgd. Water from Kehena Ditch is used for plantation and ranching purposes.

Basal water in the area is exploited by two plantation wells. Hoea Well, elevation 52 feet, was developed in 1900 and Waikane Well, elevation 26 feet, was developed in 1920. Water produced by these two wells is too salty for human consumption and is used by the plantation for irrigation purposes. According to the Collins report these two wells together have been producing an average of 2.73 mgd in recent years. Their location at a low elevation suggests that wells further inland might produce water of better quality. Without careful inspection and analysis of the locality, test drilling and pumping tests, the expectable quality of water from such wells remains conjectural. Such wells might, if our present understanding of water phenomena is correct, reduce the capability of existing wells. It seems reasonable to suppose that a location about two miles down (southeasterly) the coast would be more favorable to basal water development, but again it must be said that forecast as to quantity and quality would require inspection, analysis, and a program of tests. In any case, these uncertainties when taken together with the transmission distance to Kawaihae of about 24 miles and the pumping lift for adequate service of about 300 feet rules this resource out of our consideration for solution of the problem of water service for the population growth forecast which forms the basis of the present study. In a longer perspection, the time may come when investigation and exploration of this water resource might be justified.

Collins, in his study referred to above, summarized water available to the plantation as averaging just over 38 mgd. In dry weather when the plantation's need is greatest the figure is naturally substantially lower. As a matter of fact it is understood that the plantation people feel that they do not now have enough water for optimum irrigation. For that and other reasons the plantation is giving serious thought to converting in part at least to overhead irrigation. As stated previously, this system requires the use of less water per acre than does furrow irrigation. However, bringing irrigation at the plantation up to optimum practices will tend to offset this saving. Whether in the long run the plantation will need less water or, on the contrary, more water will probably remain in question for some years.

In common with the situation in some other areas the plantation is gradually phasing out of domestic water service and the Board of Water Supply is becoming the major organization providing domestic water service in the area. There are no major problems evident in this process which require comment in the present report. If a development of modest proportions were to take place at or near Mahukona, it is possible that the Board of Water Supply could, from the standpoint of water availability, serve the development by an extension of one of their present small systems. The Mahukona area is further discussed under South Kohala.

Suggestions have been made that perhaps water could be stored near the end of the Kohala Ditch during "off season" for irrigated farming in the northern part of North Kohala. This would require an exceedingly large storage capacity, the cost of which would appear to rule out any such projects on economic grounds, except of course, on a very minor scale.

As to the North Kohala area, then, it appears reasonable to summarize the water situation as follows: (1) There are adequate local water resources for the present population and for the estimated population growth; (2) there are no evident extraordinary problems in providing for water service in the area; (3) area water resources are aggressively exploited for sugar cane irrigation; (4) present developments fall somewhat short of today's full requirements for this purpose; (5) although the area presents certain possibilities for further water development, success would be uncertain and costs would be relatively high; (6) use of basal water in the area for export to South Kohala does not appear competitively favorable for service to the forecast population growth there; and (7) storage of "off season" Kohala Ditch water for irrigated farm lot development is not believed to be practicable.

SECTION VI

SOUTH KOHALA AREA

GENERAL

This brings us to the third and last area in the planning project, South Kohala. It is in South Kohala that the significant growth in the whole Planning Project is forecast. For that reason any developable and feasible water resource in South Kohala has a built-in geographic advantage. Therefore, a somewhat different format must be pursued regarding this area.

In the first place, it will be necessary to take up the question of what water requirements are necessary to make possible the growth as forecast. This was not necessary in the other two areas. In the second place, it is desirable that relatively more space and more detail be devoted to the various elements that go to make up the consideration of water development in South Kohala.

It is perhaps advisable for the benefit of the reader to briefly summarize the general water situation in the area before commencing the more detailed discussions.

In the manner described in the Introduction, water occurs in the South Kohala area in the form of high level water, water perched on soil and ash beds, surface water and ground water.

High level water occurs in dike compartments underlying that portion of the Kohala Mountain crest lying within the South Kohala area. Surface water in important quantities consists primarily in several streams above and near Waimea Village. These streams are fed by the plentiful rainfall in the crest area and the runoff therefrom which, because of the relatively impenetrable Kohala Mountain shield, cannot readily infiltrate into the ground. Perched water doubtless occurs in South Kohala but unlike North Kohala has not been evaluated and exploited to any great extent. Basal ground water in South Kohala presents a complex picture. Part of the rainfall in the Kohala Mountain crest area penetrates the surface and percolates downward in the well-known manner typical of mountains in the Hawaiian chain. Other rain water penetrates the surface but is conducted down the Kohala Mountain shield taking the direction of greatest slope. It seems probable that much of this water thereby penetrates Mauna Kea lavas which are permeable and overlie the Kohala shield. Here they doubtless mix with downward percolating water which fell as rainfall on the Mauna Kea slopes. These two waters would then in all probability make their way seaward along the surface of the shield and should form a basal supply near the coastline in Mauna Kea lavas.

Apart from rather minor sources and quantities, present water development in South Kohala consists in exploitation of the above surface streams by the State and by the County of Hawaii, Board of Water Supply (hereinafter called Board). In addition the State has drilled two basal water test wells in the general coastal area.

The procedure to be followed hereinafter will be: (1) An estimate of present and future area water requirements, the latter being based upon the planning period to 1980 and development and population forecasts made elsewhere in this Planning Project. (2) An investigation and analysis of area water sources, including a description of present exploitation and an appraisal of prospective exploitation. The latter includes cost estimates, where desirable, for development and storage and quantitatively considers farming potential as well as population and resort growth. (3) A discussion of the problems of transmission of water between storage and use, including some estimates of cost in connection therewith. The South Kohala section concludes with: (4) A summary of the more important conclusions reached.

WATER REQUIREMENTS

To estimate the water requirements of South Kohala for the year 1980, the planning period, it is first necessary to determine pertinent present water use. The additional water needs of the projected increase in population can then be estimated to arrive at the total water requirements by the year 1980.

In the present analysis leading to this 1980 requirement, two water consumption elements are eliminated from consideration.

First, current water requirements for ranching purposes are being met from numerous small sources developed or operated by the ranches, as described later. It is assumed that this practice will continue and therefore, no allowance is made in the development of additional domestic water for supplying any ranching purposes since it is believed that ranch requirements for water will not materially change during the planning period to 1980, -- not, at least, to an extent that would affect the water development proposed herein which is aimed at satisfying the needs of new developments.

Second, it is not likely that any future sizeable increase in demand for farm irrigation water from the domestic water system will occur in Waimea Village. Such new farming lands as may be developed in the future will likely be located in drier areas requiring full-time irrigation as opposed to the supplementary irrigation now practiced by most farmers in Waimea Village who irrigate. Full-time irrigation with water purchased from the Board's domestic system would be quite expensive. It may be presumed, therefore, that the less expensive water from the State's Upper Hamakua Ditch System (described later) will be used for new irrigated farm undertakings.

According to the records of the Board of Water Supply, the metered water deliveries for the Kamuela System during 1961 averaged 388,745 gallons per day. The water delivered during the maximum month of 1961 (September) was 19,138,000 gallons, equivalent to 637,900 gallons per day. The population served by this system is not accurately known but the indicated average use is between 200 and 250 gallons per day per capita. This is a relatively high per capita consumption which is apparently due primarily to the use of domestic water for irrigating various farms in the Waimea Village area.

If losses due to unaccounted-for-water were assumed at 20 percent (a high normal percentage) the indicated stream diversions to meet this demand would be 466,500 gallons per average day and 765,500 gallons per day during a maximum-demand month. We are advised, however, by Mr. William Thompson, Manager-Engineer, Board of Water Supply, that actual diversions from the Waikoloa Stream during prolonged dry spells are estimated at about one million gallons per day and probably reach a maximum of one-and-one-half million gallons per day upon occasion. These high diversion rates are borne out by the fact that during dry periods in the past, reservoir storage has decreased even though the gaging records at the Marine Dam show a minimum-month average daily flow in Waikoloa Stream of 0.84 million gallons.

The apparent explanation for these abnormally high water diversions with respect to metered water deliveries is that system losses (unaccounted-for-water) are very high and must exceed 50 percent. With the further development of the Waikoloa Stream and construction of new transmission lines, it is believed that existing system losses can be reduced to a more reasonable figure of not greater than 25 percent.

It is concluded, therefore, that for design purposes, applicable to the future, current water diversions from Waikoloa Stream can be assumed at 485,000 gallons for an average day and 800,000 gallons per day during a maximum-demand month.

Future water requirements for the South Kohala area have been estimated on the basis of the projections of population growth and hotel construction which are basic to the present study.

For planning purposes, it can be assumed that there will be a higher per capita use of domestic water in the drier and warmer climate along the westerly coastline than further inland at Waimea Village where temperatures are lower and rainfall more plentiful. Since population projections are based on the South Kohala area as a whole rather than specific residential areas, estimated average per capita metered water consumption is assumed at 130 gallons per day. The actual per capita consumption will probably be higher along the coast and lower in Waimea. The 130 gallons per capita per day estimate includes industrial and commercial use of water but not hotel use. For hotels, an estimated daily use of 350 gallons per room has been assumed.

Table 2 is an estimate of total water requirements for South Kohala for the planning period and under the various stated assumptions. These requirements may be summarized as follows:

	Total Water Development Requirements	
	1970	1980
Average Day, MG	1.144	2.497
Maximum Month, mgd	1.479	3.192
Maximum Month, MG	40.8	85.8
Annual, MG	386	822

WATER RESOURCES AND DEVELOPMENT

Miscellaneous: It seems advisable, before proceeding to more promising resources for water development to dispose of a miscellany of relatively small and geographically scattered water sources and prospects in the area.

The various large and small ranches in the South Kohala planning area obtain water for their cattle principally from such sources as mountain streams, plantation ditches (see North Kohala) and springs. Parker Ranch, the largest in the area, obtains an average of between six and seven hundred thousand gallons of water a day from some eight streams, ditches (in North Kohala) and springs in the Kohala Mountain. Kahua Ranch (see North Kohala) diverts stream and ditch water and recently

TABLE 2

ESTIMATED NEW WATER REQUIREMENTS
SOUTH KOHALA

	1970	1980
Projected New Population	2,950	7,750
Projected New Hotel Rooms	540	2,120

	Delivered Water Requirements		Water Production Requirements – including 15% for System Losses	
	1970	1980	1970	1980
Population Requirements:				
Avg. Day -- gpcd	130	130	150	150
Avg. Day -- MG	0.384	1.008	0.442	1.159
Maximum Day @ 150% x Avg. Day -- MG	0.576	1.512	0.662	1.739
Maximum Month @ 125% x Avg. Day -- MG	14.40	37.80	16.56	43.47
Annual Total -- MG	140.2	367.9	161.2	423.1
Hotel Requirements:				
Max. Day @ 350g/r/d MG	0.189	0.742	0.217	0.853
Max. Month @ 95% occupancy -- MG	5.39	21.15	6.20	24.32
Annual Total @ 75% occupancy -- MG	51.7	203.1	59.5	233.6
Combined for 1970-1980:				
Avg. Day -- MG	0.573	1.750	0.659	2.012
Max. Day -- MG	0.765	2.254	0.879	2.592
Max. Month -- MG	19.79	58.95	22.76	67.79
Annual Total -- MG	191.9	571.0	220.7	656.7

drilled a well at a relatively high altitude in the Kohala Mountain to develop perched water. It is reported, however, to be only a low-producing well. Huehue Ranch diverts water from Waiaha Stream above Kailua and imports it into the South Kohala area. When there is water surplus to the needs of Huehue Ranch it is made available to Puuwaawaa Ranch. At times, Puuwaawaa Ranch must haul water by truck for its ranch purposes.

Brackish water from dug wells near the coastline at Puako is used for irrigating salt-tolerant grasses for cattle forage. The Parker Ranch in recent years has also developed some irrigated pastures higher up by diverting the surplus flows of the Waikoloa and Keanuiomanu Streams below Waimea Village.

A well recently drilled some distance inland of Kaupulehu Bay reportedly encountered ground water although somewhat high in chlorides (350 ppm). There is evidence of fresh water outflow to the sea at various points along the shoreline between Puako and Kailua but the prospect of developing enough local ground water to supply potential recreational, resort and residential developments for this coastal area does not appear promising. However, additional exploratory wells inland of this coastline could determine more definitely the extent of developable ground water of suitable quality.

Brackish ground water has been developed in the Mahukona area by dug wells but there is no evidence that good quality ground water can be obtained. Again, as along the Puako-Kailua-Kona coastline, exploratory drilled wells in this area might locate a satisfactory supply of ground water.

The Federal Government is sponsoring considerable research on processes for demineralizing brackish and sea waters. While progress is being made, results to date indicate that costs of water so treated will be relatively expensive and generally not competitive with the development of surface or ground water. Both the initial cost of construction and the cost of operation are high, whether brackish water is treated by the ionic-membrane process or sea water is demineralized by evaporation or freezing. These costs would probably range between $1.50 and $2.50 per thousand gallons of water for the smaller type installations envisioned for possible use to supply isolated developments along the coastline, for example Kiholo Bay. While such unit costs are comparatively high, they are not necessarily prohibitive if other factors are so favorable as to overbalance this cost.

There is a small perennial stream which flows down the westerly slopes of Kohala Mountain which offers some prospects for this area. The dry-weather discharge of this stream should be measured over an adequate period of time to determine whether its development for supplying water to Mahukona is feasible.

The extreme southerly part of the area is supplied domestic water from the Board's Waiaha-Kailua System. That is, this is water imported into this Planning Project Area. This cannot be considered as a source by itself to solve the growth problems of South Kohala, but it may be integrated into a long range plan as discussed later.

Perched Water: There is doubtless perched water in South Kohala as there is in North Kohala. Except for the exploratory Kahua well mentioned above, records that we have consulted do not show any significant efforts to identify and exploit it. It seems likely that the reason for this lies in the fact that promising soil and ash bed outcrops are more difficult to find and evaluate in South Kohala. For the present, this resource must remain in the conjectural class.

High-Level Water: As has been discussed previously, it is known that there is high-level (dike confined) water under the crest area of Kohala Mountain. This water forms the principal resource of the Hamakua and North Kohala areas, largely because nature in eroding the major windward canyons and valleys created a condition where high-level water is relatively easy to exploit. It is otherwise in the South Kohala portion of the Kohala Mountain crest.

Any development of the Kohala Mountain high-level water from the southerly slopes poses economic problems of sizeable magnitude and would involve considerable risk. In addition, the development of such water might reduce the historic flow of the Lower Hamakua Ditch, and could raise legal questions of water rights.

Quite apart from proposals for further high-level water development in the Hamakua and North Kohala areas, several proposals have also been made for such development in the South Kohala area, namely in the crest area above Waimea Village.

Stearns suggested a drilled well in the general vicinity of the present 60 MG Waimea Reservoir. Douglas (Bureau of Reclamation Report, "Waimea Plain Project, Island of Hawaii, 1948") proposed a horizontal tunnel some six miles long at about the 2,000-foot level starting at a point five miles west of the Post Office at Waimea Village and heading N 25° E under the heavy rainfall area. Wentworth ("Additional Water Supply Prospects for the Waimea Plain, Hawaii, 1955") recommended a test-well drilling program above Waimea Village to obtain hydrological information, but expressed considerable doubt that large amounts of water could be developed by tunneling in the Kohala Mountain dike complex at or above 2,000 feet in elevation.

During World War II, the U. S. Marine Corps drilled a well (No. 3) on the grounds of the CCC Camp in Waimea Village from ground level to a depth of 885 feet (the bottom being at approximately 2,000 feet above sea level) without encountering water. The results of this well together with the known elevations of springs issuing from the sides of the Honokane Canyon and the several canyons feeding the Lower Hamakua Ditch indicate that the water table in the southerly slopes of the Kohala Mountain is well below 3,000 feet in elevation and probably below 2,000 feet.

Any attempt to develop the high-level dike-confined waters of the southerly portion of the Kohala Mountain whether by wells or tunnels will be accomplished with considerable risk, even if preceded by test-well drilling. The cost of test-well drilling for this purpose would be high because of the depth of necessary holes and difficulty of access. Even if water in adequate quantity was found, the cost of developing and delivering such water might be prohibitive.

Stearns reports that two springs (No. 22 and No. 23) located at an elevation of about 3,550 feet in the southwest rim of Kawainui Canyon (a branch of Waipio Valley) produce an estimated dry-weather flow of one million gallons of water per day. This water now flows into the Lower Hamakua Ditch. Since they are not readily accessible their flows have not been measured. While available information indicates that these sources would not produce sufficient water to meet the total projected needs of South Kohala (1980), they could serve to supplement other developed sources.

The cost of developing these springs, constructing some five miles of pipeline, access road, pumping plant and power line are estimated at about $400,000. The delivered water cost, including amortization of the construction costs and pumping expenses, would be about 20 cents per thousand gallons of water exclusive of charges that might be made for purchasing the water.

Since the springs are located on Bishop Museum lands, the water rights may be assumed as being legally owned by the Trustees and subject to the provisions of the lease in favor of the Hawaiian Irrigation Company, Ltd. While the water of the springs might be diverted "upstream" on government land by tunneling or by drilled or dug wells, the water rights under Hawaiian law would presumably remain with the Bishop Museum. Inasmuch as the Hawaiian Irrigation Company, Ltd. is as stated presently investigating means for obtaining more water for the Ditch, the Company might not look with favor on the diversion of this water to South Kohala. It also raises a question of propriety in taking water now used beneficially for agricultural purposes and diverting it to domestic use.

High-level ground water of the Kohala Mountain is, therefore, not thought to be a feasible source of water for development to meet the projected 1980 domestic water requirements of South Kohala.

Basal Water: The known geology of the area suggests that rainfall might reach basal bodies of water by two means of travel.

First, rain falling on exposed areas of permeable Kohala (Pololu series) basaltic flows located in the southwesterly portion of the Kohala Mountain slopes can be presumed to infiltrate to basal water bodies and flow out to the sea in the Kawaihae Harbor area. While the rainfall in this area is relatively light, some ground water might be contributed by adjacent ground-water areas.

The second, and more likely, is basal water in Mauna Kea (Hamakua series) basaltic flows. It will be recalled that Hamakua lavas are quite permeable and occurred later than the trachyte-andesite shield of Kohala Mountain which they buried.

It is therefore reasonable to assume that rain water which infiltrates the Hamakua lavas will tend to flow down the surface of the underlying Kohala Mountain shield. Such water, either from rainfall on Hamakua lavas or led into them from Kohala Mountain by the shield should accumulate as basal ground water at and just beyond the sea-level intersection of the Hamakua lavas and the Kohala Mountain shield. The watershed for this basal water body is the entire area inland of the Kawaihae-Puako shoreline extending to the Mauna Kea Mountain slopes east of Waimea and including the southerly slopes of Kohala Mountain.

In the lower portion of this area the rainfall is very light with annual precipitation averaging only about ten inches near the shoreline. Very little if any of such light rainfall could contribute to a basal water body. In the inland part of the watershed near the easterly end of Waimea Village on the other hand, the annual mean rainfall increases to about 40 inches. This heavier annual rainfall, while quite moderate, produces some stream runoff and ground water infiltration, particularly during infrequent periods of heavy rainfall.

On the southerly slopes of the Kohala Mountain, however, rainfall is much higher and reaches a maximum of about 135 inch a year. This heavy annual rainfall produces both visible surface runoff (perennial streams) and ground water infiltration.

An extensive 1960 study of this watershed by the present authors, based on measured stream discharges and estimated rainfall infiltration (after allowing for transpiration and evaporation), indicated a total annual rainfall contribution to the basal water supply equivalent to between 25 and 50 million gallons a day. If only a portion of this water were recoverable, it would meet the projected needs of the South Kohala area, particularly the lower elevation lands where pumping costs would be within economic limits.

Also, when the State's Upper Hamakua Ditch system is put into full operation the water used for irrigation, which is not evaporated from the ground surface or transpired by vegetation, will percolate to the water table. This infiltration increment, while quite small, will nevertheless add to the basal water supply.

Two recent wells have been drilled to exploit this basal water.

An exploratory well just north of the Waimea-Kawaihae Highway was drilled by the State Department of Land and Natural Resources at an elevation of 600 feet above mean sea level and some 8,000 feet inland of the shoreline. This well showed a very small drawdown (about 1/3 foot) at a pumping rate of 175 gpm. The chlorides averaged about 300 ppm and the water temperature was found to be 81°F.

A more recent well by the same Department was drilled about midway between Kawaihae Harbor and Puako. The well is located about 6,000 feet inland of the shoreline at an elevation of approximately 392 feet. A pumping test of the well at approximately 185 gpm showed little or no drawdown but higher chlorides (500 ppm) than the first exploratory well. The temperature of the water was 77°F. The static level of the water is between three and five feet above mean sea level as compared to 3^+ feet at the first exploratory well.

While neither of these two exploratory wells can be considered as more than partial successes, further exploration appears warranted because of the probable existence of basal water of acceptable quality inland of the shoreline. Such water, if it can be developed, would have a high potential value for supplying future needs of this area. It would seem that the most favorable locations for developing basal water might be either a site in the Hamakua lavas inland of Puako or in the Pololu lavas just north of Kawaihae Harbor.

Before drilling further exploratory wells, however, it is suggested that a comprehensive survey of the shoreline be made to determine where the greatest outflow of basal water to the sea occurs along the Kawaihae-Puako shoreline. Such an investigation should provide information to indicate the most favorable sites for locating wells inland of the shoreline, inland, that is, at sufficient distances to preclude undue tidal mixing of the floating fresh water with the underlying salt water.

While the amount of ground water that may be developable in this area is at present unknown, the well adjacent to the Waimea-Kawaihae Highway can provide an estimated 200,000 gallons of water a day. Although it is somewhat brackish, it can be used satisfactorily if mixed with the low chloride stream water as is planned. Accordingly, water from this well is included as part of the required water diversions for meeting the future water demands of South Kohala. It is assumed that this well water would be used solely to meet peak demands by supplying 0.2 mgd for the maximum day, 6.0 mgd for the maximum month and 12.0 mgd on an annual basis.

Surface Water: The several streams on the southerly slopes of the Kohala Mountain provide water sources which merit serious consideration for meeting the needs of South Kohala for the 1980 projection.

The two principal streams available for development are Waikoloa and Kohakohau, and a lesser stream, Hauani, all above and near Waimea Village. As heretofore noted, there is also an ungaged perennial stream on the westerly slopes of the Kohala Mountain north of Kawaihae Harbor. It is not believed that the flow of this latter stream is sufficient to warrant the cost of its development and conveyance in the initial development of water but it might be feasible for development in the future as a small supplementary source, particularly to serve the Mahukona area.

The mean daily flows, minimum monthly flows, minimum daily flows, and years of record for Waikoloa, Kohakohau and Haunai Streams as given on the following page.

STREAM DISCHARGES

	Mean Daily mgd	Minimum Monthly mgd	Minimum Daily mgd	Years of Record
Waikoloa (Marine Dam)	6.03	0.84	0.70	15
Kohakohau	7.04	0.28	0.18	6+
Hauani	1.21	0.001	0.00	6+
TOTAL	14.28	1.12	0.88	

The Waikoloa Stream has a better low water discharge than the Kohakohau Stream although the latter has a higher average annual discharge by approximately 1.0 million gallons per day. Estimated average diversions by Parker Ranch are 120,000 gallons per day from Kohakohau Stream and 160,000 gallons per day from Waikoloa Stream, both diversion points being above the existing measuring stations and therefore not included in the above tabulation.

The stream discharge figures show that the mean daily flow of 14.28 million gallons is sizeable but that minimum monthly and minimum daily flows are quite small. These extreme variations in flows are characteristic of many Hawaiian streams. It is also apparent that the minimum flows of the Hauani Stream over and above present diversions are so small, or non-existant at times, as to discourage the further development of this source of water as part of the South Kohala domestic water system.

The water of Kohakohau Stream is owned primarily by the Government since the watershed is situated almost wholly within Government lands. The water of the Waikoloa Stream, on the other hand, is derived from both Government and Parker Ranch Company lands. The legal rights to the water of the Waikoloa Stream were in part adjudicated in Carter v. Territory, 24 H. 47 (1917). The decree has not completely settled the rights of the respective parties so that the matter is somewhat uncertain today. An optimum development of the water of Waikoloa Stream (and to a lesser extent the Kohakohau Stream) through regulation of its discharge by means of storage would depend on a clarification of these water rights between the parties, either by agreement, legal action or otherwise. Since the Parker Ranch Company and the State are major landowners in the Waimea-Kawaihae area, both therefore having a vital interest in the development of these lands, it would appear that a mutually satisfactory agreement for the use of this water can be assumed.

Besides the aforementioned streams, water from various streams which originally flowed into the Waipio group of canyons is captured by the Upper Hamakua Ditch System described later. Since surface runoff is the source of this water, the flow of the ditch fluctuates widely from a few hundred thousand gallons to in excess of 40 million gallons a day in response to the effect of rainfall.

The Board furnishes domestic water (and some irrigation water) in South Kohala through its three interconnected systems. The three systems have a common source, Waikoloa Stream, where water is diverted and stored in three open reservoirs (capacity of approximately 15 MG) at about elevation 3,000 feet, just above and to the north of Waimea Village. Some water is also diverted from the Hauani Stream for domestic use in Waimea Village.

On the order of one-half million gallons of water is taken per day from the Waikoloa Stream below the Marine Dam gaging station. The stream discharge tabulation above includes this water. The exact amount of water so diverted is not known since there are no measuring devices on the Kamuela-Puako-Kawaiahe System except for the individual service meters. A part of this system water is taken from Hauani Stream but the quantity is quite small compared to Waikoloa Stream diversions and further development of water from Hauani Stream does not appear feasible. Hauani Stream's contribution to the system is not significant in the overall picture and will be disregarded in the following discussions of water for South Kohala.

The Upper Hamakua Ditch System was originally constructed by private enterprise in the period 1906-1910. It served the Hamakua Coast sugar plantations for cane fluming and other purposes until 1948 when the lease with the Territory expired. Subsequently, the State (Territory) Government has constructed a 60 MG storage reservoir, a 4.5 MG distribution reservoir and several miles of pipeline to make this water available to the Puukapu lands at Waimea Village and to the State's Lalamilo lands lying to the west and below Waimea Village.

The Board uses water from the Upper Hamakua Ditch System for its Ahualoa-Honokaa-Paauhau System which conveys the water to the service area located in the Hamakua area. To this extent water is conveyed outside the South Kohala watershed.

When the Ahualoa-Honokaa-Paauhau System was originally designed, it was planned that the Board would provide adequate storage to make unnecessary the taking of water from the Upper Hamakua Ditch during the several peak irrigation months. To provide storage, the Board has been using the old Puu Pulehu (Puukapu) Reservoir, installed and used when the system was in private hands. Since this reservoir leaks badly, the Board has been diverting many times over the quantity of water required to furnish the relatively small metered consumption in Hamakua of four million gallons per month. Considerable water loss also occurs in the open ditch and tunnel system used for conveying this water below the Waimea Reservoir to and some distance below the Puu Pulehu Reservoir.

The Board is now expanding this system to serve the upper homestead areas extending from above Honokaa to Paauilo. When this new addition is completed, the metered water consumption from the Ahualoa-Honokaa-Paauhau System is expected to increase to about 300,000 gallons per day, or a little more than double current consumption.

Some further consideration of the Puu Pulehu Reservoir is indicated. This reservoir had an original capacity of 250 to 300 million gallons. Its present capacity as a result of "silting" is somewhat reduced and may be more in the neighborhood of 200 million gallons. It has a large surface area and is somewhat shallow in places.

Because of its relatively large capacity, it has from time to time received considerable attention as a possible storage facility for either irrigation water or for domestic water. Its use by the Board has shown such high leakage losses as to make its use under present conditions very questionable. For this reservoir to be of any real value, it would have to be rehabilitated and made reasonably watertight. It is not known at present the extent of leakage or where it occurs. If the dam is the cause of the trouble, its repair might not be too expensive. On the other hand, if leakage is occurring through the bottom and/or the reservoir sides, the repair work might be excessively costly.

Since, in addition to the probable high cost of repairing this reservoir, it is located some six miles east of the Waikoloa

Stream Intake (in the opposite direction of the major part of the service area) at an elevation which would require the water to be pumped a minimum of 50 feet to get over the Waimea saddle, it does not appear to warrant serious consideration as a storage reservoir for inclusion in any proposed South Kohala domestic water system.

The State has recently opened up the first increment of its Lalamilo farm lots subdivision. This increment consisting of 25 lots ranging in size from 17 to 52 acres (total, about 500 acres) is now under partial irrigation. Current charges for water at Lalamilo based on acres cultivated are as follows:

Acreage service charge -- $2.25/acre/month

Water use charge -- 8¢/1,000 gals. up to 50,000 gals/mo.
7¢/1,000 gals. 50,000 to 500,000 gals/mo.
6¢/1,000 gals. 500,000 to 1,000,000 gals/mo.
5¢/1,000 gals. over 1,000,000 gals/mo.

The State's Upper Hamakua Ditch System presently supplies water to a portion of the first increment.

There is an additional area of some 500 to 600 acres in the upper portion of the State's Lalamilo lands which can be opened up for irrigated farming and considerably more good farming land in the Puukapu area which could be planted to irrigated crops.

With a water storage capacity of some 60 million gallons, this ditch system can provide water (approximately 3 mgd) for irrigating an estimated 1,000 to 1,500 acres. The actual number of acres that can be served by this system will depend on the type of crops grown, the locations of the acreages irrigated with respect to natural rainfall and the irrigation practices and methods used by the farmers.

The water of the presently developed Upper Hamakua Ditch System is fully committed by Legislative action to the planned irrigation program for the Waimea-Lalamilo area except for a "reasonable quantity" allotted to the Ahualoa-Honokaa-Paauhau domestic system. This Ditch System could be enlarged by the addition of more terminal reservoir storage as there is considerable surplus water available on an annual basis. Critical dry periods seldom extend over more than a few months and if more complete regulation of the flows of the Ditch were accomplished, additional water could be made available for either domestic or agricultural purposes.

Expansion of storage on such systems as this are more costly on a unit volume basis because low flows during dry periods are already committed to the initial storage facilities. For this reason, the construction of additional storage facilities on the Upper Hamakua Ditch System using surplus water not now committed is not particularly attractive. The regulation of the Waikoloa and Kohakohau Streams appears more feasible for the development of domestic water.

Discharge figures for the Waikoloa and Kohakohau Streams have been previously given. Figures 2 and 3 of this report show the respective duration-discharge curves for these streams. From these curves it can be seen that the flows are very low for a good percentage of the time. (Compare with Figure 1 which shows the more uniform flow that occurs in the Lower Hamakua Ditch which is supplied from springs issuing from dike compartments.)

It is apparent from the stream flow records of the Waikoloa and Kohakohau Streams, and their respective duration-discharge curves, that storage of stream water will be required to meet the projected water requirements for South Kohala. To determine what these storage requirements would need to be, an analysis of the stream discharges during the more critical historic dry-weather periods has been made. The three most severe low-flow periods are:

	Stream Discharges		
	Waikoloa Stream MG	Kohakohau Stream MG	Total MG
(1) Dec. 29, 1952 to Feb. 7, 1953 -- 41 days	39.5	9.9*	49.4
(2) Jan. 12, 1954 to Mar, 3, 1954 -- 51 days	52.1	13.0*	65.1
(3) Dec. 24, 1961 to Feb. 19, 1962 -- 58 days	79.2	19.2	98.4

* Prior to establishment of Kohakohau Stream gaging station - estimated at 25% of Waikoloa Stream flow.

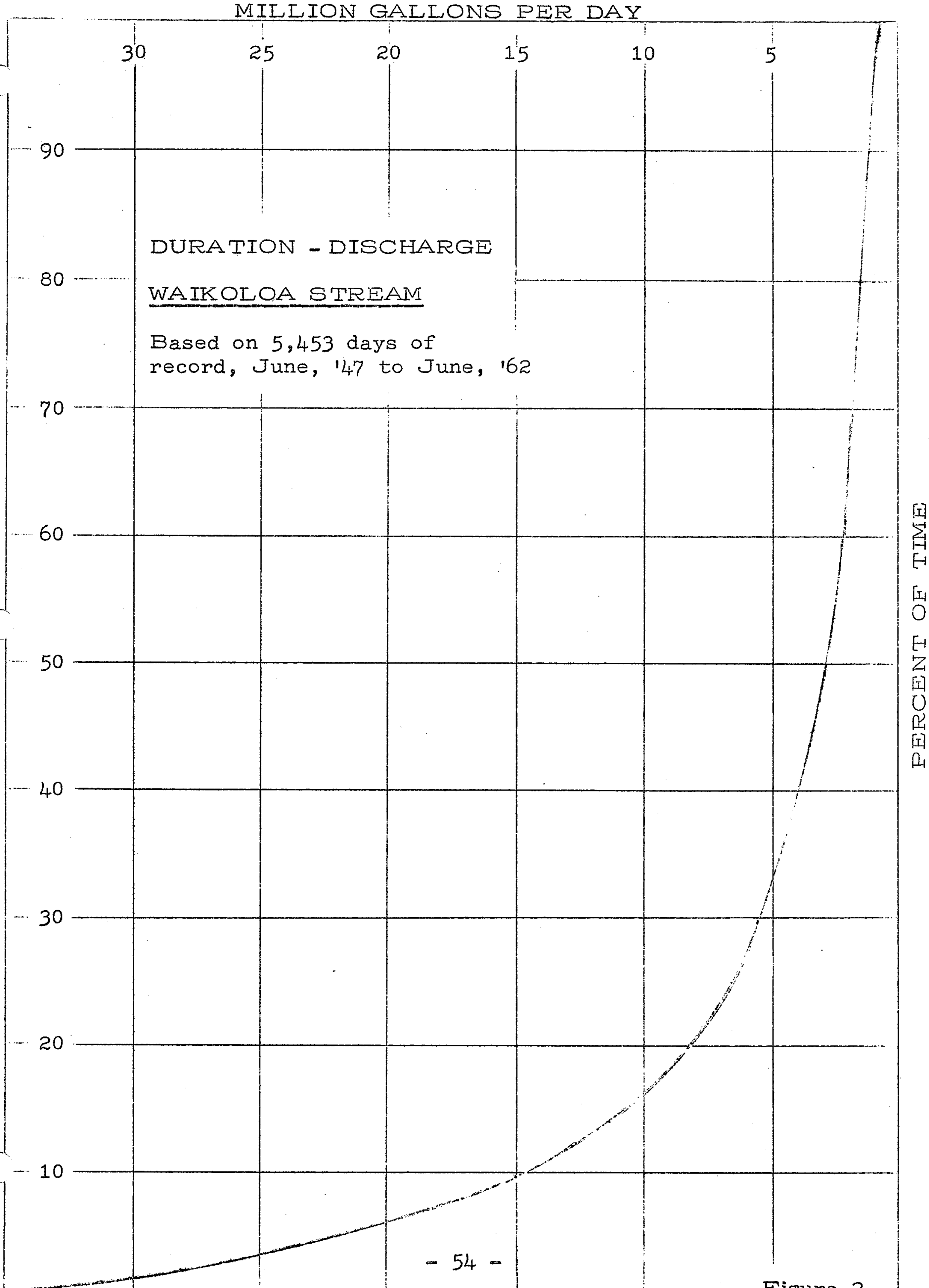
MILLION GALLONS PER DAY
30
25
20
15
10
5
90
80
70
60
50
40
30
20
10
DURATION - DISCHARGE
WAIKOLOA STREAM
Based on 5,453 days of
record, June, '47 to June, '62
PERCENT OF TIME

Figure 2

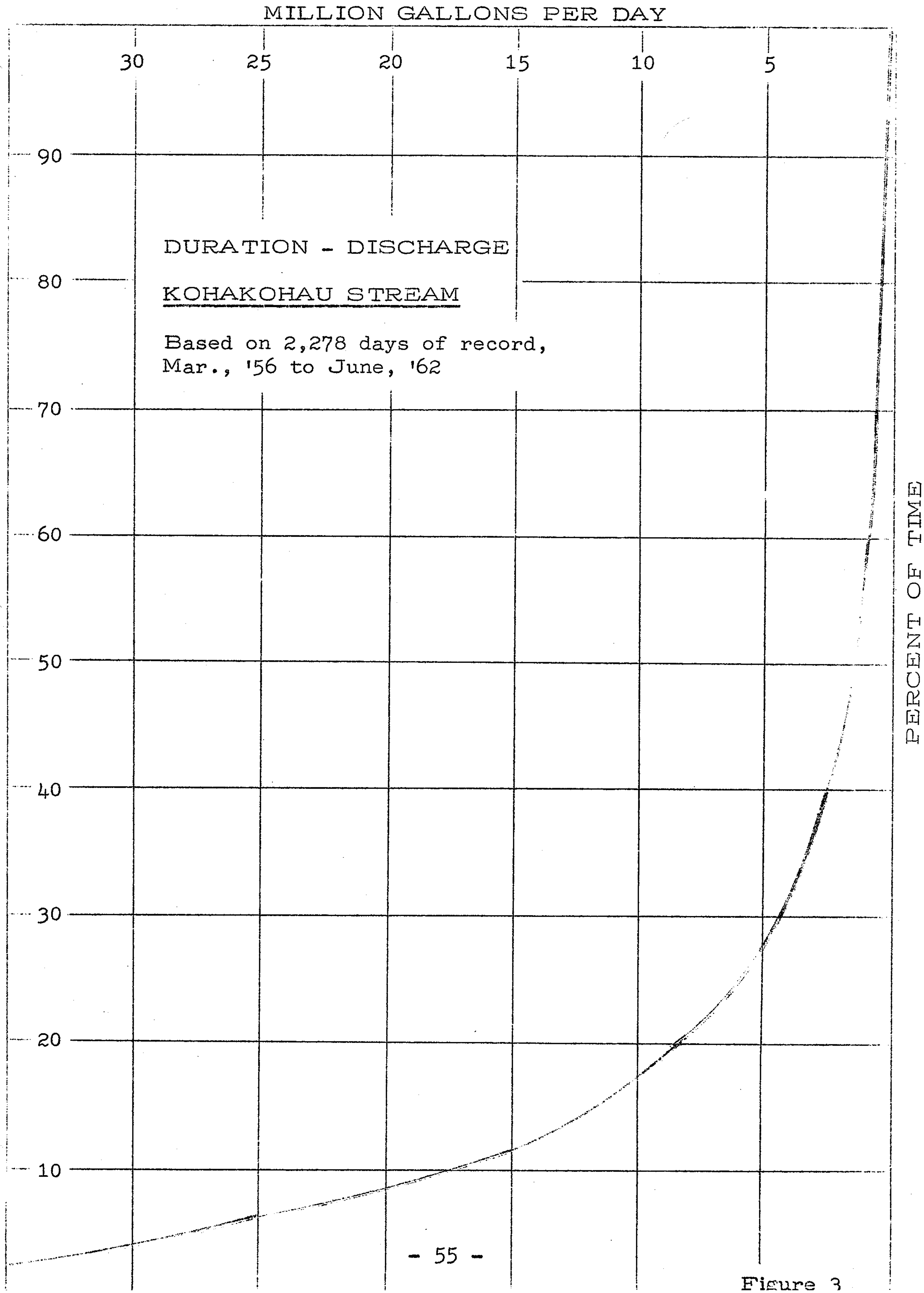
MILLION GALLONS PER DAY
30
25
20
15
10
5
90
80
70
60
50
40
30
20
10
DURATION - DISCHARGE
KOHAKOHAU STREAM
Based on 2,278 days of record, Mar., '56 to June, '62
PERCENT OF TIME

Figure 3

For purposes of meeting the 1980 maximum-month demand, the 51-day period from January 12 to March 3, 1954 was the most critical. Using this historic record of low stream flow as representing expectable future dry-weather flows, the storage requirements for the Waikoloa and Kohakohau Streams can be determined. The 51-day water production requirements, based on the maximum-month demand rate would be 146 million gallons. Of this amount, 65 million gallons would be divertable from the Waikoloa and Kohakohau Streams. The balance of 81 million gallons would have to come from storage. Allowing for evaporation and leakage losses in the reservoirs of 0.3 percent of storage capacity per day, the calculated total storage required would be 95 million gallons.

Existing storage reservoirs have a capacity of 15 million gallons. These reservoirs, with possibly some rehabilitation work, could be utilized. Thus, the new storage required would be 80 million gallons.

Various sizes and types of reservoirs might be constructed to achieve this total storage quantity. Any plan finally adopted for reservoir construction will necessarily depend on detailed engineering studies and a program for incremental construction to meet water demands.

For the purposes of this planning report, the construction of four 20-million gallon reservoirs is proposed.

These reservoirs would be balanced cut and fill type, square in dimension, uncovered and lined with one-half inch thick asphalt planks. Experience in Hawaii has shown that this type of lining provides "watertightness" at reasonable cost.

Estimated costs of construction are shown in Table 2.

It is contemplated that the water diverted from these streams would have to be filtered to remove the esthetically unattractive "tea color". For this purpose, a rapid sand filter with alum or other coagulant is included in the cost estimates.

The annual cost of providing this stream water, exclusive of operating costs, is calculated on an amortization period of twenty years for the asphalt lining and fifty years for all other construction at an interest rate of four percent.

The computed annual cost is $86,755 which, based on a yearly metered water use of 822 million gallons (1980), is equivalent to $106 per million gallons or 10.6 cents per thousand gallons.

This estimated cost is reasonable and justifies the construction of the proposed facilities to meet the water requirements for the projected population as developed in this planning project.

Cost estimates in Table 3 (and elsewhere herein) are approximate only. No field investigations or detailed designs have been made as would be required to make firm estimates of construction costs. The estimates given here, however, should serve as reasonable ones for planning purposes.

TABLE 3

COST ESTIMATES OF WAIKOLOA AND KOHAKOHAU WATER DEVELOPMENT

First Priorty	Estimated Costs
1- 20 MG Reservoir - Waikoloa	$ 240,000
2- Rehabilitation of existing reservoirs (15 MG)	20,000
3- Rapid sand filter - nominal capacity, 20 mgd (expandable to 4.0 mgd)	350,000
	$ 610,000
Second Priority	
4- 20 MG Reservoir - Kohakohau	$ 240,000
5- Two 20 MG Reservoirs - Waikoloa	480,000
6- 8-inch Pipeline - Kohakohau to Waikoloa	73,500
7- 12-inch Pipeline - Waikoloa to Mamalahoa Highway	55,000
8- Addition to rapid sand filter to provide capacity of 4.0 mgd	150,000
	$ 998,500
TOTAL	$1,608,500

The above cost estimates are based on 1962 prices and include allowances for engineering and contingencies.

The above estimates of storage required, construction costs and amortization costs are based as stated, on supplying the total estimated domestic and resort water needs for South Kohala by the year 1980 (exclusive of water from the existing State drilled well). To the extent that additional basal water may be developed in the Kawaihae-Puako area, the storage facilities for the Waikoloa and Kohakohau Streams can be reduced. The pumping and amortization costs of supplying basal water from drilled wells should total about 15 to 20 cents per thousand gallons. The exact cost will be dependent upon the depth of the wells, quantity of water pumped and average monthly rate of pumping. While this cost is higher than that found above for the diverted stream waters, the difference would be offset by the savings in transmission line costs. The development of basal water, if possible, to serve the lower elevation lands is therefore desirable.

WATER TRANSMISSION

It is not possible at this time to predict with any degree of assurance where the projected five-fold increase in population in South Kohala by 1980 will take place. There are a number of plans for developing hotels and residential sites in South Kohala at various stages of completion. Some of these are very tentative at present and may be revised considerably. Under the existing status of such planning, no valid estimates of sizes and costs of water transmission facilities can be maue.

The present Waimea-Kawaihae pipeline with an approximate capacity of 850,000 gallons per day is quite adequate for existing requirements but will undoubtedly be too small before 1980 to meet expected increased demands. The expected developments at Kaunaoa and Hapuna beaches suggest the need of a transmission main of adequate size to extend along the shoreline from Kawaihae to Puako. To provide a two-way feed to Hapuna and Kaunaoa beaches, and permit extension of a water line wouth of Puako, another high-pressure line, more or less paralleling the existing pipeline, from the Waimea-Kawaihae transmission line to Puako would appear desirable.

Based on the (uncertain) plans for future development in the South Kohala area, it would appear that the following principal transmission pipelines and storage facilities might be required: (1) 50,000 linear feet of 8-inch diameter pipeline from Waimea Village to Kawaihae ($475,000); (2) 18,000 linear feet of 8-inch and 6-inch diameter pipeline from Kawaihae (Waikui) to Puako ($190,000); (3) 20,000 linear feet of high pressure pipeline from the Waimea-Kawaihae transmission line to Puako as a primary feeder line ($140,000); and (4) a 1.0 MG concrete tank at Kawaihae (Waikui) and a 0.5 MG concrete tank at Puako for pressure regulation and emergency storage ($215,000). The estimated costs total $1,020,000.

The extensive shoreline between Puako and Kailua-Kona has a number of bays and seaside areas which offer some attraction for recreational, resort and residential development. This area is, however, now largely inaccessible and development appears to be some years in the future.

The probable ultimate solution to the water supply problem of this coastline is the gradual extension of both the Kailua-Kona and Kawaihae-Puako systems towards Kiholo Bay, constructed following, or more or less concurrently with, the proposed new shoreline highway. This should be considered as a long-range plan to be undertaken when firm development plans justify the construction of these water system extensions. Since this coastline is relatively long, such a transmission line would need a series of booster pumps and small storage tanks to provide proper water service. An alternate method would be to install a high-level transmission line with feeder lines and pressure breaker tanks at each area of development. The facilities to serve this area cannot be planned at this time but will depend on the pattern and rate at which development takes place.

The shoreline from Kawaihae Harbor to Mahukona and beyond to the North Kohala area offers some prospects for future development. Water for Mahukona might be provided from either the Waimea-Kawaihae system or, as stated in the previous Section, from North Kohala. The extension of either of these two systems to Mahukona likely will depend on which of the intervening areas is first developed, thus, making more practical the extension of one or the other water systems.

Pending the time that complete transmission lines are constructed along these coastlines, (Puako to Kailua and Mahukona to Kawaihae or North Kohala) demineralization of brackish or sea water for isolated and restricted developments may be feasible. Elsewhere in the State, it has to date been found more practicable to construct long transmission pipelines to convey water from suitable watersheds to dry areas than to demineralize brackish or sea waters.

SUMMARY

From the above study, the following major conclusions appear to be supportable: (1) Under proper conditions of development, the area is self-sufficient in water resources for the planning period and the development projections; (2) Irrigation water for about 1,000 to 1,500 acres can be provided from existing facilities; (3) New water developed for domestic use will probably be too expensive for further expansion of irrigated farming; (4) Water for domestic and resort development should be developed from streams near Waimea Village; (5) To 1980 this would require four new 20 MG reservoirs to be built as required; (6) This water would cost at 1980 consumption rates, under 11 cents per

1,000 gallons in the reservoir; (7) New cost of transmission facilities for this water to 1980 might total just over $1,000,000 in capital outlays; (8) Because of this, basal water developed in the shore area would be advantageous; (9) Despite present disappointments, there is reason to believe that such basal water can be successfully exploited; and (10) A program of investigation is recommended.

D R A I N A G E

D R A I N A G E

Occasional heavy rainfalls create drainage and flood problems in the planning area. While heavy downpours of rain may occur as often as once or twice a year, serious flooding occurs less frequently. The most critical area, Puukapu watershed in Waimea, has had flood conditions of varying intensities eight times during the last twelve years.

The Hamakua coastal area is noteworthy for its many gulches originating in the Mauna Kea slopes and extending downward to the sugar cane lands and to the coastal highway. Most of these gulches represent individual and separate watersheds. They vary in size and water carrying capacities and hence in flooding characteristics. Many of them have in the past, when subjected to heavy local rainfall, caused flooding problems of varying proportions to the cane lands and to the highways. Because of the many watersheds that potentially can create flooding conditions under heavy local rainfalls, the control of flood damage along the Hamakua Coast at the present time is of doubtful economic justification.

A study to determine what corrective measures might be taken and an estimate of their costs compared to historical records of flood damage in the Hamakua coastal area would provide the necessary information to determine the economic feasibility of such a program. It is understood that some reconnaisance type studies have been made by the U. S. Soil Conservation Service although no specific determinations have been reached relative to more detailed investigations.

At Waimea Village, flood damages over the years in the Puukapu watershed have been frequent and extensive. The average annual damage to crops, land, roads and utilities is estimated at $41,250. Flood damage in 1958 was particularly bad when some 958 acres were flooded. Agricultural damage amounted to $147,020 and non-agricultural damage was $39,360, or a total of $186,380.

The areas in or adjacent to Waimea Village subject to flooding by the Waikoloa Stream, its tributary Lanimaumau Stream, and other unnamed drainageways above Mamalahoa Highway, include principally the farm and ranch lands south of Mamalahoa Highway and along Kahilu Road, Kuhio Village and the westerly end of Waimea Village extending to Lalamilo. Depending on the intensity and areal distribution of rainfall, all or only a portion of this total area may be flooded at any one time.

Currently, the planning of a flood control project for the Puukapu watershed is underway, having been authorized in August of 1962. Actual construction work is to begin about July 1, 1963. The project is being carried out under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress, 68 Stat. 666) as amended. The U. S. Soil Conservation

Service made the feasibility study and will prepare the plans for construction. The State Department of Land and Natural Resources will be the contracting agency. The estimated total cost of the project is $849,520, of which $595,390 will be contributed by the Federal Government (P.L. 566 Funds) and the balance will be by the State and other local agencies and benefitted individuals. The locations of the proposed dikes and water storage areas are shown on one of the planning maps of the overall report.

SEWAGE AND WASTE DISPOSAL

SEWAGE AND WASTE DISPOSAL

The Planning Project Area, being primarily agricultural in nature, has a total population of only 13,288 persons (1960) living for the most part in small communities, camps and on homesteads, where domestic sewage or industrial waste treatment plants have not been required. Except for sewage and industrial wastes discharged into the sea through outfall sewers, such wastes are disposed of locally on an individual residence basis mostly by means of cesspools.

Although there may be come isolated and localized problems associated with the prevailing method of sewage disposal in this area, none of a serious enough nature is known which might require more sophisticated methods of disposal. This is borne out by the fact that the State Department of Health has not proposed any studies for this area to determine sewage treatment plant needs.

The locations and other data of the various ocean outfall sewers along the Hamakua Coast are shown in Table 4.

As can be noted from Table 4, all the outfall sewers discharge domestic sewage or sugar mill wastes into the sea without prior treatment. Inasmuch as this is a somewhat sparsely settled coastline and the outfall sewers discharge from steep coastline cliffs, no serious public health problems are involved.

TABLE 4

Location	Owner or Community Served	Population Served	Industrial Waste	Treatment	Measured or Estimated Avg. Daily Flow MGD
Hakalau	Hakalau Sugar Company	---	Sugar Mill	None	8
Hakalau	Hakalau Sugar Co. Camps	570	---	None	0.225
Ookala	Kaiwiki Sugar Company	---	Sugar Mill	None	2
Ookala	Kaiwiki Sugar Co. Camp	400	---	None	0.075
Paauilo	Hamakua Sugar Company	---	Sugar Mill	None	3
Paauilo	Hamakua Sugar Co. Camps	550	---	None	0.10
Paauhau	Paauhau Sugar Co.	---	Sugar Mill	None	2
Paauhau	Paauhau Sugar Co. Camps	550	---	None	---
Honokaa	Honokaa Sugar Company	---	Sugar Mill	None	3
Honokaa	Honokaa Sugar Co. Camps	550	---	None	0.1
Halaula	Kohala Sugar Company	---	Sugar Mill	None	---
Halaula	Kohala Sugar Co. Camps	1000	---	None	---

(Above data taken from 1957 Inventory -- Municipal and Industrial Waste Facilities -- U. S. Department of Health, Education and Welfare.)

On the other hand, the disposal of the mill wastes, including as it does much floating "bagasse," presents waste problems which affect fishing, navigation and in some instances swimming or potential swimming areas. The disposal of sugar mill wastes in the ocean has long been a problem in Hawaii. Many plantations have made the required corrections to their waste disposal methods where such wastes created particularly bad conditions, especially near populated coastlines. It can be assumed that all, or nearly all, untreated disposal of sugar mill wastes in Hawaii will be corrected in time. The correction of each such problem must take into consideration the seriousness of the ocean-disposed waste and the economy of the sugar plantation involved.

The present methods of individual cesspool disposal of sewage within the Planning Project appears satisfactory, or at least not unsatisfactory. The construction of sewage treatment plants or ocean outfall sewers to serve projected population increases in the North Kohala and South Kohala areas does not now appear necessary except for hotels and concentrated housing developments, particularly in the South Kohala area.

The extent that treatment plants may be needed cannot be determined until more information is known of the population to be served and the type and concentration of such developments. In some instances it may be possible to dispose of the untreated sewage through outfall sewers in the ocean. A comprehensive study of the offshore ocean currents, wind affects and other factors would need to be investigated in each instance to determine the feasibility of ocean disposal of sewage without treatment.