EXECUTIVE CHAMBERS
HONOLULU

BENJAMIN J. CAYETANO
GOVERNOR

April 15, 1996

Mr. Milton D. Pavao, Manager
Department of Water Supply
County of Hawaii
25 Aupuni Street
Hilo, Hawaii 96720

Dear Mr. Pavao:

With this letter, I accept the Final Environmental Impact Statement for the Kohala Water Transmission System, North and South Kohala, the Island of Hawaii, as satisfactory fulfillment of the requirements of Chapter 343, Hawaii Revised Statutes. The economic, social and environmental impacts which will likely occur should this project be implemented are adequately described in the statement. The analysis, together with the comments made by reviewers, provides useful information to policy makers and the public.

My acceptance of the statement is an affirmation of the adequacy of that statement under the applicable laws but does not constitute an endorsement of the proposed action.

I find that the mitigation measures proposed in the environmental impact statement will minimize the negative impacts of the project. Therefore, if this project is implemented, the County of Hawaii, Department of Water Supply and/or its agents should perform these or alternative and at least equally effective mitigation measures at the discretion of the permitting agencies. The mitigation measures identified in the environmental impact statement are listed in the enclosed document.

With warmest personal regards,

Aloha,

Benjamin J. Cayetano

BENJAMIN J. CAYETANO

Enclosure

c: Lawrence Miike
✓ Office of Environmental Quality Control

ATTACHMENT TO ACCEPTANCE LETTER FROM GOVERNOR BENJAMIN CAYETANO TO MILTON PAVAO REGARDING THE KOHALA WATER TRANSMISSION SYSTEM ENVIRONMENTAL IMPACT STATEMENT MITIGATION MEASURES

The following list of mitigation measures identified in the final environmental impact statement will minimize the negative impacts of the project. If the project is implemented, the Department of Water Supply and/or its agents should perform these or alternative and at least equally effective mitigation measures at the discretion of the permitting agencies.

Phase I - Construction Impacts

Air Quality

The Department of Water Supply must follow best management practices to control dust in construction areas. These measures may include watering exposed dry soil areas and roadways, covering trucks hauling dusty material, erecting dust screens, and installing landscaping in completed open areas as soon as feasible.

Visual

The design of the collection and pressure-breaker reservoirs must be sensitive to visual aspects. To soften their appearance in the region's vistas, the Department of Water Supply must finish the reservoir structures in earth tone colors and landscape the sites appropriately.

Landforms

Pipe trench excavations will temporarily alter the existing terrain. The Department of Water Supply must ensure that the trenches are backfilled and returned to their original grade and condition.

Water Resource

System pumping is expected to begin at 5 or 6 mgd and build up to 10 mgd in 10 to 15 years. To assure that the water withdrawal would not adversely affect the aquifer, the Department of Water Supply must closely monitor water levels and quality and other elements during the Phase I operation. The monitoring records are essential in determining if any corrective action should be taken to maintain the integrity of the aquifer.

Water Quality

The Department of Water Supply must comply with Best Management Practices as approved through the National Pollution Discharge Elimination System (NPDES) permit process for controlling storm runoff during construction.

Archeological and Historical Remains

Site 19775, a probable burial platform, must be preserved by realigning the access road. The Department of Water Supply must realign the access roadway in such a way to avoid the site and provide an acceptable buffer. In addition, to facilitate any alignment changes during construction of the access roadway for the pressure breaker reservoir and Kawaihae terminal reservoir, the Department of Water Supply must have an archaeological monitor present to avoid impacting any archaeological features.

Phase I - Operational Impacts

Air Quality

The Department of Water Supply must obtain the appropriate Air Pollution Control Permit from the Hawaii Department of Health to operate the diesel-fueled generators.

Noise

In view of the proximity of the well sites to residential areas, the Department of Water Supply must design the generator enclosure or surround to have sufficient quieting measures to keep the noise level of the diesel-fueled power generators at equal to or lower than the ambient background noise at the nearest residential areas during the most quiet hours, before sunrise. The Department of Water Supply must ensure that the proposed submersible type pumps for use in the wells will not produce any audible noise at the surface.

Project Financing

The Department of Water Supply must prepare and submit a project financing proposal to the Hawaii County Council. The Department of Water Supply must not implement this project until developments subscribing to water from the water system commit to pay facility charges (to cover the capital costs of the system), in accordance with the financing proposal.

Phase II

The construction date for phase II has not been set and will only occur after the year 2000. Between now and then, especially during phase I implementation, pertinent information about primary and secondary impacts will be discovered. Therefore, if and when phase II is ready for implementation, the Department of Water Supply must prepare a separate environmental assessment to evaluate the remainder of this project.

Secondary Impacts

The Department of Water Supply must ask the Hawaii County Council and other relevant state and county agencies to explore and implement, if appropriate, the possible mitigation measures for secondary impacts listed below:

Mitigation for Housing. The State and County should focus efforts to provide private sector involvement in financing and developing housing in Kohala. This would include active designation and development of primary and secondary support communities to house employees working at resort areas.

Mitigation for Public Services. State and County agencies should carefully track potential growth in demand for services in Kohala. The agencies should be encouraged to plan for significant increases in demand for public services and facilities.

Mitigation for Recreation. The potential for outdoor recreation expansion and improvement in Kohala is great. State and County agencies should consider the following actions:

- Accelerated expansion of Hapuna Beach State Recreation Area.
- Creation of new coastal state parks.
- Expansion of County coastal parks.
- Encouragement of public park creation in all large private sector projects
- Vigorous action by the County and State to ensure access rights to and along the coastline consistent with state law. All private development projects should be evaluated for consistency with long-term access and trail programs at State and County levels.

- Actions to safeguard native Hawaiian gathering, fishing and hunting rights from direct or indirect encroachment because of continued development.

Mitigation for Social and Community Impacts. Whenever government agencies consider permitting conditions for proposed development in Kohala, due consideration should be given to the following:

- Policies that encourage the creation of jobs desired by Kohala residents, to be filled primarily by Kohala residents, in order to conserve to some degree the existing structure and generational continuity of Kohala.

- Support of affordable housing in order to retain housing opportunities for Kohala residents.

- The impacts of gated communities on the larger community.

- The involvement of all interest groups, and in particular the Hawaiian community, in planning decisions that will affect economic, social and land use patterns of Kohala.

- Continuing and expanded emphasis on Hawaiian culture in Kohala resorts.

1996 FEIS HAWAII
KOHALA WATER TRANSMISSION
SYSTEM

FILE COPY

COUNTY OF HAWAII
Department of Water Supply

FINAL ENVIRONMENTAL IMPACT STATEMENT

For

KOHALA WATER TRANSMISSION SYSTEM

North and South Kohala Districts
Island of Hawaii

FINAL

ENVIRONMENTAL IMPACT STATEMENT

FOR

KOHALA WATER TRANSMISSION SYSTEM

NORTH AND SOUTH KOHALA
COUNTY OF HAWAII

Proposing Agency:

DEPARTMENT OF WATER SUPPLY
COUNTY OF HAWAII

Submitted by:

________________________ Date: Nov. 22, 1995
Milton D. Pavao, Manager

Prepared by:
Megumi Kon, Inc.
Hilo, Hawaii

November 1995

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SECTION 1 - SUMMARY

1.1 PROPOSING AGENCY

Hawaii County Department of Water Supply
25 Aupuni Street, Hilo, HI 96720

1.2 ACCEPTING AUTHORITY

Governor, State of Hawaii
c/o OEQC, 220 South King Street #400, Honolulu HI 96813

1.3 DESCRIPTION OF PROPOSED PROJECT

The purpose of the proposed Kohala Water Transmission System project is to provide a high quality and reliable potable water supply that would meet the estimated future needs of North Kohala and coastal area of South Kohala, including the Kawaihae Hawaiian homestead tract. The project would be carried out in two phases. See **Figure 3.3-1 on page 3-4** for map showing the system.

Phase I would consist of 6 wells at 3 sites located mauka of the Hawi-Niulii Highway in the Halawa area with total pumping capacity of 12 mgd (2 mgd to be for standby). Pumped water from the supply wells would be collected through a pressure-main located mainly on Pratt Road and transmitted to two 3.0-million gallon (mg) collection reservoirs situated mauka of Akoni Pule Highway near Puakea Ranch. From these reservoirs, a 36-inch diameter main that follows Akoni Pule Highway, Kawaihae Road, and Queen Kaahumanu Highway would transport the water by gravity flow to a 1.0-mg pressure-breaker reservoir in Makiloa , then to three 1.0-mg terminal reservoirs located in Kawaihae, Kauanoa, and Lalamilo.

Phase I would also include the connection of the proposed supply well system to the existing North Kohala water systems through new pipelines and booster stations. The installation of pumps at one well at the DWS Hawi site and one well at a Makapala site would be completed as part of the proposed supply well system (or earlier if funds become available).

In the event the utility company (HELCO) is not able to service the power needs of the Phase I supply pumps, the DWS is prepared to provide the needed power through use of portable diesel-fueled generator at each well site. The generators would be used until HELCO service becomes available.

Phase II would increase the supply well system by 6 wells at 3 sites located mauka of the Hawi-Niulii Highway. Two sites would be in the Makapala area and one site in the Honomakau area. The additional wells would have a total pumping capacity of 10 mgd. Also, included in Phase II would be one 6-mg collection reservoir at the Puakea site and one 1-mg terminal reservoir at Lalamilo.

1.4 SIGNIFICANT BENEFICIAL AND ADVERSE IMPACTS

1.4.1 BENEFICIAL IMPACTS

Many projected impacts would be considered by most parties to be beneficial, such as:

- **reliable supply** of all ground-water for North and South Kohala water systems that would be served by the proposed supply wells.
- **employment** during construction - potential for 1,480 full-time jobs during the two-year Phase I and 480 full-time jobs during the one-year Phase II. Of the total 1,960 jobs generated 914 or 46.6% would be on the island;
- **earnings** during construction - potential of $50.2 million in Phase I and $16.3 million in Phase II in income earnings by workers in construction and construction industry support activities; and,
- **government revenues** during construction - potential of $6.1 million in Phase I and $2.0 million in Phase II from excise tax and income tax revenues.

More important than these economic impacts during construction, however, are the secondary economic impacts that would be produced by resort construction and operation, by housing construction, and by visitor and resident spending, such as:

- **employment** - direct and indirect potential resort hotel cumulative employment ranges between 1,000 and 6,000 permanent jobs by the year 2014, and between 2,000 and 11,000 jobs by 2024. These figures do not include resort and housing construction, which are expected to require as many as 20,000 labor years.
- **earnings** - direct and indirect potential resort hotel operations worker earnings range between $220 and 541 million by year 2014, and between $393 and $927 million by year 2024. Worker earnings from construction of the resorts would have a wide range from a low of $1.3 billion to a high of $1.6 billion over the next 20 years.
- **benefit/cost ratios** which average over 4:1 would be associated with annual state and county revenues. Under the Historical Trend scenario, by year 2020, these revenues are projected to rise to over $300 million and $100 million, respectively.

1.4.2 NEUTRAL AND MIXED IMPACTS

Other impacts might be considered neutral, such as population growth, which engenders a number of side-effects both desirable and undesirable. Approximate population increase estimates range from as low as 6,000 by the year 2010 (and 11,000 by 2020) under the **Historical Trends** scenario to as high as 12,000 by 2010 (and 26,000 by 2020) in the **As-Planned** scenario. Most of the population increase in the **Historical Trend** scenario is derived from in-migration of workers, while new residents of the Hawaiian Homes project at Kawaihae account for 90 percent of the growth in the **As-Planned** scenario.

Another category of impacts may be regarded as "mixed," i.e., beneficial or adverse depending upon the standpoint or taste of the observer, such as changing the ethnic makeup or encouraging development opportunities in areas previously impractical.

1.4.3 ADVERSE IMPACTS

The following impacts would be considered by most observers to be adverse:

- Potential for housing shortages for workers (and families) drawn to Kohala for jobs;
- Potential for government infrastructure to fall behind the demand created by project-driven population growth;
- Potential for crowding of recreational areas;
- Potential for increased polarization of Kohala residents into two social groups based on income, which might also coincide with ethnic and cultural identity;
- Potential for social change that might promote the decay of traditional Hawaiian culture and values;
- Potential for undesired effects of property value increases, including property tax increases for individuals on fixed incomes, and the possibility that children of current residents would have to relocate out of Kohala to find affordable housing.

These potentially adverse effects are wholly or largely mitigable through government regulation of development activities that employ water from the proposed project.

1.5 PROPOSED MITIGATION MEASURES

The following measures are suggested to mitigate adverse impacts:

Housing. Included in State policies pertaining to resort development are strategies to cluster resorts in "Resort Destination Nodes" of Mauna Kea and Mauna Lani/Waikoloa within Kohala. These nodes would provide employment centers around which the State and County could focus efforts to supply economic incentives for private sector involvement in financing and developing social and physical infrastructure systems.

Property Tax. Affected individuals and communities could be targeted by County tax policies sheltering them from the undesirable side effects of property tax increases, within the limits of fairness to other County residents.

Public Facilities and Infrastructure. It is essential for the maintenance of adequate public services and facilities in growing regions that State and County agencies carefully track potential growth. The proposed project has substantial potential to greatly increase demand for these. It is beyond the scope of this document to recommend individual projects for consideration.

Recreation

- Accelerate expansion of planned State and County parks (e.g., Hapuna Beach State Recreation Area and Kapaa Beach Park) to anticipate demand;
- Create new coastal state parks, e.g., Pololu/Akoakoa State Park;
- Encourage public park creation in all private sector projects of sufficiently large size;

- Vigorous action by the County and State to ensure access rights to and along the coastline consistent with State law; and,
- Encourage actions to safeguard native Hawaiian gathering, fishing, and hunting rights from direct or indirect encroachment as a result of continued development.

Social/Community Impacts. Mitigation measures sometimes suggested for socioeconomic impacts are complex, controversial and often unrealistic. For the purposes of this document, it is simply suggested that whenever government agencies consider permitting conditions for proposed development in Kohala, that due consideration is given to:

- Policies that encourage the creation of jobs desired by Kohala residents, to be filled primarily by Kohala residents, in order to conserve to some degree the existing structure and generational continuity of Kohala;
- Support of affordable housing to retain housing opportunities for Kohala residents;
- The impacts of gated housing communities on the larger community;
- The involvement of all interest groups, and in particular the Hawaiian community, in planning decisions that will affect economic, social and land use patterns of Kohala; and,
- Continuing and expanded emphasis on Hawaiian culture in Kohala resorts.

1.6 ALTERNATIVES CONSIDERED

The following alternatives to the proposed project were considered by the Department of Water Supply.

- Alternative 1 was to participate in a proposal to recover and transport water from east Hawaii (area mauka of Hilo) to upper Waimea by increasing the proposal's capacity and extending a pipeline to transmit the additional supply from the upper Waimea terminus of the proposal to the coastal area.
- Alternative 2 was use of desalination to process the needed amount of fresh water from brackish water sources in the South Kohala coastal area.
- Alternative 3 was use of high-level ground water aquifers in the Kohala Mountain slope above Waimea as the supply source and extending a pipeline to transmit the water from the source area to the coastal area.
- Alternative 4 was no action.

1.7 UNRESOLVED ISSUES

The following environmental issues addressed by this DEIS are not resolved at this time.

- The long term potential water need for the North Kohala area lying generally on the north of Mahukona is estimated to be 4.3 mgd. Although available general data appears to suggest good possibility of withdrawing this additional amount of basal water from the Hawi aquifer system (beyond the 20 mgd by the proposed action), a more definitive determination is necessary.

The Department of Water Supply will arrange with the USGS to determine the feasibility of withdrawing the additional amount necessary to meet the estimated long term potential water needs of northern North Kohala. The determination will guide the Department of Water Supply in deciding if any adjustment should be made to the proposed capacity of Phase II.

- The USGS water resources study for the Hawi aquifer pointed out that it is possible that pumping of the Hawi aquifer could cause some reduction of streamflow near the mouth of Pololu Stream.

  The Department of Water Supply will arrange with the USGS to obtain the necessary field data to determine if there is a hydraulic connection between Polulu Stream near its mouth and the basal aquifer and, if there is, to estimate the size of the possible reduction in streamflow in Pololu Stream near its mouth. The information is necessary to assess the potential impact on Pololu Stream, if there is a reduction in streamflow near its mouth.

1.8 COMPATIBILITY WITH LAND USE PLANS AND POLICIES

State and County policy clearly supports the development of water system infrastructure as necessary to support existing and planned needs. The provision of water is a key element in the unfolding of the development concepts envisioned for Kohala in the Hawaii County Plan, in the West Hawaii Plan, and more generally in the Hawaii State Plan. Most of the supporting elements, such as road infrastructure, land ownership, and appropriate State Land Use Districts and County Zoning are in place. Private developers will be able to implement their plans for resorts within the areas served by the water system. Development plans for the Department of Hawaiian Home Lands' Kawaihae project would also be furthered by the presence of water.

1.9 LISTING OF PERMITS AND APPROVALS

Federal

U.S. Army Corp of Engineers	404 Permit for Streambank Improvements - may be required if segment of pipeline crosses streambed

State of Hawaii

Department of Land and Natural Resources	Conservation District Use Application -may be required since short segment of Akoni Pule Highway is located within a conservation district
Commission on Water Resource Management	Well Construction & Operation Permits
Department of Transportation	Approval–Project construction plans.

Department of Health	Approval–New water source/system for potable public water supply.
	NPDES Permit for grading.
	Air Pollution Control Permit for use of diesel fueled generator at well sites, if they are to be used
	Fuel Storage Permit for diesel fueled generators at well sites, if generators are to be used
County of Hawaii	
Department of Public Works	Grading Permits and Building Permits.
Planning Department	Approval - Project construction plans.
Department of Water Supply	Approval - Project construction plans.

SECTION 2
PURPOSE AND NEED FOR THE PROPOSED PROJECT

2.1 PURPOSE OF PROJECT

The purpose of the proposed Kohala Water Transmission System project is to provide a reliable and high quality potable water supply that would meet the estimated future needs of North Kohala and coastal area of South Kohala, including the Hawaiian Home's Kawaihae Master Plan Area.

- The objective in North Kohala is to upgrade the existing county systems to fully use basal ground water supply which would provide all-weather reliability and also bring the systems into compliance with safe drinking water regulations.

- The objective in the South Kohala coastal area is to supplement the county's Kawaihae-Lalamilo-Puako Water System with basal ground water from the Hawi Aquifer System in North Kohala, in two phases of approximately 10 mgd each.

2.2 NEED FOR THE PROJECT

The Hawaii County Water Use and Development Plan, a component of the State Water Plan, points out that proposed development plans in the South Kohala coastal area would require more water than is available in the area's ground water aquifers.[1] The imbalance between need and supply is not expected to occur immediately. However, because of the large volume of anticipated water needs and long lead time necessary to construct a major water system, the proposed project is being considered now to assure that water will be available when needed. The Hawaii County Department of Water Supply (DWS) will construct and operate the proposed water system.

The estimate of future water needs and available water resources in the northwest Hawaii region are discussed in the following sections. The DWS generally follows the concept of "water follows land use" in its water facilities planning. In this respect, the Hawaii County General Plan is used as the guiding document (see Figure 6.5-1, page 6-14). Where development plans are available for parcels within a water service area, estimates of water need are based on the plans.

2.2.1 FUTURE WATER NEEDS

SOUTH KOHALA. South Kohala is the only district in the island where the estimated future potable water needs are higher than the estimated capacity of the water supply available from proven sources within the district. The uplands in and around Waimea Village and the coast between Kawaihae and Anaehoomalu are the areas of the district

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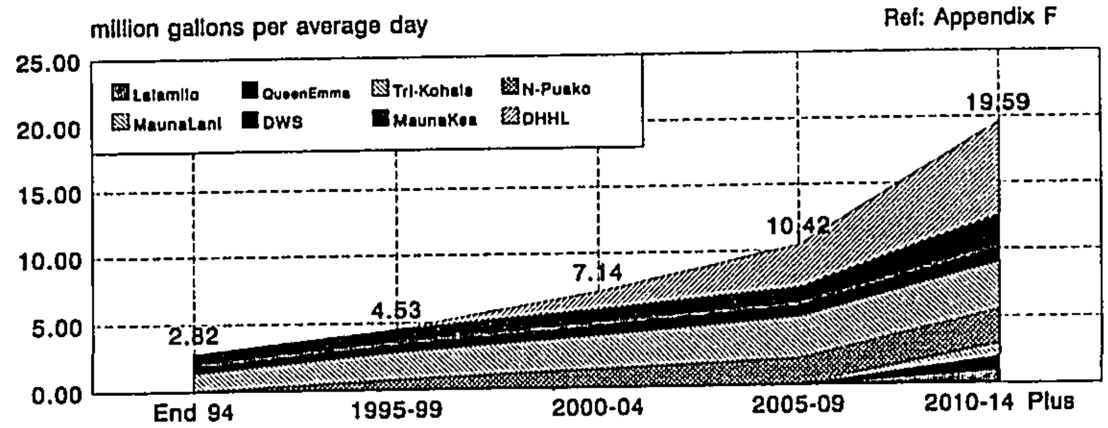
[1] State Commission on Water Resource Management, for HC Department of Water supply by M. Kon, Inc. *Hawaii County Water Use and Development Plan, Review Draft.* Feb 1992. Page 1-19.

Figure 2.2-1
DWS Kawaihae-Lalamilo-Puako System
ESTIMATE OF FUTURE POTABLE WATER NEEDS



	End 94	1995-99	2000-04	2005-09	2010-14 Plus
DHHL			1.28	3.14	7.05
MaunaKea	1.02	1.16	1.23	1.36	2.48
DWS	0.46	0.58	0.72	0.83	0.98
MaunaLani	1.34	2.04	2.55	3.12	3.56
N-Puako		0.75	1.36	1.97	2.52
Tri-Kohala					1.00
QueenEmma					1.00
Lalamilo					1.00

2020-14 Plus column includes needs to build out after Yr-2015 or not scheduled (see Appendix F)
The estimate assumes the listed potential water users will meet their needs from the DWS system

where larger future water needs are anticipated. The Hawaiian Home's Kawaihae Master Plan Area which covers a huge tract extending from the ocean to above the Kohala Mountain Road is included as part of the Kawaihae to Anaehoomalu area. The lands in Lalamilo which were recently transferred to Hawaiian Homes from the State will probably pose additional water needs. However, since the land use for the parcel is not yet determined, the water requirement for the parcel is not included in the South Kohala need estimate at this time.

Upland Areas. For the purpose of this EIS discussion, upland areas include that part of Waimea (Kamuela) generally from Puukapu along the South Kohala-Hamakua boundary of the district to Lalamilo and Ouli lands mauka of the well field in Lalamilo.

The primary source of water supply for all existing uses in the uplands is the Kohala Mountain streams. Although normally sufficient, experience shows that during prolonged dry weather, flows in these streams can drop to very low levels and reduce available water supply. High level ground water sources are being explored for supplementary water supply during periods of low stream flows. Three independent water systems provide domestic, irrigation and livestock water in the upland areas.

The County DWS system supplies domestic water in Waimea from Puukapu to Lalamilo farm lots and Waiaka, including areas adjacent to Kawaihae Road. Many farms use domestic water for irrigation since they are unable to obtain supply from the State's irrigation system. The DWS system draws its water from diversions at the Waikoloa and Kohakohau Streams. Raw water from the streams is stored in three open reservoirs with a total capacity of 150-mg. It is then treated by filtration, disinfected, and stored in a 4.0-mg covered concrete tank.

The raw water reservoirs can sustain a constant average demand of about 3.5 mgd.[2] For planning purpose, the DWS uses a yield of 3.0 mgd to allow for leakage and other losses. The estimated future need for the system is 2.4 mgd. Because of the low reliability of surface water sources, the DWS is planning on using high-level ground water for supplementary supply. The first one will be a 0.72 mgd pump capacity well being developed by the Parker Ranch to provide for part of its Parker 20/20 water needs. It will be dedicated to the DWS and connected to the Waimea water system.

The State's Waimea Irrigation Water System provides agricultural irrigation water to farms in Puukapu and Lalamilo. Surface water diverted from Kohala Mountain streams flows through the Upper Hamakua Ditch to the system's 60 MG Waimea Reservoir and 110 MG Puu Pulehu Reservoirs. The water is then distributed to farm lots in the Puukapu and Lalamilo sections of Waimea. The system has been partially rehabilitated to improve its transmission and storage capacities. However, even with these improvements, insufficient storage and inadequate distribution lines have precluded the State from expanding the system's service area. One deep and one shallow well have been drilled in the Waimea forest reserve area to tap high level ground water to supplement the stream sources during drought periods. Pumps have not been installed at these wells. The Federal Natural Resources Conservation Service is considering a long range plan to expand the State's irrigation system. It is currently under environmental review.

Parker Ranch operates an extensive system of distribution lines to provide livestock water for its widely spread pasture lands in the Waimea area. The system's supply comes from the high level intakes in Waikoloa, Kohakohau, Alakahi, and Haunani Streams. The Ranch also uses the DWS system where it is accessible.

The total estimated future need for potable, irrigation and livestock water in the upland areas is approximately 16.8 mgd.[3]

Because of future needs of the three systems described above, unreliability of the Kohala Mountain stream sources during prolonged droughts, and inexperience with the behavior and capacity of high-level ground water sources, **the DWS plans to use its mauka water sources for lands located generally above the DWS Lalamilo well field.** Also, during normal weather, the DWS plans to continue supplying the upper section of the Honokaa System with gravity flow water from the Waimea System to save on pumping costs.

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2 State DLNR-Division of Water and Land Development. Staff Report on Storage Requirement, Waimea Water System, Hawaii. Sep 1982.

3 Appendix F, page F-7. See South Kohala District, Total 80102-Waimanu line, 21.80 mgd total less 5.04 mgd for DHHL Kawaihae irrigation or net 16.8 mgd. The projection is to year 2010 or to build-out in some cases. Unscheduled estimates are also included in the 2010 to Buildout period.

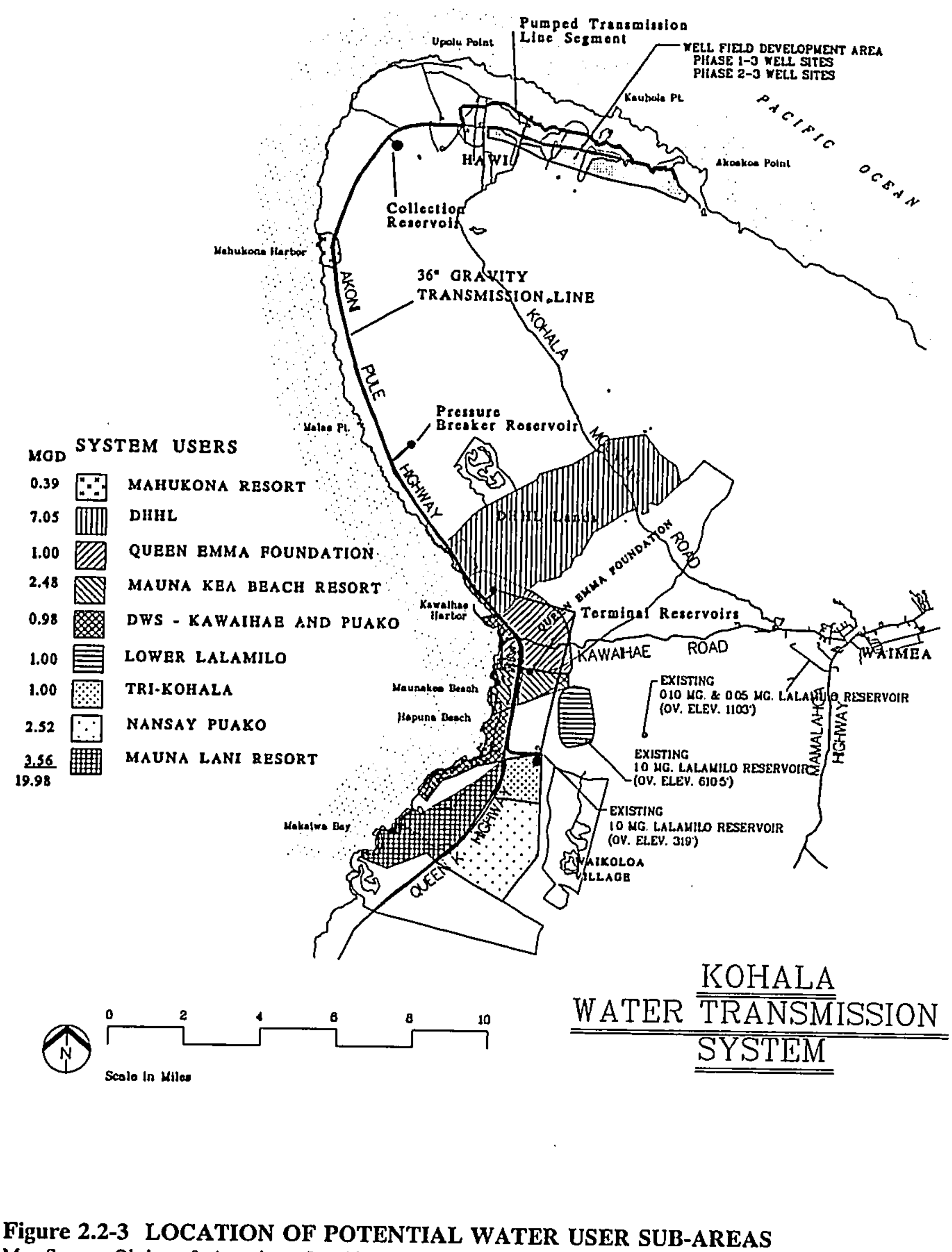

Figure 2.2-3 LOCATION OF POTENTIAL WATER USER SUB-AREAS
Map Source: Okahara & Associates, Inc. / D. Haserot

Coastal Areas. Potable Water. South Kohala's coastal area between Kawaihae and Anaehoomalu is the premier resort location for the island of Hawaii. The area is served by two potable water systems - one private and one public. The private Waikoloa Water Company's system serves the Waikoloa Beach Resort, Waikoloa Village and Waikoloa Highlands areas. The County DWS through its Kawaihae-Lalamilo-Puako system serves the coastal area from the Hawaiian Home's industrial tract in Kawaihae to Puako, including the Mauna Kea Beach Resort and Mauna Lani Resort.

The potable water need estimates for potential water users in the service area of the DWS system illustrated in **Figure 2.2-1.** The total need for the system is 19.59 mgd. The estimate includes the full requirement for the DHHL Kawaihae Master Plan Area. Depending on the final land uses in future phases, parts of the mauka sections may be serviced from another water system. The Queen Emma Foundation, Tri-Kohala Development and the State's lower Lalamilo lands do not have defined development plans, however, estimates for these lands are included to show possible needs since they are in areas designated for resort or urban expansion in the County's General Plan. The actual volume and timing of their needs may vary largely from the estimates. Details of the estimates are included in **Appendix F**. The user sub-areas are shown in **Figure 2.2-3.**

The potable water requirements of Nansay Hawaii's Ouli project which may be supplied with water from an on-site well, and the Waikoloa Resort and Village would require an additional 0.74 mgd and 16.05 mgd, respectively. See the summary below.

Non-Potable Water. The golf course and landscape irrigation water needs of the three existing resorts are met through their own brackish water wells. Where feasible, the resorts use part of the effluent from their wastewater treatment plants for irrigation. The proposed Nansay Puako project would also have its own brackish water irrigation system. The combined irrigation water needs of the existing resorts, Nansay, Queen Emma, and State total 12.28 mgd. Waikoloa Resort and Village would require 3.50 mgd.

Summary of water needs for South Kohala coastal area.

DWS System	19.59 mgd
Nansay Ouli Parcel	0.74 mgd
Waikoloa Resort/Village System	16.05 mgd
Sub-Total Potable Water	**36.38 mgd**
MKB/MLR/Nansay/QEF/State Properties	12.28 mgd
Waikoloa Resort/Village System	3.50 mgd
Sub-Total Non-Potable Water	**15.78 mgd**
Total-Potable and Non-Potable Water	**52.16 mgd**

NORTH KOHALA. South of Mahukona. The primary water user in this section of North Kohala is the Kohala Ranch Water.Company. This private purveyor services the domestic water needs of the Kohala Ranches subdivisions, and the Kohala Makai and Kahua Shores developments. The water company estimates a potable water need of 1.60 mgd for domestic use and 1.50 mgd of non-potable water for golf course irrigation.

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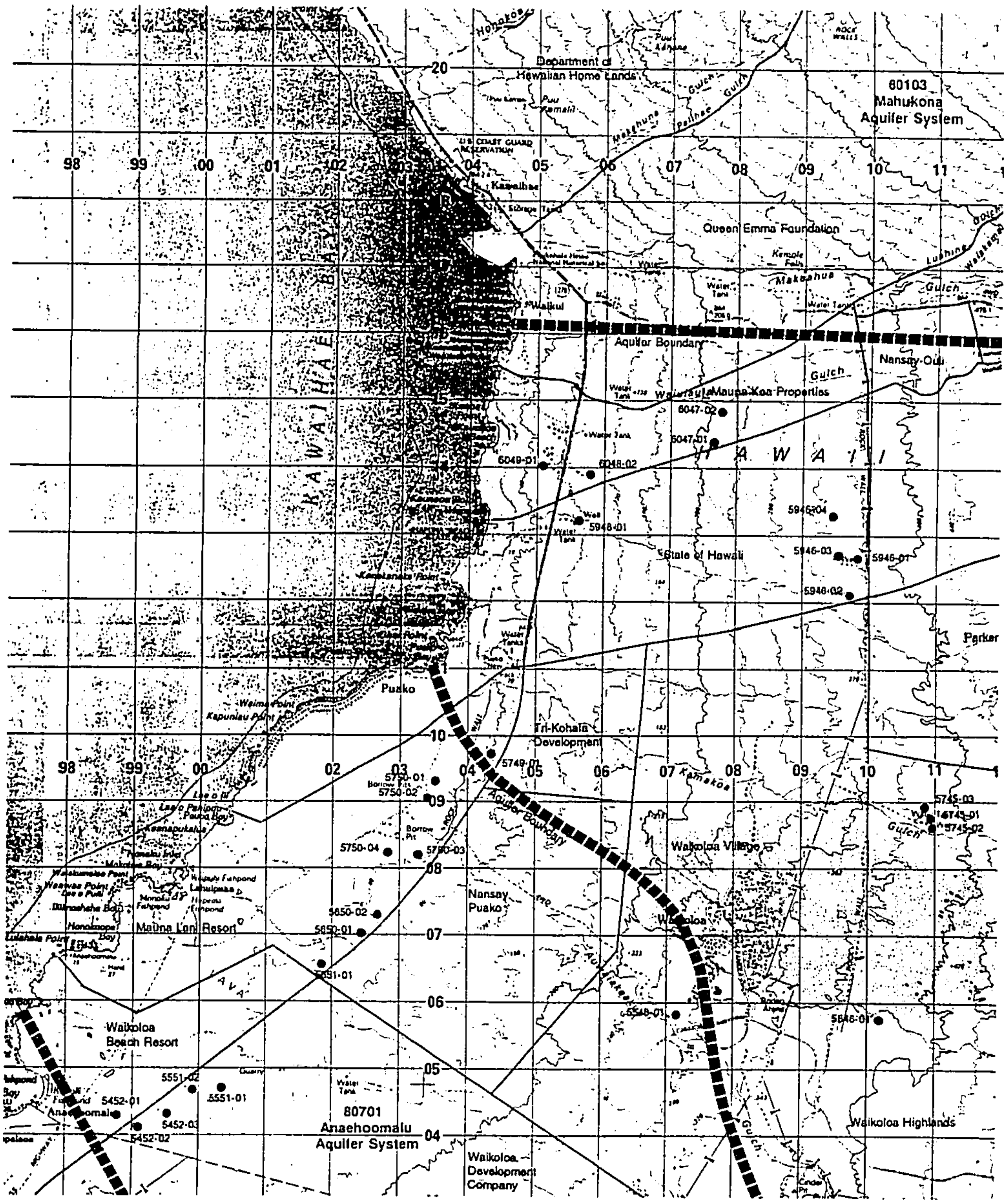


Figure 2.2-4 LOCATION OF ACTIVE WELLS - South Kohala Coastal Area
Data Source: DLNR-DWRM Well Index and Map

Other than the developments mentioned above, there are no other areas in this section of North Kohala that are designated for urban or urban expansion uses in the County General Plan. See **Figure 6.5-1** on page 6-14, and **Figure 6.2-1** on page 6-8.

Mahukona and north. A large part of the area north from Mahukona to Pololu Valley (formerly Kohala sugar plantation land) is currently owned by Chalon International of Hawaii. There are also many privately owned parcels varying size from small houselots to large agriculture, ranch and forest lots.

The DWS has three systems whose service area extends from Kokoiki Homestead to Makapala. Based on historical trend, the DWS estimates the need for their systems to year 2015 at 0.63 mgd. Chalon Hawaii estimates their present development plans would require 0.64 mgd of potable water, which includes 0.39 mgd for its Mahukona project. The combined total with the DWS need would be 1.27 mgd. Chalon plans to obtain water for its irrigation needs from the Kohala Ditch. Because of concerns expressed during consultation about the availability of sufficient water for long term future needs, 3 mgd was included in Chalon's estimate. **The total estimated need for northern North Kohala comes to 4.27 mgd.**

The following computation gives an idea of the population that can be supported with the figures discussed above. Based on an assumed average per capita consumption of 150 gallons per day, the 1.27 mgd and 4.27 mgd estimates would translate to populations of about 8,600 to 28,600 persons. The population projections for the North Kohala District are shown below for comparison purpose (no adjustments have been made to the data for future population residing in areas south of Mahukona).

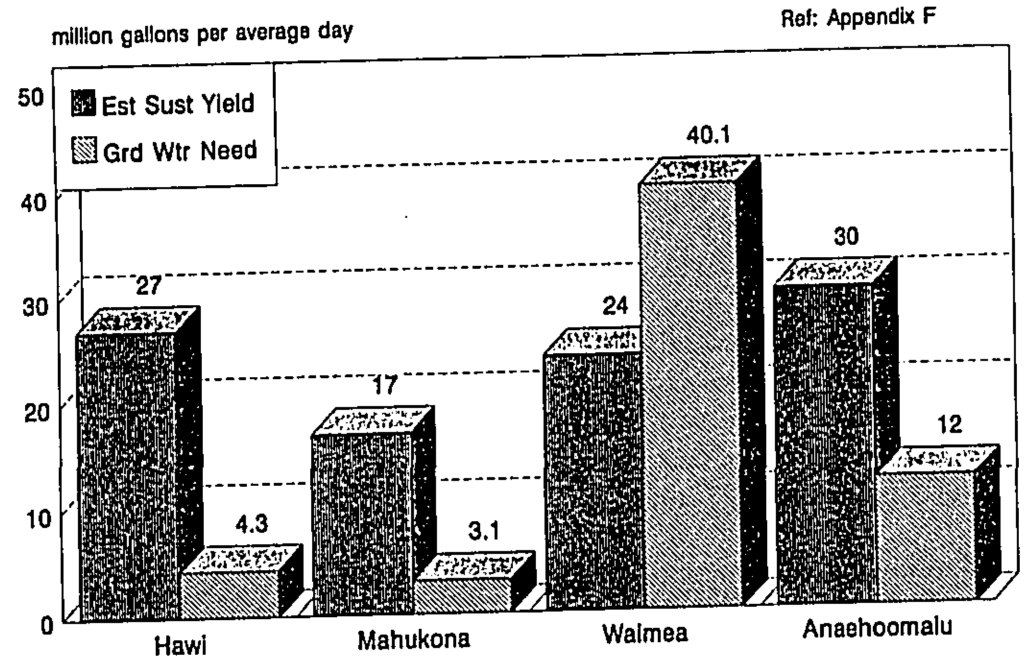
	Yr 2005	Yr 2010	Yr 2020
County General Plan Series A . . .	5,363		
County General Plan Series B . . .	6,721		
County General Plan Series C . . .	7,998		
State DBED M-K Series		8,470	
State Land Transport Master Plan (preliminary)			11,800

From a practical viewpoint, if northern North Kohala is to maintain its rural and agricultural characteristics, as desired by many of its residents, the amount reserved for long-term needs appears reasonable. The availability of basal water in the Hawi aquifer to meet the reserved amount is discussed below on page 2-9 under Hawi [80101].

2.2.2 SUPPLY SOURCES

All of the current potable (fresh) water needs of the coastal area serviced by the DWS system and the non-potable (brackish) irrigation water needs of the existing resorts are supplied by wells that draw from the Waimea and Anaehoomalu aquifer systems. There are about 8 fresh water wells and 19 brackish water wells operating in the coastal area. The location of these wells are shown in **Figure 2.2-4.** There are other wells that have drilled but not operating and others with permits but have not been drilled. Most of the brackish water wells are located along the Queen Kaahumanu Highway.

Figure 2.2-2
COMPARISON OF TOTAL GROUND WATER NEED AND
ESTIMATED SUSTAINABLE YIELD IN SELECTED AQUIFERS



Total Ground Water Need is sum of fresh and brackish water needs.
Aquifer System Code: Hawi-80101, Mahukona-80103, Waimea-80301, Anaehoomalu-80701
Totals for Waimea & Anaehoomalu aquifer systems include needs for Waikoloa Resort/Village

Figure 2.2-2, above, shows a comparison of projected needs versus estimated sustainable yield in selected aquifer systems. The reviewer is encouraged to read the sections on aquifer classification and sustainable yields in **Appendix F**, immediately following page F-7. Since the ratio between fresh and brackish water for the total supply developable is not available, it should not be assumed that the full value of the estimated sustainable yield is available as fresh water.

Waimea [80301]. Although it would be ideal to supply the needs of an area with ground water from an aquifer in the vicinity of the area, it is not a feasible solution for the South Kohala coast. Note in Figure 2.2-2 that in the Waimea aquifer, the ground water needs exceed the estimated sustainable yield by 16.1 mgd or about 67%. The difference between need and supply is so large it is unlikely that the water budget can be balanced even if some of the estimates fall short of their projections. Also, timing of shortage in supply would depend on the progress of developments, which in turn would depend on market forces and conditions. As discussed in the section on "upland areas", p. 2-2, the resources available in the mauka area would be needed to meet the future requirements of that area. Thus, to continue development in the coastal area as envisioned in county and state plans and policies, importation of supplementary water from sources outside of the district is necessary. See **following page and sections 3.2 and 4** for discussions on possible sources.

The DWS strategy is to construct a pumped water collection line and a gravity flow water transmission system with capacity to ultimately transport 20 mgd from North Kohala to South Kohala coast. The recovery and storage components would be constructed in two phases of approximately 10 mgd each. The second 10 mgd phase would be constructed when demand develops and warrants the addition. Upon completion of the first phase, the DWS plans to place the Lalamilo wells on standby use for emergency and maintenance events. The reason for the change to standby is primarily to reduce pumping cost, which is a continually rising operational cost. The average ground elevation of the proposed Phase I wells in Hawi is about 400 feet compared to an average ground elevation of 1100 feet for the four existing wells at Lalamilo. Although the pumped water at the Hawi wells must be raised to the collection tank elevation of 675 feet, the difference in pumping lifts would still be about 38% less than at Lalamilo. The reduction in power cost alone, at today's cost, could amount to $50,000 per year for every million gallons of water pumped.

Anaehoomalu [80701]. It appears that the resorts and others that require irrigation water for their developments can continue to seek additional water from the adjacent Anaehoomalu aquifer [80701]. At present, about 13 brackish water wells tap into this aquifer for irrigation water. They are mostly located along Queen Kaahumanu Highway. There are no potable water wells located in the coastal part of this aquifer system. The State Department of Land and Natural Resources drilled an exploratory well (5347-01) near the South Kohala-North Kona boundary at elevation 1545 feet. It did not produce potable water. Of the 30 mgd estimated sustainable yield for this aquifer, a significant portion is probably brackish.[4]

Mahukona [80103]. The Kohala Ranches project has two potable water operating in the Mahukona aquifer system. One well at ground elevation 1840 has a 1.0 mgd pump. The second well is at ground elevation 1800 with a 1.5 mgd pump. Two exploratory wells were drilled in the Hawaiian Home's Kawaihae tract. One well produced brackish water. The other well which was located near the Kohala Ranch well produced potable water but pumping test resulted at a low yield of about 0.20 mgd. The need for a deep well in this aquifer system (because of inland distance and high elevation) to obtain potable water increases the cost of water recovery.

Hawi [80101]. The Hawi system affords the best alternative to providing the needed amount of fresh water for the South Kohala coast. The USGS in its study of ground water availability in the Hawi aquifer concluded that withdrawal of 20 mgd above the existing 0.6 mgd withdrawal at the DWS Hawi well is feasible if pumping centers are spaced adequately and well depths are limited.[5] In addition, a preliminary analysis by USGS shows that withdrawing an additional 4 mgd beyond the 20 mgd from the Hawi aquifer is possible from wells that have proper spacing, depth and pumping rate.[6]

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4 State Commission on Water Resources Management by George A.L. Yuen and Associates. *Water Resources Protection Plan, Review Draft.* Mar 1992. (see Appendix F, page A74)

5 See Appendix B, USGS Report, pages 52 and 55.

6 The DWS will arrange with USGS to verify the preliminary analysis. In the interim, this item is listed as an unresolved issue in section 12.

SECTION 3
GENERAL DESCRIPTION OF PROPOSED ACTION

3.1 OBJECTIVES

The objectives of the proposed Kohala Water Transmission System project are:

- to provide a high quality and reliable potable water supply that would meet the estimated future needs of North Kohala and the South Kohala coastal area, including the Kawaihae Hawaiian homestead tract.
- to assure that the operation of the proposed project will not in any way adversely affect the Hawi aquifer system.

3.2 HISTORICAL PERSPECTIVE

The potable water supply for the South Kohala coast resorts, other than at Waikoloa, first came from the County's Waimea water system through the Kawaihae Road pipeline. Because of increasing demands from planned coastal developments and low reliability of the Waimea system during dry weather, exploration for ground water was initiated in the coastal area. The first major fresh water source discovery in the coastal area was made in 1969 at Waikoloa by Boise Cascade. Currently, two major fresh water pumping centers provide for the needs of the coastal developments. One center is in Lalamilo at about elevation 1100 feet. The other center is located above Waikoloa Village at about elevation 1200 feet.

The State's ground water exploration program yielded a high quality ground water source in Lalamilo in 1977. Two production two wells were put into operation in 1982 and 1983. Since then, two more wells were added in 1985 and 1992. The combined pumping capacity of the four wells is 5.3 mgd (since one well is kept on standby for emergencies and maintenance, the effective capacity is 3.9 mgd). Present pumpage is about 2.8 mgd. The Mauna Kea Beach and Mauna Lani resorts are participants in the repayment of the general obligation bond issued to finance the first well in Lalamilo. In return, the resorts received a commitment for 1.4 mgd of water from the Lalamilo wells. The remaining wells were financed through appropriations from the State legislature. Today, the Lalamilo wells provide all of the supply for the County's Kawaihae-Lalamilo-Puako System.

The other major fresh water pumping area is operated by the Waikoloa Water Company. Since its first well the company has continued to drill additional wells to keep up with the needs of the Waikoloa developments. The company has three wells at one site and one well at another site, both of which are located above Waikoloa Village. These wells provide potable water for the Waikoloa Village-Highland area and the makai Waikoloa Beach Resort area. The combined pumping capacity of the wells is about 4.6 mgd. Average water use is about 3.2 mgd.

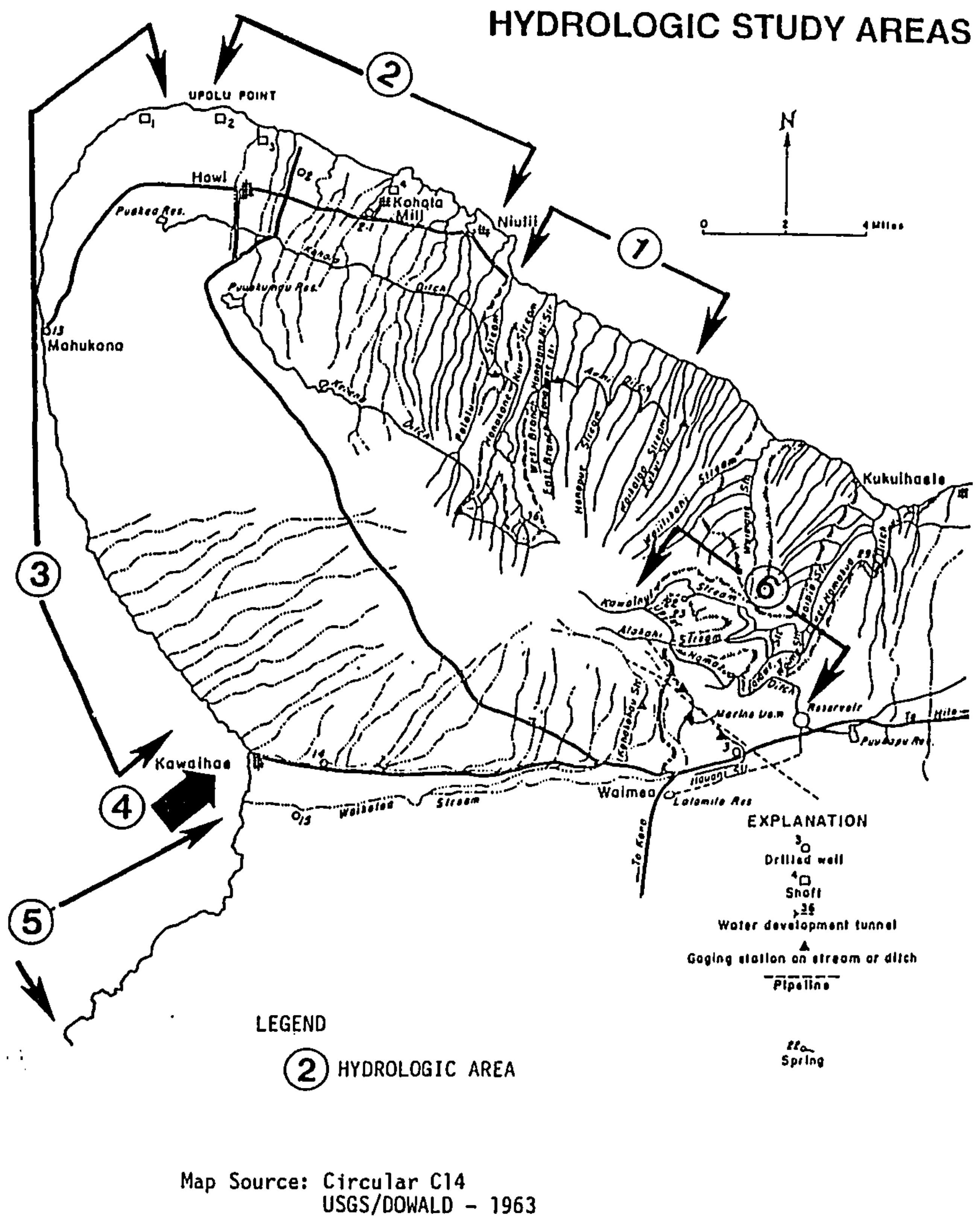

Figure 3.2-1 HYDROLOGIC STUDY AREAS
Source: Thompson, *Feasibility Study For Kohala Coastal Water System*, June 1988.

Besides the eight fresh water wells there are about 19 brackish water wells operating in the coastal area. Except for a State operated well for Hapuna Park, the other 18 wells are owned and operated by the existing resorts, primarily for golf course irrigation. The wells for Mauna Kea Beach and Hapuna Park draw water from the Waimea aquifer system [80301. The wells for Mauna Lani and Waikoloa Beach resorts draw their water from the Anaehoomalu aquifer system [80701], except for two wells that draw from the Waimea aquifer system. Average total irrigation water use is currently about 7.7 mgd.

Demand for water from the DWS system has continued to grow. Since the Lalamilo wells were put on line, consumer services have increased steadily from 281 to 608 meters and consumption from 0.481 to 2.822 million gallons per day (July 1982 to June 1994).[1] A recent estimate show a projected need of 19.6 mgd for the South Kohala DWS system. The Waikoloa Water Company and Nansay's Ouli systems estimate their potable water needs at 16.8 mgd, for a three system total of 36.4 mgd. The combined total of potable and projected irrigation water needs would be 52.2 mgd[2] for the coastal area properties, including the Kawaihae Hawaiian homestead land.

The high growth potential of the South Kohala coast and the limited capacity of the Waimea aquifer system were recognized early by the DWS. In 1988 the DWS initiated a study to investigate the northwest Hawaii region for additional sources of water for its Kawaihae-Kawaihae-Lalamilo-Puako system.[3]

The DWS study evaluated six hydrologic areas in northwest Hawaii region shown in **Figure 3.2-1** on the facing page. A major criterion in the search for a suitable area was the availability of 20 mgd of ground water for transfer to South Kohala. The study concluded that Hydrologic Area No. 2, the sector between Polulu Valley and Upolu Point in North Kohala, is the area of choice for water development to fill the needs of South Kohala. The study selected Area No. 2 for the following reasons:

1) "There is excellent ground water availability and good recharge from the heavy rainfall in the upper areas.
2) With the closing of the sugar industry, competition for ground water is lacking.
3) The proposed pipeline from North Kohala to South Kohala will also furnish water to the drier region of North Kohala where development projects have been proposed.
4) Ground water can be developed by deep wells at a reasonable elevation, not exceeding 600 feet, with a significant reduction in pumping costs as compared to the present Lalamilo wells in operation, 600 feet versus 1200 feet.
5) The wells can be developed on an incremental basis; that is, as the demand arises additional wells will be drilled to meet such demands.
6) Much of the area that the pipeline will traverse is undeveloped at present; pipeline rights-of way should not be an insurmountable problem."

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1 Hawaii County Department of Water Supply. *Table No. 8 Services, Consumption, and Revenue of Various Systems.* Fiscal Years 1982 to 1994.

2 See Appendix F, pages F-6 and F-7 for details on projected needs. See Section 2.2 for discussion on needs.

3 Hawaii County Department of Water Supply. *Feasibility Study For A Kohala Coastal Water System, A Preliminary Report.* Prepared by W. A. Thompson, Consultant. June 1988. See Appendix A for copy.

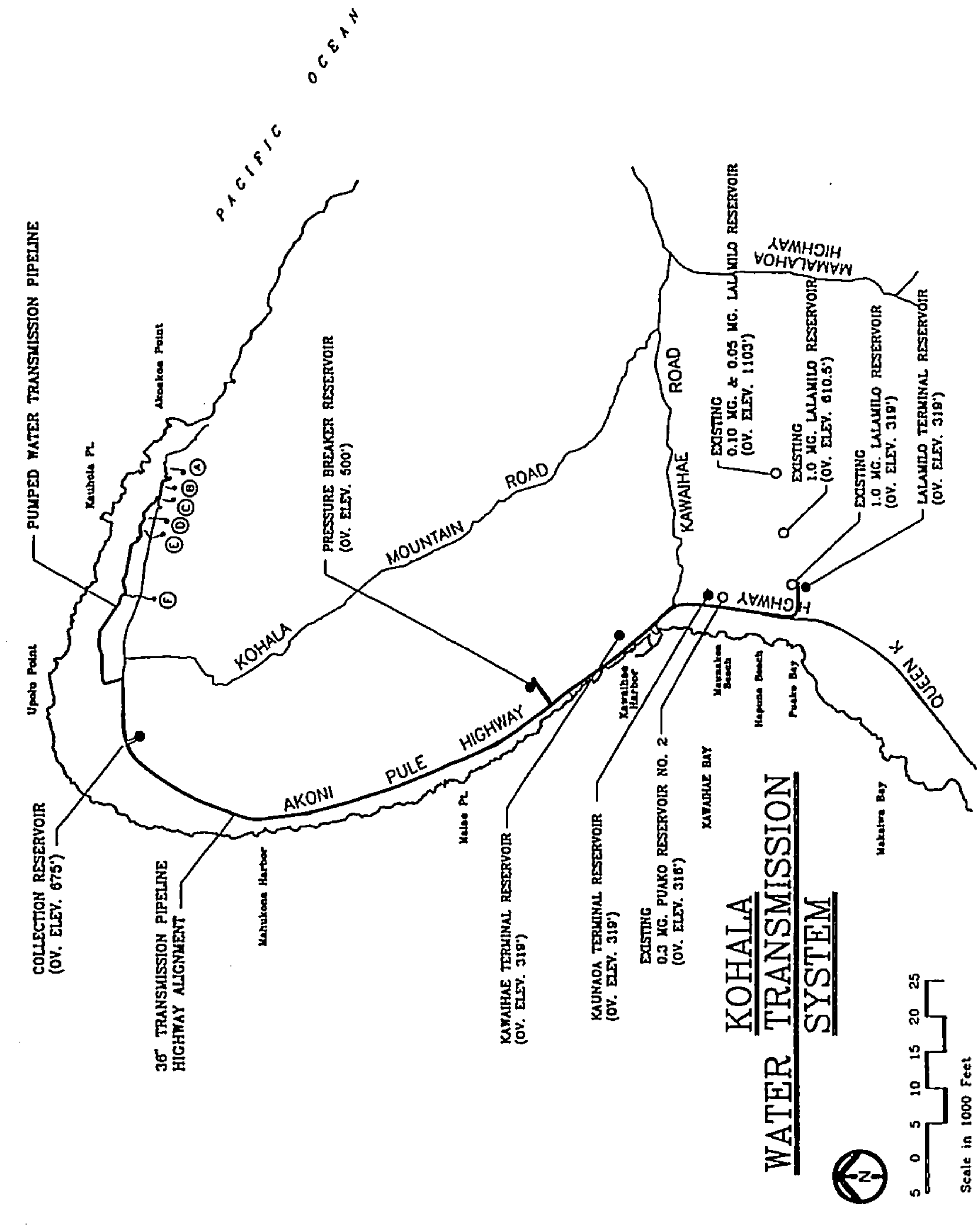


Figure 3.3-1 GENERAL ARRANGEMENT OF WATER SYSTEM COMPONENTS
Map Source: Okahara & Associates, Inc.

To confirm their finding, the Department of Water Supply contracted the U.S. Geological Survey to do a ground water availability study of North Kohala. The purpose of the study was to assess ground-water availability in the basal aquifer of the North Kohala area lying between Pololu Valley and Upolu Point (the same area as Hydrologic Area No. 2). Although the aquifer extends eastward beyond Pololu Valley (Stearns and MacDonald, 1946) the eastward area was excluded from the study because of the rugged terrain it encompasses and the resultant difficulty in obtaining water. For this study, spatial distributions of rainfall, runoff, evapotranspiration, and groundwater discharge were calculated for the entire Kohala area.

Additionally, a program of test-well drilling was instituted in the basal aquifer to obtain information on geology, water levels, water quality, and thickness of the freshwater and transition zone in the aquifer. A total of 12 test wells were drilled at altitudes ranging from about 108 to 630 feet above sea level. Aquifer tests were conducted at five locations to determine the hydraulic conductivity and geometry of the basal aquifer; a numerical model was constructed and calibrated (using field data from the test wells) to simulate the movement of water into, through, and out of the basal aquifer.

Numerical simulations were then used to estimate the response of the ground water system to selected groundwater development scenarios and to determine if 20 mgd of fresh groundwater is available for development. Model results indicate that 20 mgd of fresh ground water is available from the basal aquifer but well spacing, depth, and pumping rates of individual wells are important.[4]

With strong development interest continuing along the Kohala coast and substantiation of water availability, the DWS obtained funds from the State Legislature in 1991 to begin planning of the proposed Kohala Water Transmission project. This draft environmental impact statement is part of the planning effort.

3.3 TECHNICAL CHARACTERISTICS

3.3.0 PROJECT LOCATION AND TAX MAP KEYS

The proposed project spans the North and South Kohala Districts of Hawaii County. The ground water recovery and collection component of the project are in North Kohala. A gravity flow transmission pipeline that follows the coastal highway carries the collected water from North Kohala to the South Kohala coastal area. A pressure-breaker reservoir on the transmission line is located in North Kohala at Makiola. The three terminal reservoirs are located in South Kohala at Kawaihae, Kaunaoa, and Lalamilo.

The Tax Map Parcels affected directly by project components are:

5-2-05:1	5-2-06:3	5-3-03:1	5-3-04:1	5-4-03:2	5-4-03:3
5-5-02:23	5-6-01:51	5-9-03:4	6-1-01:3	6-2-01:63	6-8-01:6

4 See Appendix B, USGS Report, Page 55.

3.3.1 SYSTEM COMPONENTS. The general arrangement of the system's components is shown on **Figure 3.3-1.** The system is proposed for construction in two phases of 10.0 mgd capacity each. The components in each phase are described below.

Note: Because of discussions during the consulting and scoping process for the DEIS, the DWS made the following changes in the arrangement of the system's components: 1) relocated part of the pumped water transmission line - between Walaohia Gulch and Kahei - from the Hawi-Niulii Highway to Pratt Road to avoid disruption of traffic and business along highway; 2) relocated the collection reservoir site from the Upolu Airport access road to an area mauka of Puakea Ranch to reduce visual impact; and, 3) relocated the pressure-breaker reservoir site from the south boundary of the ahupua'a of Pahinahina (which runs along the Kohala Ranches subdivision) to mid-way between the north and south boundaries of the ahupua'a of Makiloa to reduce visual impact.

- **Phase I - Recovery and Collection Component** consisting of:

  Six wells at 3 sites located mauka of the Hawi-Niulii Highway in the Halawa area at about the 400-foot elevation. The well sites are designated **C, D, and E,** as shown on **Figure 3.3-1 and 3.3-2.** Each site would have two deep wells with a 2-mgd pump in each well. One well at one of the sites will be kept as a standby well. See **Figures 3.3-3, 3.3-4, and 3.3-5** for well site maps.

  Three on-site temporary generators, to power the two deepwell pumps at each site. Each diesel-fueled generator set would be enclosed in a sound attenuated container (40 feet x 8 feet x 9.5 feet high). Each site would also have two 5,200 gallon above-ground diesel fuel storage vaults. See **Table 3.7-3** for features to avoid fuel leakage and contaminate ground water source. The generators are proposed for use until adequate power from HELCO becomes available.

  Pumped water transmission pipeline to transport water from the well sites to the collection reservoirs. The pipeline varies in size from 16 to 36-inch diameter and runs mainly along Pratt Road. The beginning segment is located within the Hawi-Niulii Highway. The ending segment leading to the collection reservoirs is located within the Akoni Pule Highway. See **Figures 3.3-1 and 3.3-2.**

  Two 3-mg collection reservoirs located at about 650-foot elevation and 2,000 feet mauka of Akoni Pule Highway in the Puakea Ranch vicinity. The reservoirs would be 150 feet in diameter and 25 feet high. See **Figure 3.3-6.**

- **Phase I - Gravity flow transmission pipeline component** consisting of a 36-inch diameter pipeline and a 1.0 mg pressure-breaker reservoir located at about the 475-foot elevation and 4,000 feet mauka of Akoni Pule Highway in the *ahupua'a of Makiloa.* The pipeline starts at the collection reservoirs and runs south within the rights-of-way of the Akoni Pule Highway, Kawaihae Road and Queen Kaahumanu Highway to the terminal reservoirs at Kawaihae, Kaunaoa, and Lalamilo in South Kohala. See **Figures 3.3-1 and 3.3-7.** This component takes up 43% of the Phase I project cost.

- **Phase I - Terminal reservoir component** consisting of three 1.0-mg terminal reservoirs in South Kohala at the Hawaiian Home Land's Kawaihae project area, Kaunaoa site above Hapuna, and Tri-Kohala site above Puako. The reservoirs would be 100 feet in diameter and 20 feet high. See **Figures 3.3-8, 3.3-9, and 3.3-10.**

- **Phase I - Interconnection component** consisting of three booster pump stations at Kapaau, Kynnersely and Hawi, one 0.10-mg reservoir at Kapaau, and pipelines to connect the proposed system to the existing North Kohala systems.

- **Phase II - Recovery and Collection Component** consisting of:

  Five wells at 3 sites designated **A, B, and F,** at locations shown in **Figures 3.3-1 and 3.3-2.** Well sites A and B would be in the Makapala vicinity and mauka of the highway at about 400-foot elevation. Well site F would be located in the Hanaula vicinity and mauka of the highway at about 600-foot elevation. Well sites A and B would have two wells each with 2-mgd capacity pumps. Well site F would have one well with a 2-mgd pump. One well at one of the sites would be kept on standby. Power for the pumps are anticipated to be from the HELCO grid. See **Figures 3.3-11, 3.3-12 and 3.3-12.**

  One 6-mg collection reservoir located in the same collection reservoir site for Phase I. The reservoir would be 225 feet in diameter and 25 feet high.

- **Phase II - Terminal reservoir** located in the same site as the Phase I Tri-Kohala terminal reservoir. Although currently sized for 1.0-mg, the actual size may be changed during actual design.

3.3.2 SUMMARY OF PRELIMINARY COST ESTIMATES

PHASE I		
Well Development Area	$ 7,700,000	12.7%
Pumped Water Transmission Line	6,700,000	11.1%
Gravity Transmission Line	25,770,000	42.7%
Reservoirs	12,500,000	20.7%
Connection to Existing North Kohala Systems	1,750,000	2.9%
Electrical Facilities	6,000,000	9.9%
Total Phase I System Development	**$ 60,420,000**	**100.0%**
PHASE II		
Well Development Area	$ 9,290,000	47.4%
Additional Reservoirs	10,320,000	52.6%
Total Phase II System Development	**$ 19,610,000**	**100.0%**
PHASE I & II TOTAL	**$ 80,030,000**	

Note: Estimate is based on 1993 material and labor costs. No major cost for land acquisition is expected.

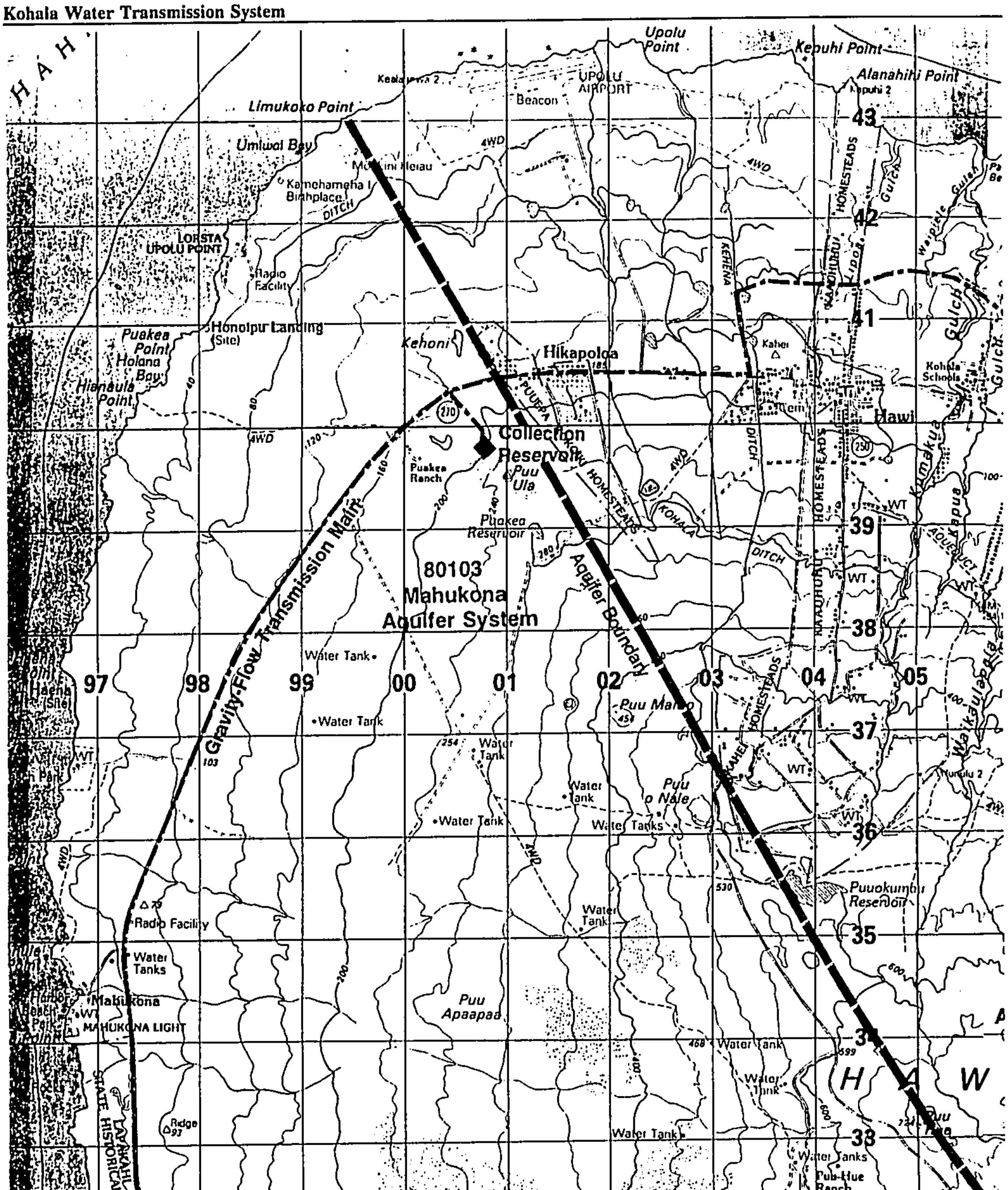
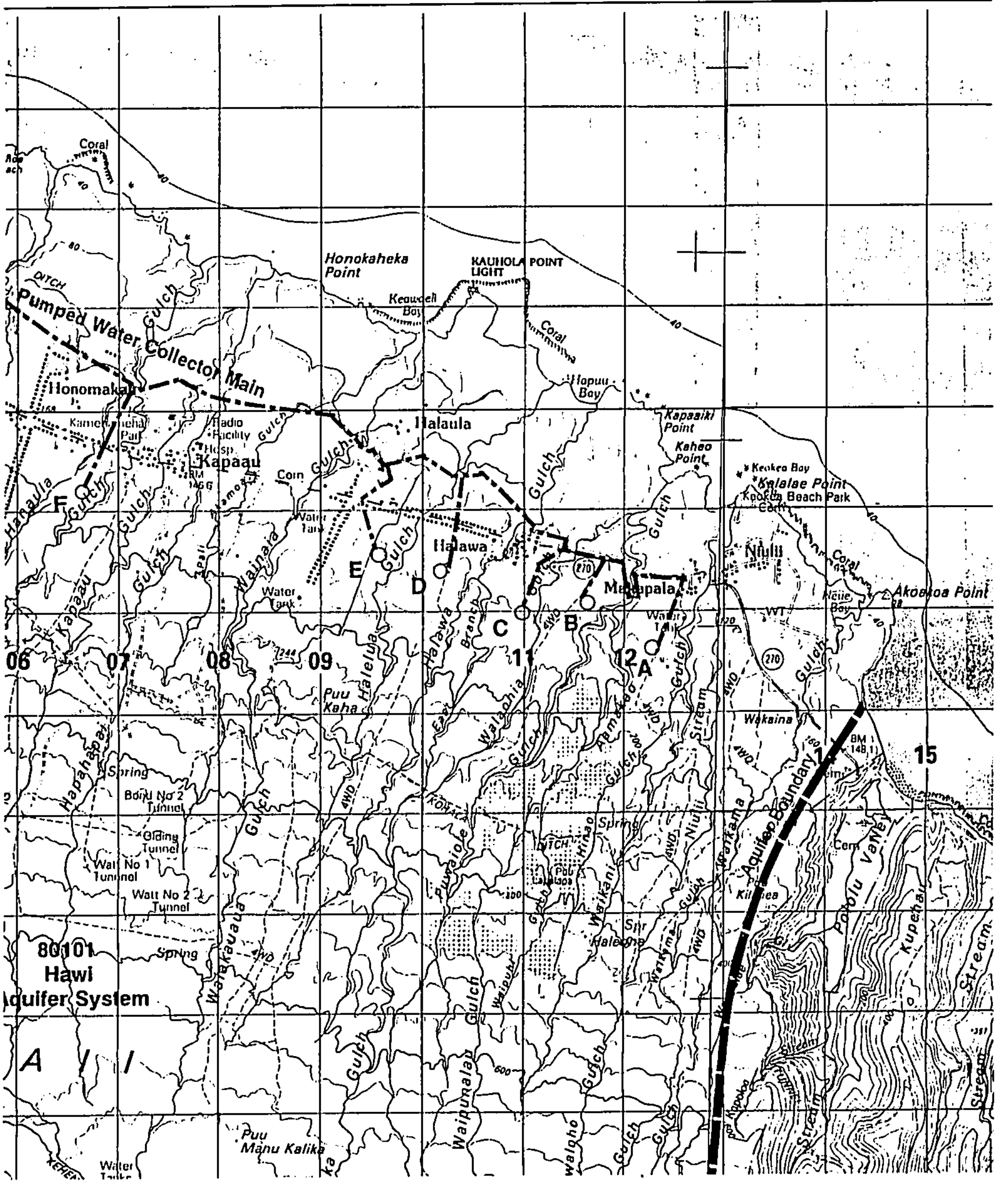


Figure 3.3-2 LOCATIONS OF WELL SITES AND COLLECTION LINES & RESERVOIR SITE
Info Source: Okahara & Associates, Inc.


Pumped Water Collector Main
Honokaheka Point
KAUHOLA POINT LIGHT
Coral
Honomakau
Kapaau
Halaula
Halawa
Makapala
Niulii
Kapaaiki Point
Kaheo Point
Kalalae Point
Keokea Beach Park
Akoakoa Point
Water Tank
06
07
08
09
11
12
15
A
B
C
D
E
F
Puu Kaha
Spring
Bond No 2 Tunnel
Walt No 1 Tunnel
Walt No 2 Tunnel
80101
Hawi
Aquifer System
Aquifer Boundary
Pololu Valley
Puu Manu Kalika

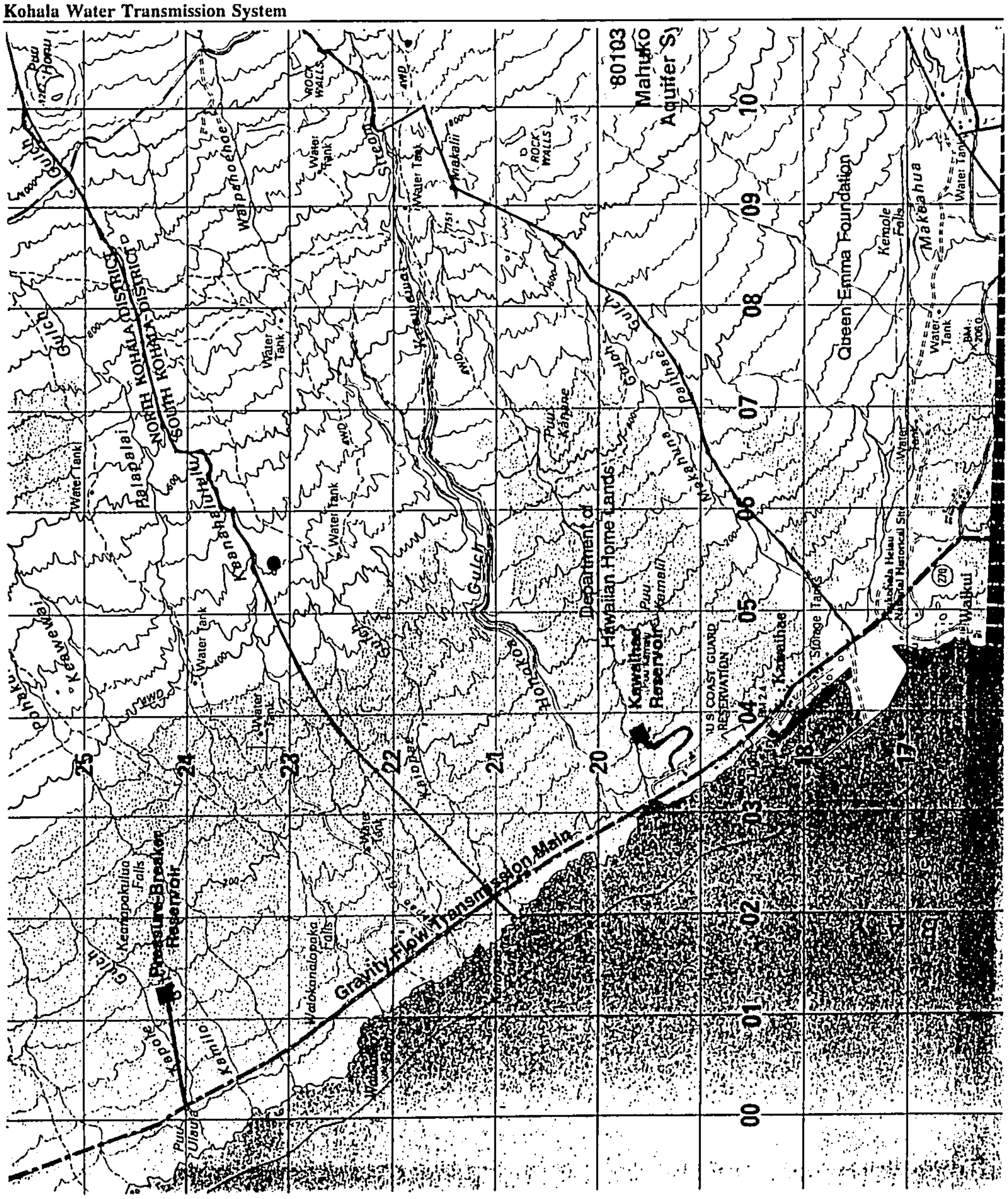
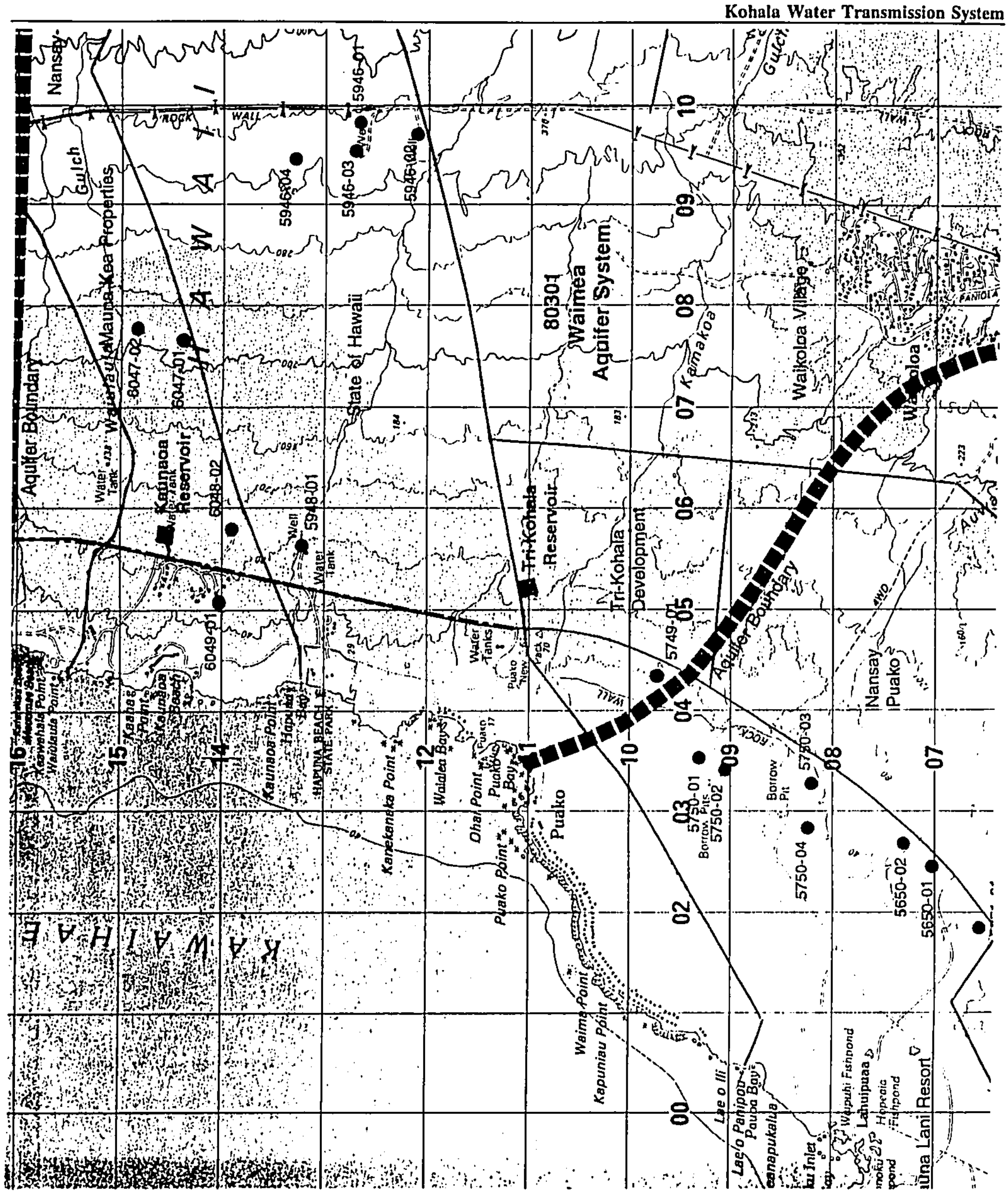


Figure 3.3-2A LOCATIONS OF PRESSURE BREAKER AND TERMINAL RESERVOIRS
Info Source: Okahara & Associates, Inc.


Aquifer Boundary
Waikoloa Village
Waikoloa
Mauna Kea Properties
Kaunaoa Reservoir
Tri-Kohala Reservoir
Tri-Kohala Development
80301
Waimea
Aquifer System
State of Hawaii
Nansay Puako
Puako
Puako Point
Puako Bay
Ohai Point
Waialea Bay
Kanekanaka Point
Hapuna Beach State Park
Hapuna Bay
Kaunaoa Point
Mauna Lani Resort
Waima Point
Kapuniau Point
Borrow Pit
Water Tank
Water Tanks
5946-01
5946-02
5946-03
5946-04
6047-01
6047-02
6048-01
6048-02
6049-01
5948-01
5749-01
5750-01
5750-02
5750-03
5750-04
5650-01
5650-02
K A W A I H A E
W A I

3.4 ENVIRONMENTAL CHARACTERISTICS

3.4.1 AESTHETICS. The aesthetic characteristic of the proposed project is essentially benign in the sense that upon completion the major part of the project's components would be buried in the ground. These components include the well and pumps, the pumped-water collection pipelines from the wells to the collection reservoirs, and the gravity-flow pipeline in the highway rights-of-way. The electrical and motor control building and temporary generator containers and fuel storage vaults would appear as low buildings at the well sites. Depending on final design requirements, the stacks (about 10 inches diameter) from the diesel generator engines may rise about 30-35 feet above the ground. Earth colored finishes on the units together with on-site landscaping would blend the facilities with the surrounding area. The collection and pressure-breaker reservoirs are relatively large and bulky components that must be carefully treated to avoid negative impact. Their treatment is discussed below under Vistas.

3.4.2 VISTAS. The leeward slopes of the region where the collection and pressure-breaker reservoirs are located are largely void of man-made intrusions. The vistas enjoyed most often and commonly along these slopes are those seen by motorists driving the coastal highways in the region. For that reason, all of the project's reservoirs are located mauka of the highway to preserve existing views toward the skyline and along the shoreline. They would also be located sufficient distance away from the highway to reduce their visibility to motorists. To the extent possible, the designers plan to avoid large scarring cuts in the hillside by careful siting of the reservoirs. In addition, to reduce the unnatural appearance of the concrete tanks, the structures are to be finished in earth-tone colors that would blend with on-site landscaping and growth in the surrounding area.

3.4.3 GROUND WATER RESOURCES. The primary activity of the proposed project is to recover groundwater from the Hawi aquifer and transport it to South Kohala. The basal aquifer from which the supply is to be recovered is recharged continually, primarily by infiltration of rainfall. The U.S.G.S. concluded from its study that the withdrawal of 20 mgd is feasible with proper well spacing, depth and pumping rates.[5]

3.4.4 STREAM FLOW. Of the four types of groundwater found in the islands–dike, perched, confined basal, and unconfined basal, only the first three contribute to stream flow. Unconfined basal groundwater flows directly into the sea and does not contribute to streams.[6] The coastline of the Hawi aquifer system is rocky and not rimmed with a sedimentary caprock that would be a barrier to free flow of basal water.[7] In addition, since the streambed elevations are higher than the basal water table, withdrawal of basal water by the proposed project would not affect stream flow near the wells (see page 9-4 Water Resources for effect of pumping at Pololu Stream mouth).

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5 Ibid Note 4, Page 55.

6 State of Hawaii Commission on Water Resource Management. *Hawaii Stream Assessment.* Page 5, 6. Prepared by Hawaii Cooperative Park Service Unit, National Park Service. December 1990.

7 State of Hawaii Commission on Water Resource Management. *Water Resources Protection Plan.* Page V-25. Prepared by George A.L. Yuen and Associates Inc. June 1990.

3.4.5 WETLANDS. The biological survey notes that in the authors' judgement the location of the pipeline in the roadbed will preclude direct effect to wetlands. The authors also noted that although the survey did not constitute an Army Corp of Engineers wetland determination, it is not anticipated that there will be any direct project effects on wetlands. See **Appendix D**, Biological Survey.

3.4.6 COASTAL WATER QUALITY. The withdrawal of basal water by the proposed project will decrease the discharge of groundwater at the shoreline in North Kohala, and increase the discharge in some areas of South Kohala. See **Appendix C** for two-part report on the effect on water quality and nearshore marine communities from the proposed project. The conclusion of the report is as follows:

"Several studies were conducted to determine the potential effect of the proposed project on water chemistry and marine community structure. Of particular interest with respect to the marine communities were edible benthic algae (limu) in North Kohala and reef-building corals in South Kohala. Concern for these two aspects of the marine ecosystem were centered on the perception that: 1) limu depend on nutrients from land for growth, and a reduction of these nutrients will result in decreased algal abundance, and; 2) corals can be negatively impacted by changes in water chemistry as a result of input of materials from land.

The studies revealed that there appears to be no potential for negative impacts to marine ecosystems in either North or South Kohala from the diversion of groundwater. The primary reasons for this conclusion stem from the physical properties of the marine environments in both districts. Direct exposure to tradewind generated wind and swells, as well as long period swells from the north result in extremely well-mixed nearshore environment in North Kohala. As a result, groundwater diffusing to the ocean is rapidly diluted by the infinitely large reservoir of ocean water to background oceanic concentrations. Measurements made during rare conditions when seas were relatively calm showed only relatively small horizontal and vertical gradients of groundwater constituents (freshwater, NO_3^- and PO_4^{3-}). Reducing these gradients by the amount of groundwater that is proposed to be pumped to South Kohala would have virtually no qualitative effect on nearshore water chemistry. During typical conditions, the effect of such pumpage would likely not even be measurable. In addition, the effects of the project would be insignificant because the primary input of freshwater to the coastal region of North Kohala is by surface flow (streams) which will not be affected by the alteration in groundwater flow.

Measurements of the ratio of stable isotopes $^{15}N/^{14}N$ have proven to provide a reliable tracer for the origin of nutrients incorporated into tissue of marine plants. Measurements of $\delta^{15}N$ in marine algae (limu) collected in coastal areas revealed that plants growing in freshwater (streams or groundwater) have a distinctly different $\delta^{15}N$ signature than plants growing in ocean waters. Limu collected on the rocks in the area of mixing between freshwater and ocean water had ratios that were primarily oceanic in nature. While sampling was limited due to dangerous sea conditions, the isotopic ratio of limu kohu collected offshore revealed that tissue N was totally of oceanic origin. These results indicate that marine waters without influence from land contain sufficient nutrients for growth of limu that is used as a foodsource. Owing to the intense mixing that characterizes the nearshore area of North Kohala, groundwater is rapidly diluted to oceanic concentrations within the zone that most algae grows. In addition, because of the diffuse discharge characteristics of groundwater in the North Kohala area, limu responding to freshwater are generally growing with input from point source stream discharge which will not be affected by the proposed project. These results indicate that changes in groundwater discharge will not have any affect marine algae.

As reef corals typically grow in oceanic water, it is important to consider the potential for negative effects from changes in groundwater input that will occur as a result of the proposed project. There will be no effects to reef corals or associated communities in North Kohala where groundwater input to the ocean will be decreased. While groundwater input will increase with the project in South Kohala, the scientific literature documents that corals can tolerate decreases in salinity and increases in nutrients to certain levels. Measurements of the gradients of salinity and nutrients at the South Kohala study sites indicate that while there are steep gradients of salinity and nutrients near the shoreline, there is no effect to coral abundance. With the increase in groundwater flux associated with the project, water chemistry will not change from present conditions with respect to exceeding the physiological tolerance of corals. At present, well-developed coral communities exist in the region of highest groundwater input. In addition, regardless of the level of input, groundwater that enters the ocean and is not diluted with ocean water persists as a surface layer that is not exposed to bottom-dwelling organisms. In sum, it is clear that the projected changes in groundwater flux from the Kohala Water Transmission System will not have any effect on nearshore marine communities."

3.4.7 NOISE. Diesel-fueled generator sets would be located at Well Sites C, D, and E to power the pumps at the well sites. A noise study (see **Appendix E**) to examine the effect of the diesel generator sets on neighborhood noise levels reported the following:

The 800 kw generators were all assumed to be installed in quiet containers, with estimated noise levels of 72 dBA at 50 feet distance. The nearest residences to the three sites are at distances ranging from 1,200 to 1,400 feet distance from the well sites where the generators are planned to be located.

The noise descriptor currently used by federal agencies to assess environmental noise is the Day-Night Average Sound Level (Ldn). This descriptor incorporates a 24-hour average of instantaneous A-Weighted Sound Levels as read on a standard Sound Level Meter. The minimum averaging period for the Ldn descriptor is 24 hours. Additionally, sound levels which occur during the nighttime hours of 10:00 PM to 7:00 AM are increased by 10 decibels (dB) before computing the 24-hour average by Ldn descriptor.

An exterior noise level of 55 Ldn is considered "compatible, or Unconditionally Acceptable" level of exterior noise for low-density, residential areas. The existing State Department of Health (DOH) property line noise limits, applicable only to Oahu, for single family residences limit daytime noise levels to 55 dBA from 7:00 AM to 10:00 PM, and limit nighttime noise levels to 45 dBA from 10:00 PM to 7:00 AM.

Existing average background ambient noise levels were measured at the locations shown in Enclosure 1 (see **Appendix E**) near the proposed Well Sites "C" thru "E" during the afternoon of December 16, 1994 and during early morning hours of December 17, 1994. Average background ambient noise during the late afternoon hours of 5:00 to 6:00 PM ranged from 42 to 46 dBA, and was controlled by the natural sounds of birds, farm animals, and foliage movement with the wind. During the early morning hours of 4:00 to 5:00 AM the next day, measured average background ambient noise levels were similar at 43 to 45 dBA, primarily due to foliage movement with the wind. Minimum background ambient noise level measure during periods of calm winds was 37 dBA. Based on these measurements, the existing natural (not man-made) background ambient noise levels at the existing residences near the three well sites were estimated to range from approximately 40 to 45 Ldn.

The noise level of a quieted diesel generator will decrease to levels below 72 dBA with increasing distance beyond 50 feet from the generator. Meteorological factors, temperature gradient and wind conditions, as well as local shielding effects will affect the degree of reduction of the generator noise level with increasing distance. Enclosure 4 (see Appendix E) provides the predicted range of generator noise levels with increasing distance from the generator as the shaded area.

The nearest existing residences to the three proposed well sites with operating diesel generators are located between 1,200 and 1,400 feet from the well sites. At these distances, predicted generator noise levels range between 32 and 46 dBA, with the lower near 32 dBA expected to occur during the daylight hours, and the higher levels near 46 dBA expected to occur during the early morning hours before sunrise. With daytime background ambient noise levels in the mid-40 dBA range, the generators may not be audible, and risks of adverse noise impacts are expected to be relatively low during the daytime hours.

The worse case conditions are expected to occur during the early morning hours before sunrise when background ambient noise levels are typically at their lowest levels and when generator noise levels may be at their highest levels due to meteorological factors. Under worst conditions, generator noise levels may exceed the State DOH nighttime limit of 45 dBA for residences on Oahu, and will probably be audible above the lower nighttime background ambient noise levels of 37 to 45 dBA. Approximately 5 to 10 dB of additional quieting (or sound attenuation) will be required at the three generator powered well sites to minimize risks of adverse noise impacts or complaints at the nearest residences.

3.4.8 AIR QUALITY. An air quality study was conducted to examine the potential effect on air quality from emissions emanating from the diesel generator units. See **Appendix E** for copy of the study. The study concluded as follows:

"Although there are no air quality data available for the project area, it may be surmised that current air quality conditions are relatively pristine. This is due to the absence of air pollution sources and the prevailing upwind location of the project area with respect to Kilauea Volcano.

The diesel generator units at each of the three Phase I well sites will be relatively small sources of air pollution. Based on Department of Health definitions, only nitrogen oxides emissions from an individual generator unit would be considered significant enough to warrant an ambient air quality impact assessment.

Atmospheric dispersion modeling results indicate that nitrogen oxides emissions from an individual generator unit could potentially exceed ambient air quality standards if a discharge plenum or rooftop stack is used. This is due primarily to plume downwash caused by a building wake effect that the generator enclosure would create in moderate to high wind speeds. On the other hand, the dispersion modeling results show that maximum impacts would be well within ambient air quality standards if the generator stack height conforms with good engineering practice. This would even be so even if there are cumulative impacts due to the relative nearness of the three generator sites. Thus, it is recommended that a separate stack be used to exhaust combustion gases from each generator unit and that the stack be extended to good engineering practice stack height. In the case of the proposed generator units, this means that the generator stack height should at least 2.5 times the enclosure height.

Several odorous compounds will likely be present in the generator exhaust gases at low concentrations, but these should not be detectable at or beyond the well site boundaries. To ensure that odor problems are avoided, a routine maintenance program should be established to keep the generator engines well-tuned so as to minimize unburned hydrocarbon emissions."

3.5 USE OF PUBLIC FUNDS AND LANDS

3.5.1 PUBLIC FUNDS

The Department of Water Supply (DWS) is a semi-autonomous agency of Hawaii County. The department has a separate water fund which is used solely for water purposes. Funds appropriated by the County and State for water are included in this fund.

The DWS has received appropriations from the State Legislature in 1990 and 1993 amounting to a total of $2,920,030 for planning and design of the proposed project. The appropriations have been encumbered for project activities.

The DWS is planning to recommend use of Hawaii County backed long term general obligation bonds to finance the construction of the project plus incidental costs to organize and market the bond. The estimated cost of the project is $80,030,000. A summary of the preliminary construction cost estimate is provided in **Section 3.3.2**, above.

The DWS anticipates that developments subscribing to water from the proposed water system would pay their pro-rata share of the bond repayment as a condition to obtain a water commitment. The Department of Water Supply does not plan to apply any water sales revenue or request an increase in water rates to help repay the bond issue.

3.5.2 PUBLIC LANDS

Public lands involved in the proposed project include use of rights-of-way lands of four highways and use of two parcels. The beginning and ending segments of the pressure collection pipeline from the supply wells to the collection reservoirs in the Puakea Ranch vicinity are located within the right-of-way of the Hawi-Niulii Highway and the Akoni Pule Highway. The gravity-flow transmission pipeline from the collection reservoirs to the terminal reservoirs is located within the right-of-way of the Akoni Pule Highway, Kawaihae Road, and Queen Kaahumanu Highway. All project construction within these highways must be approved by State Department of Transportation, Highways Division.

The pressure-breaker site and its related access road and utility corridor are located on State of Hawaii owned *ahupua'a of Makiloa* in North Kohala. Application for set-aside of the lands required for the reservoir site and road and utility corridor must be made to and approved by the State Board of Land and Natural Resources.

The Kawaihae 1.0 MG terminal reservoir site is located on land owned by the State Department of Hawaiian Home Lands. The assumption is that upon completion of the subdivision roadway improvements, the streets will be dedicated to the County. Access and installation of pipeline to the reservoir can be on the public streets. Application for set-aside of the land for the reservoir site must be made to and approved by the State Commission on Hawaiian Home Lands. Depending on the timing of the DHHL project, an easement may be required for the pipeline and access corridor to the reservoir.

The six well sites, collection reservoir site, and the Kaunaoa and Tri-Kohala terminal reservoir sites are on privately owned lands. The DWS will negotiate directly with the private land owners for use of the lands. No major cash outlay of project funds for land acquisition are anticipated. There may be expenses for land surveys, title searches, appraisals and other incidental work related to land acquisition.

3.6 PHASING AND TIMING

The DWS plans to construct the proposed project in two phases of 10 mgd capacity each. The schedule given below is very tentative. It is shown to indicate the relative timing between the primary activities leading to project completion. Thus, projections in the EIS that may be tied to these dates should be reviewed as being tentative also. In view of the difficult current economic conditions, it is more likely that firmer scheduling will happen only after the economy strengthens and development climate improves.

Phase I:

Planning, design, and approvals for construction .... 1993 to 1996
Construction financing approval and bond float .... 1996 to 1997
Construction .... 1998 to 2000

Phase II:

Construction .... Timetable Not Set

3.7 SUMMARY OF TECHNICAL INFORMATION

The tables and drawings listed below are included in the following pages for the information of parties interested in details on the well, booster station, and reservoir sites.

Notes on the drawings of the well sites:

- The pumped water laterals from the wells to the pumped water collection line are located in the access roadways to the well sites. The power and telephone lines for telemetering would also be located within the roadway.
- The 1,000 foot radius circle around the well site represents the area within which Department of Health regulations prohibit the placement of any wastewater cesspool, seepage pit or soil absorption system unless approved by the Director of Health.
- The 1/4 mile radius circle represents the area around a well within which Department of Health regulations prohibit construction of an injection well. An injection well means a well into which subsurface disposal of fluid occurs by injection. An example of injection well is the "dry well" commonly used to drain rainwater in parking lots and along the edge of roadways.

Table 3.7-1
PHASE I - SCHEDULE OF PROPOSED WELL SITES, RESERVOIR SITES, AND BOOSTER PUMP STATION SITES

Info Source: Okahara & Associates Inc

WELL SITE C Two-2.0 mgd wells	5-3-03:1	Site requires approximately 1.0 acre Access and utilities via existing dirt road Land owned by Chalon International of Hawaii Inc
WELL SITE D Two-2.0 mgd wells	5-3-04:1	Site requires approximately 1.0 acre Access and utilities via existing dirt road to Pratt Road Land owned by Chalon International of Hawaii Inc
WELL SITE E Two-2.0 mgd wells	5-3-04:1	Site requires approximately 1.0 acre Access and utilities via existing dirt road to Pratt Road Land owned by Chalon International of Hawaii Inc
KAPAAU BOOSTER PUMP STATION	5-4-03:2	Site requires approximately 0.75 acre Access and utilities via existing dirt road Connector pipeline along existing Hawi-Niulii Highway Land owned by Chalon International of Hawaii Inc
0.10 MG KAPAUU RESERVOIR	5-4-03:3	Same site as existing Kapaau Reservoir Existing reservoir not in use and will be removed Land owned by County of Hawaii DWS
KYNNERSLEY BOOSTER PUMP STATION	5-4-03:2	Same site as Well F of Phase II Initial site requirement approximately 0.75 acre
HAWI BOOSTER PUMP STATION	5-5-02:23	Site requires approx. 1.5 acre including proposed DWS baseyard Access via existing Hawi well site driveway Connector line will run through TMK 5-5-08:46, 56, 43, 20, and 45 along existing dirt road (makai of highway) and TMK 5-5-02:23 along existing dirt road (mauka of highway) Land owned by Chalon International of Hawaii Inc
PUAKEA COLLECTION RESERVOIR SITE Two-3.0 MG reservoirs	5-6-01:51	Site requires approximately 7.5 acres Requires slope easement from Shalon International of Hawaii Access and utilities via existing dirt road and new roads Land owned by Richard Smart Trust (Parker Ranch)
PRESSURE BREAKER RESERVOIR SITE One-1.0 MG reservoir	5-9-03:4	Site requires approximately 1.5 acres Requires new access road and utilities corridor Land owned by State of Hawaii
KAWAIHAE TERMINAL RESERVOIR SITE One-1.0 MG reservoir	6-1-01:3	Site requires approximately 1.5 acres Access road and utilities corridor to follow DHHL 10-Year MP Land owned by Department of Hawaii Home Lands
KAUNAOA TERMINAL RESERVOIR SITE One-1.0 MG reservoir	6-2-01:63	Site same location as existing 0.30 mg Kaunaoa Reservoir Site expansion required Land for expansion owned by Mauna Kea Properties
TRI-KOHALA TERMINAL RESERVOIR SITE One-1.0 MG reservoir	6-8-01:6	Site requires approximately 1.5 acres New access road from dirt road to Lalamilo wells Utilities to reservoir in easement, Tri-Kohala Development land Land owned by Tri-Kohala Development Inc

Table 3.7-2
PHASE II - SCHEDULE OF PROPOSED WELL SITES AND RESERVOIR SITES

Info Source: Okahara & Associates Inc

WELL SITE A Two-2.0 mgd wells	5-2-05:1	One well to serve as standby Site requires approximately 1.0 acre Access road and utilities to site on existing dirt road Land owned by Chalon International of Hawaii Inc
WELL SITE B Two-2.0 mgd wells	5-2-06:3	Site requires approximately 1.0 acre Access road and utilities to site on existing 60 feet wide roadway easement Land owned by Chalon International of Hawaii Inc
WELL SITE F One-2.0 mgd well	5-4-03:2	Site requires approximately 1.0 acre Access road and utilities to site on existing dirt road Access road and utilities to collector line on existing dirt road to Pratt Road TMK 5-4-06:9 (makai of highway) Land owned by Chalon International of Hawaii Inc
PUAKEA COLLECTION RESERVOIR SITE One-6.0 MG reservoir	5-6-01:51	Same site as Phase I collection reservoir site Access road to site on existing road Utilities to reservoir in existing road Land owned by Richard Smart Trust (Parker Ranch)
TRI-KOHALA TERMINAL RESERVOIR SITE One-1.0 MG reservoir, actual sizing will depend on need	6-8-01:6	Same site as Phase I Tri-Kohala Terminal Res Site Same access road as Phase I Same utilities easement as Phase I Land owned by Tri-Kohala Development Inc

Table 3.7-3
DESCRIPTION OF TEMPORARY ABOVE GROUND DIESEL FUEL STORAGE VAULTS FOR POWER GENERATORS

The diesel fuel for the temporary diesel generator sets at Well Sites C, D, and E of Phase I will be stored in above-ground storage tank (AST) system. Each storage tank will be constructed of a UL listed rectangular steel tank enclosed in secondary containment membrane and encased in six inches of reinforced concrete. The fuel storage system will be designed based on above-ground tanks manufactured by ConVault, or an approved equal. ConVault tanks have been installed for fuel storage at many locations on the Big Island, as well as, statewide and nationwide.

Some of fire safety and environmental benefits include:

1. ConVault's seamless six-inch concrete vault and insulation layers gives thermal protection that minimizes temperature change for flammable liquids stored in excessively hot or cold environments. The system contains no cold joints or hat transfer points on the bottom or sides.

2. The monolithic concrete shell provides 2-hour fire protection based on tests by Warnock-Hersy, International and Underwriters Laboratories of Canada (ULC). It is also bullet resistant.

3. Designed in a rectangular shape with a low center of gravity. ConVault tanks can withstand vehicle incursions and tipping during earthquakes and other natural disasters. Earthquake restraint hardware will be provided.

4. ConVault tanks meet NFPA 30 and 30A fire safety standards and are fitted for ground per NFPA 78. The unit also complies with the 1991 Uniform Fire Code Appendix II-F for the above ground storage and dispensing of motor fuels.

5. ConVault tanks have been certified by the California Air Resources Board for Balanced Phase 2 Vapor Recovery.

6. Primary steel tank and overfill containers bear UL labels and meet UL Standard 142. The special enclosure has been successfully exposed to a 2-hour liquid pool fire test by Underwriters' Laboratories of Canada.

7. The tank system will include secondary containment by an impervious barrier of 30 mil high density polyethylene to contain leaks from the primary tank. A leak detection access tube will be located between the inner tank and secondary barrier. In the event of a leak, a positive space shall be available to permit leaked fluid to flow to the detection tube.

8. The tank system will include a minimum 5-15 gallon, powder-coated external or internal UL listed overfill/spill containment surrounding the fill pipe. The overfill/spill container will include a normally closed valve to release spilled product into the main tank.

9. Overfill protection will be provide by two or more of the following methods: a) direct reading level gauge at tank visible from fill pipe access; b) valve located within fill pipe to close automatically at a specified fill level; c) audible high level alarm activated by a float switch at a specified fill level.

10. Tank system venting will conform to UFC and UL/UIC standards.

11. Vaults will have concrete support legs of unitized monolithic construction to provide visual inspection capability.

12. The tank system will have a coated exterior to resist weather, reflect sunlight and inhibit corrosion.

Ref: Letter No. 43753 from Okahara & Associates, Inc. to Megumi Kon, Inc.

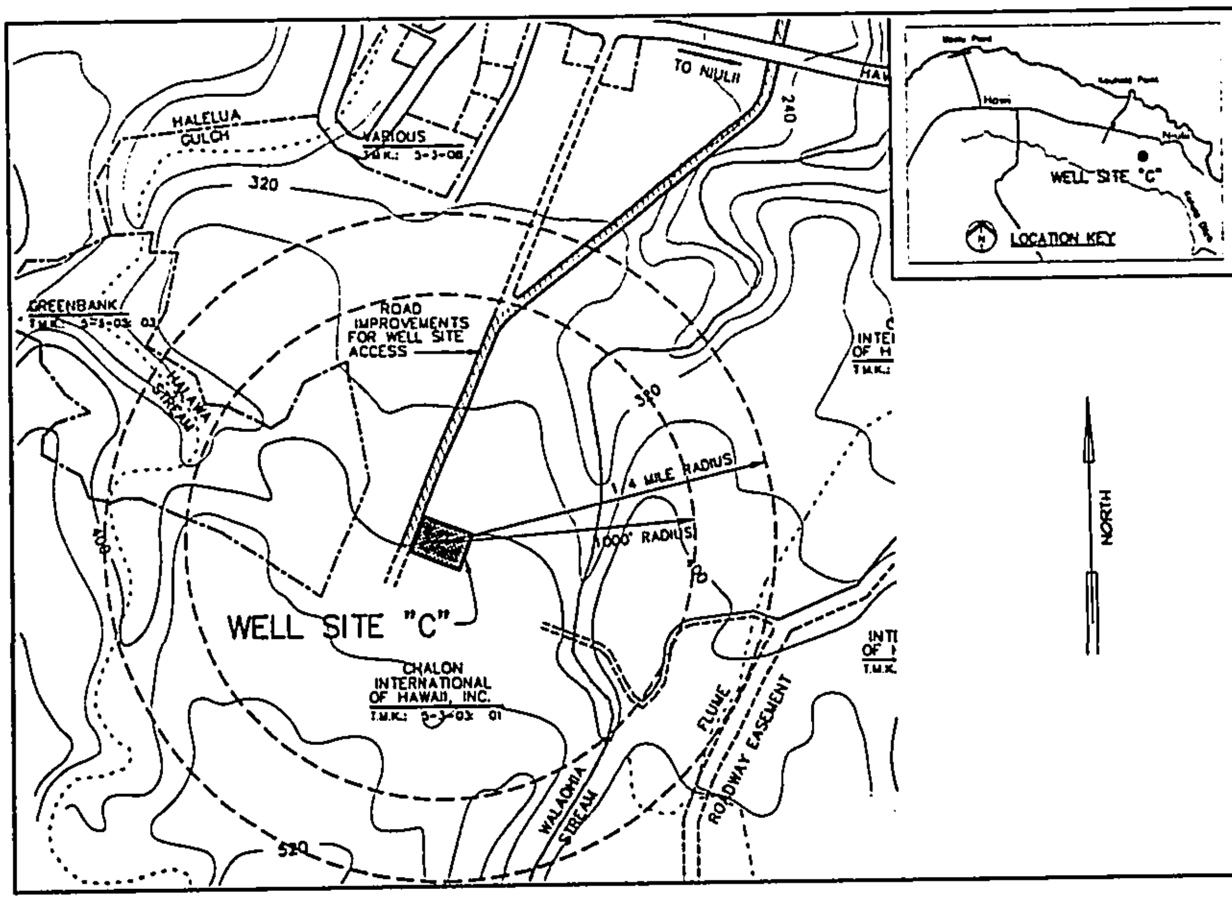

Figure 3.3-4 PHASE I - WELL SITE "C"
Map Source: Okahara & Associates, Inc.

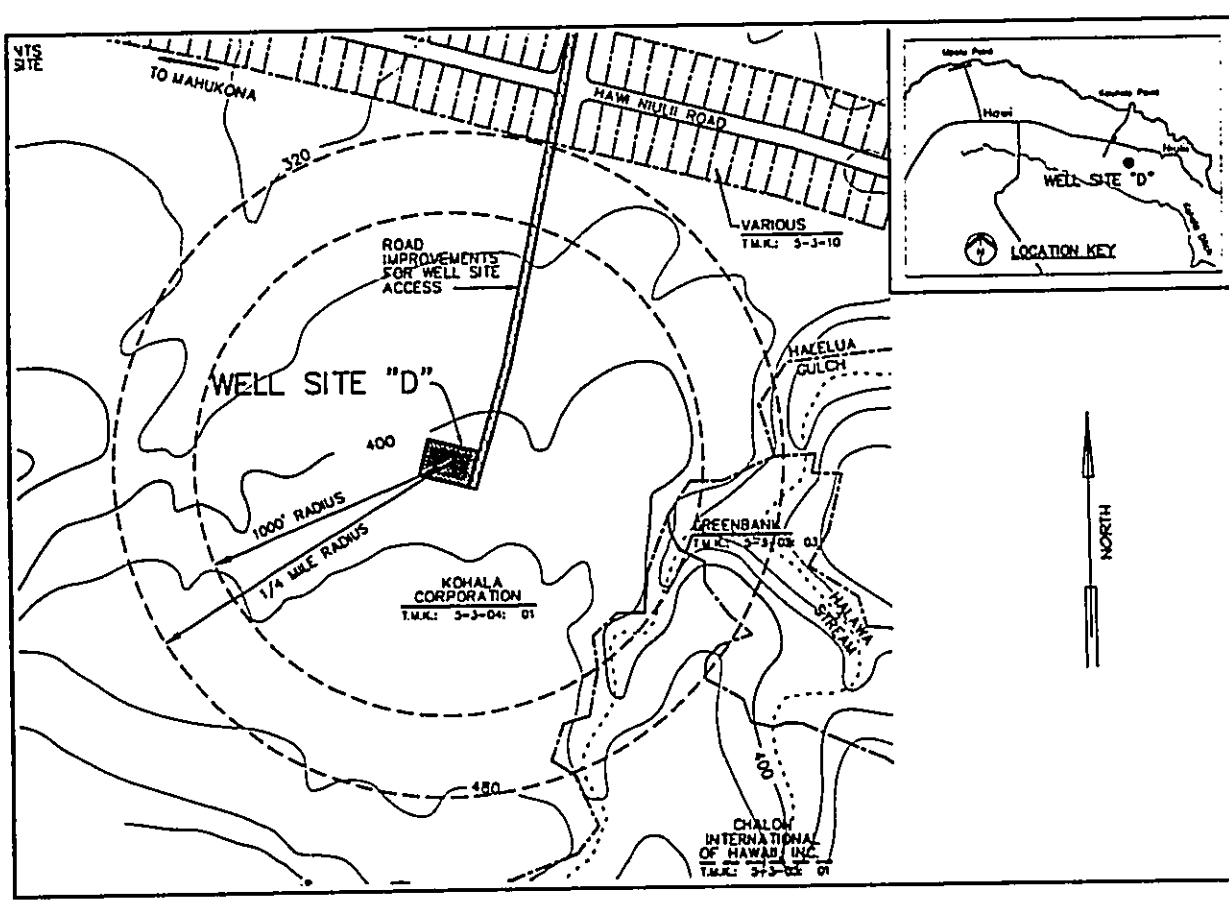

Figure 3.3-5 PHASE I - WELL SITE "D"
Map Source: Okahara & Associates, Inc.

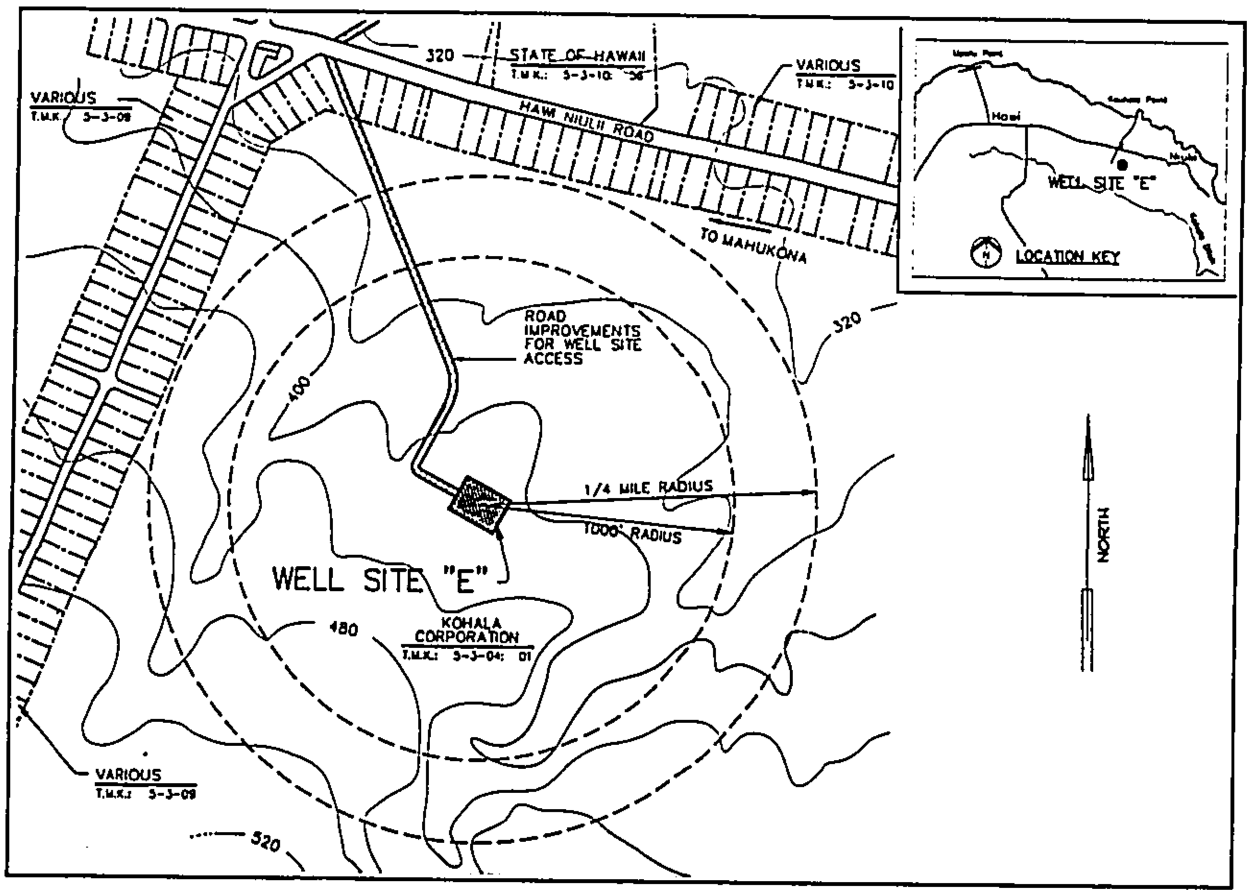

Figure 3.3-5 PHASE I - WELL SITE "E"
Map Source: Okahara & Associates, Inc.

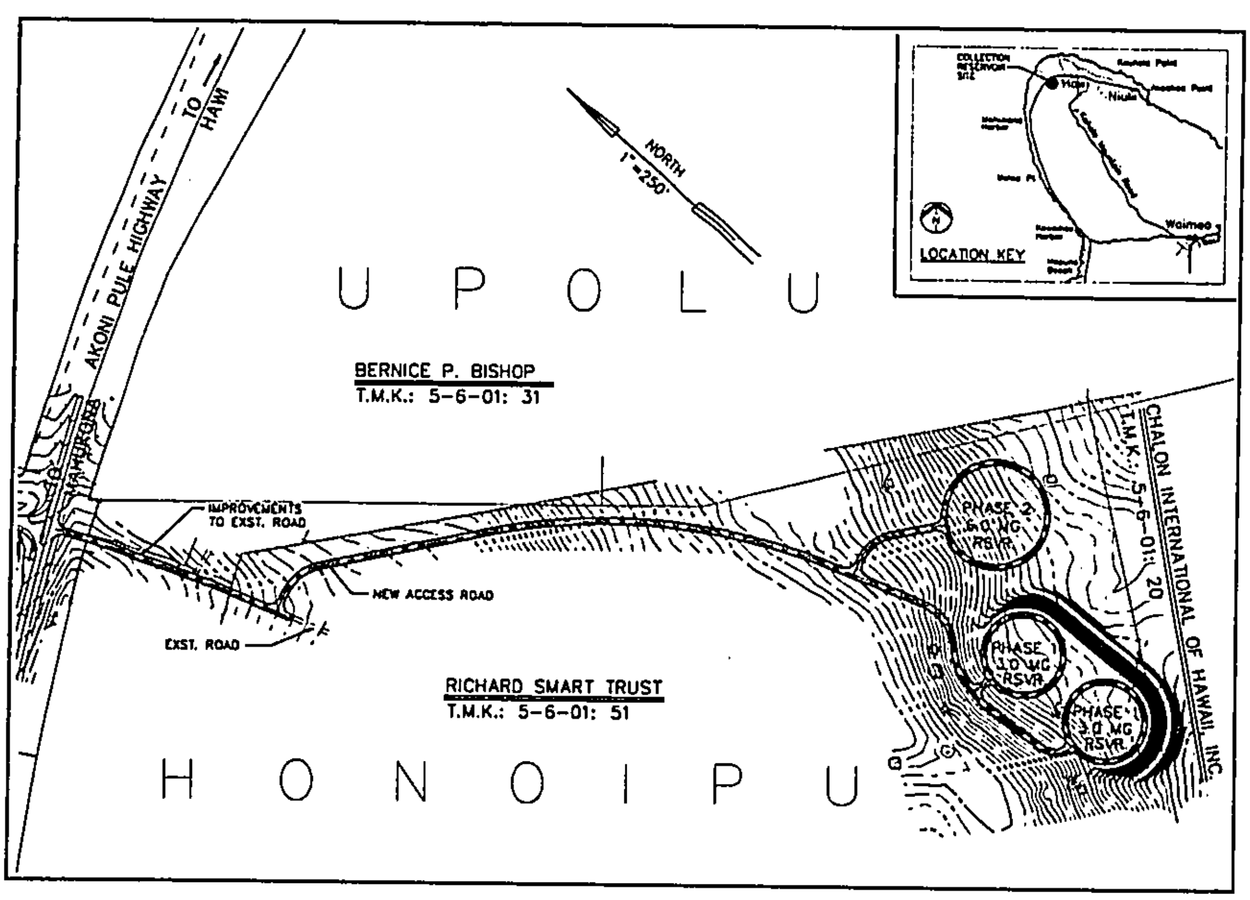

Figure 3.3-6 PHASE I - COLLECTION RESERVOIR SITE
Map Source: Okahara & Associates, Inc.

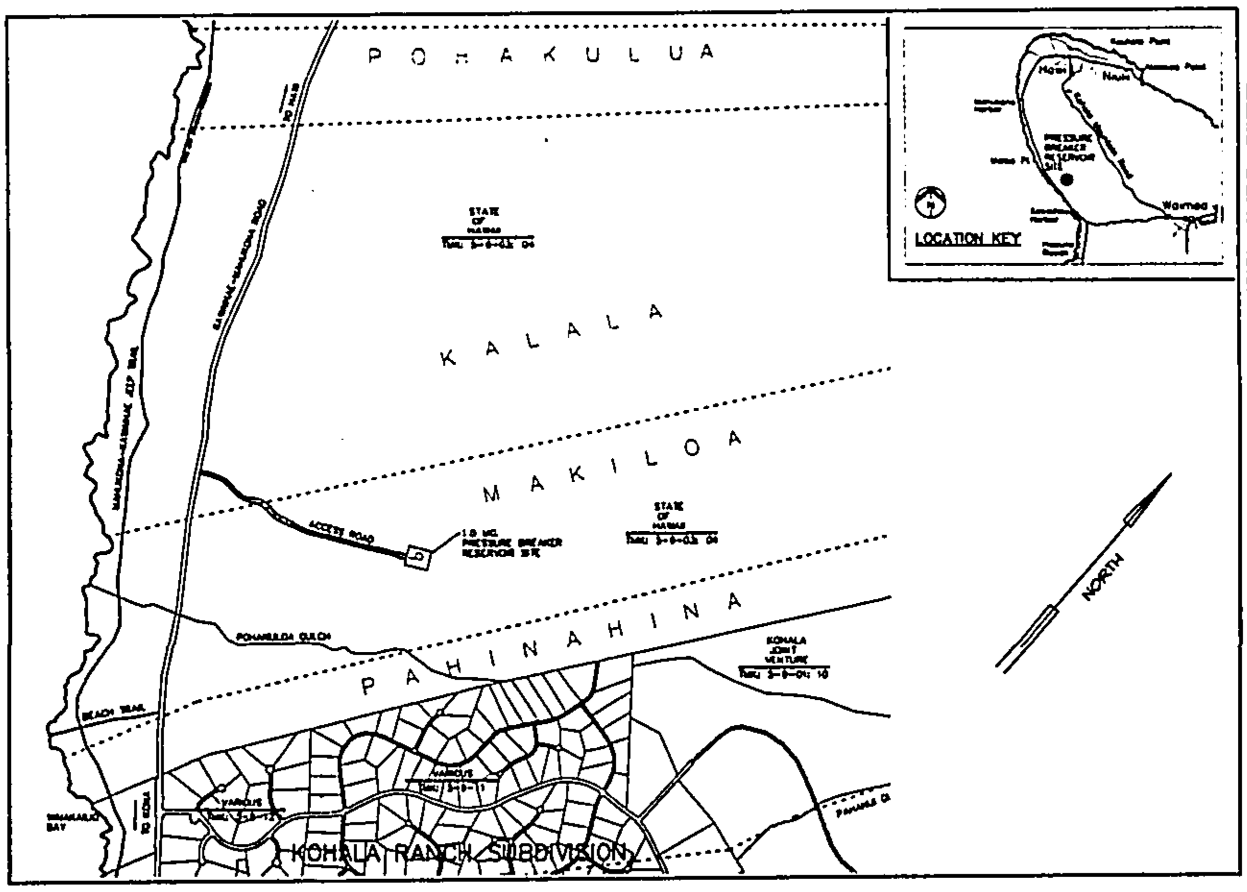

Figure 3.3-7 PHASE I - PRESSURE BREAKER RES. SITE
Map Source: Okahara & Associates, Inc.

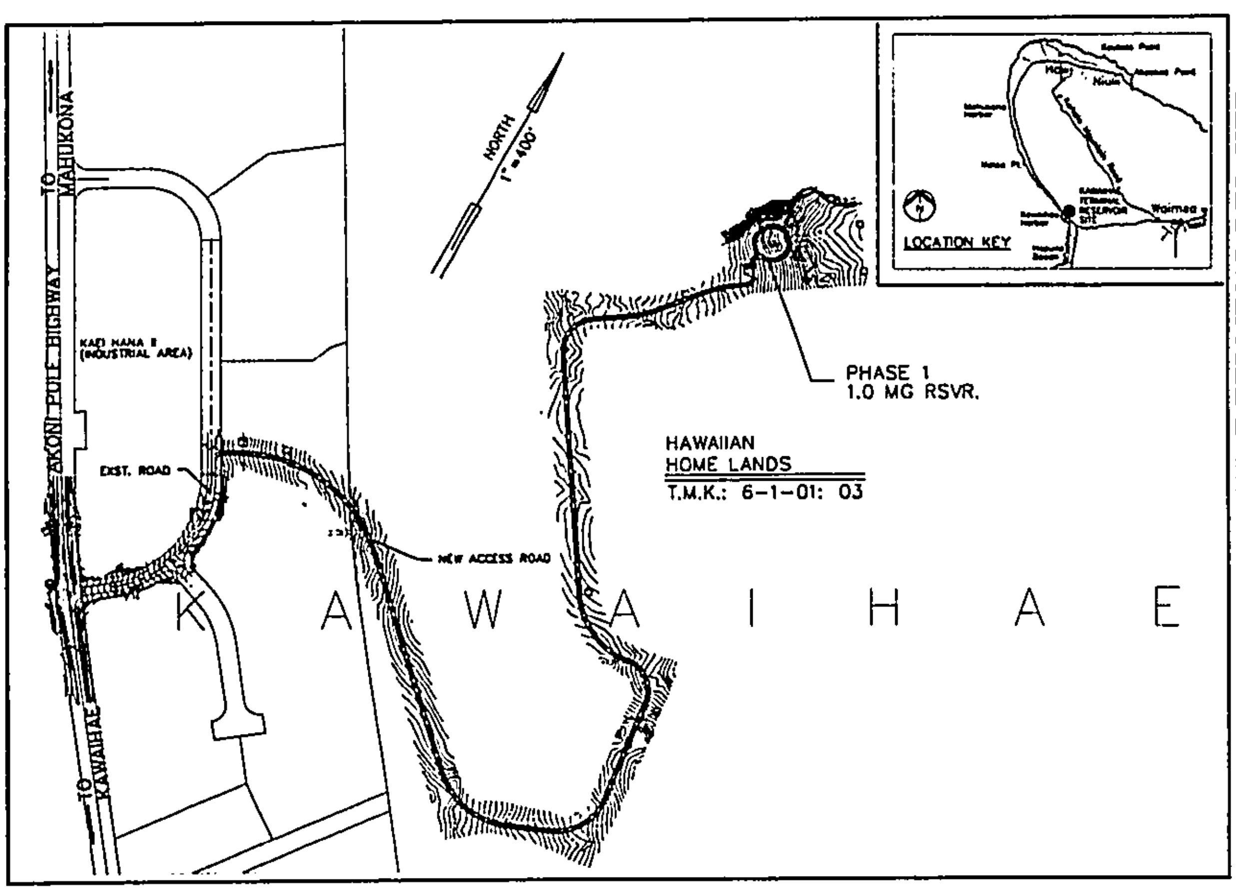

Fig. 3.3-8 PHASE I - KAWAIHAE TERMINAL RES. SITE
Map Source: Okahara & Associates, Inc.

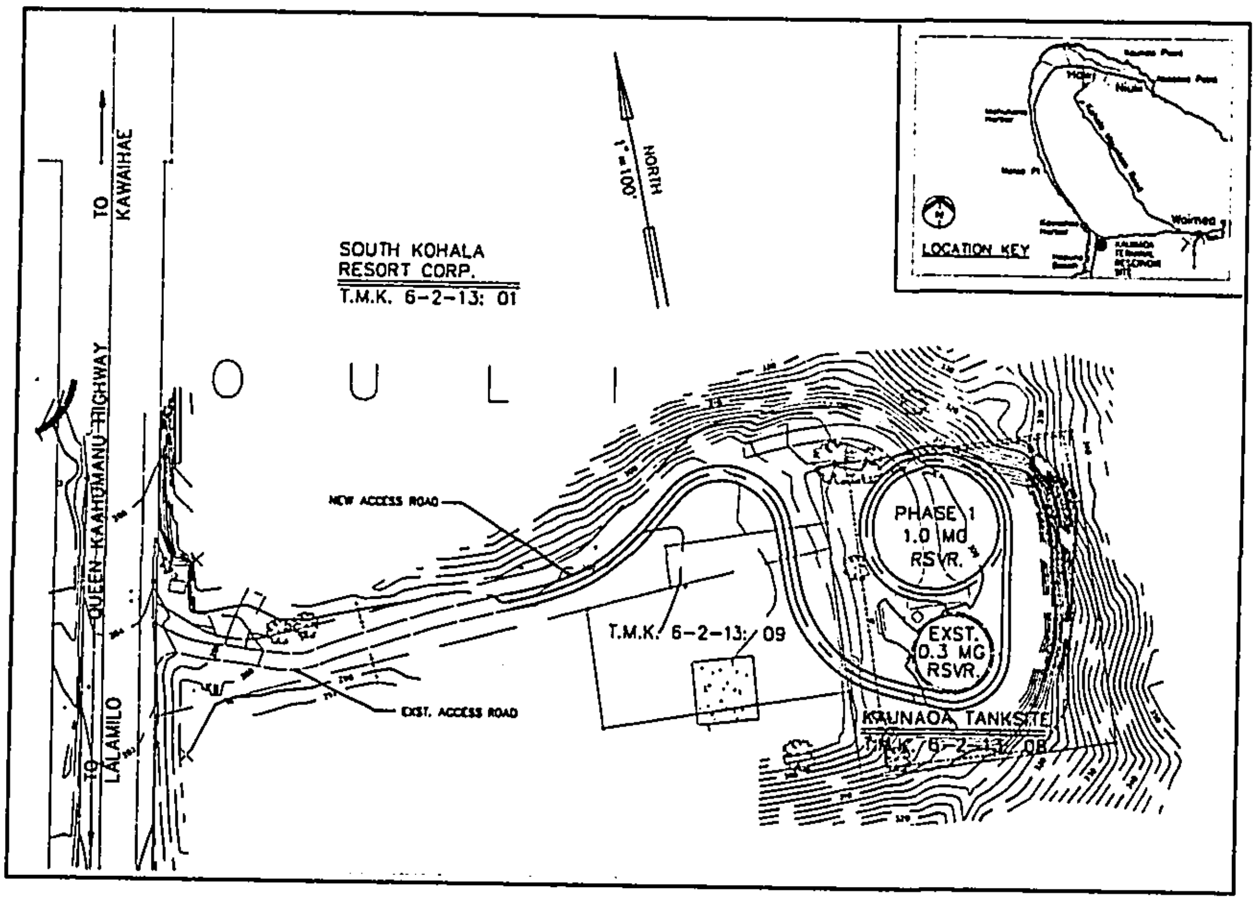

Fig. 3.3-9 PHASE I - KAUNAOA TERMINAL RES. SITE
Map Source: Okahara & Associates, Inc.

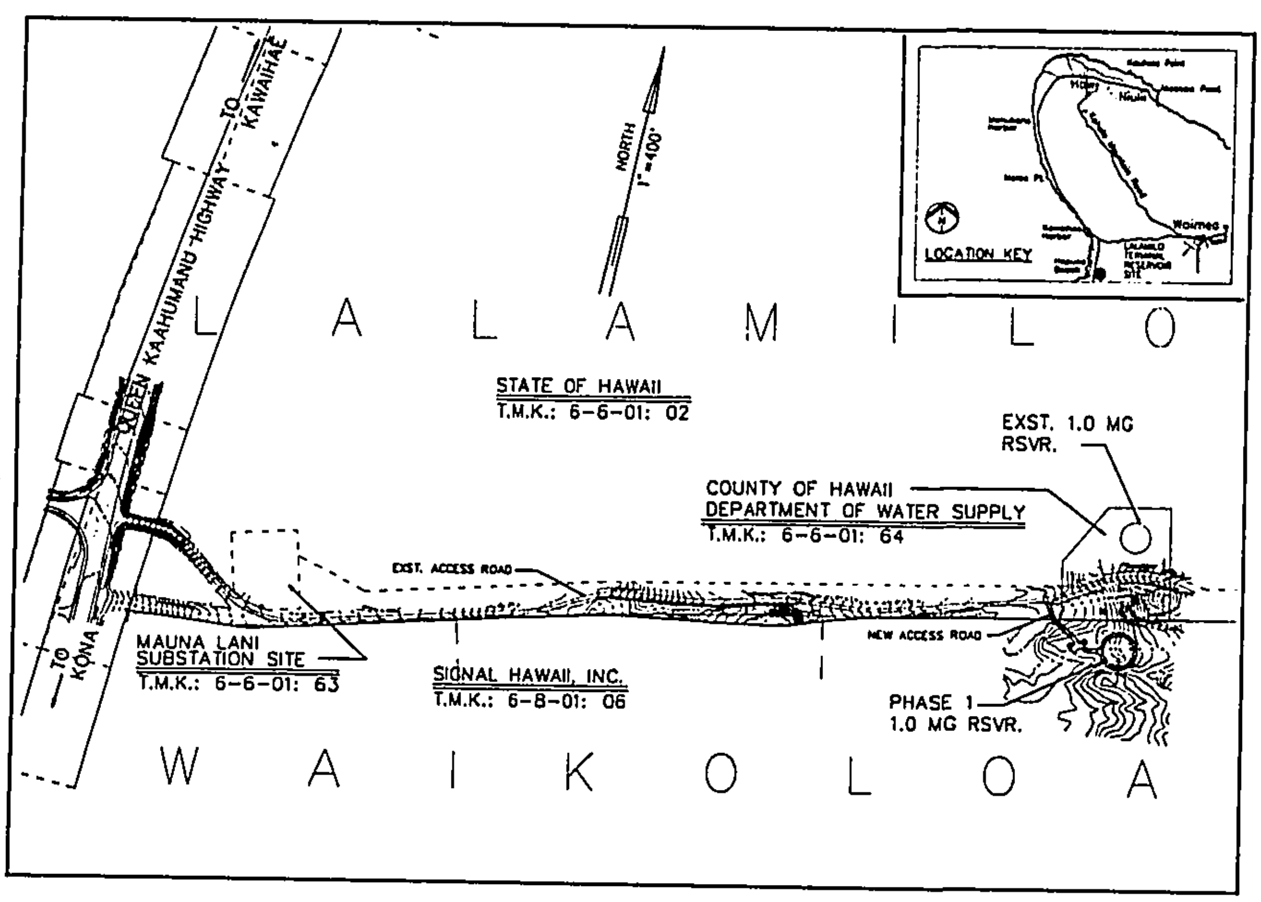

Fig. 3.3-10 PHASE I - LALAMILO TERMINAL RES. SITE
Map Source: Okahara & Associates, Inc.

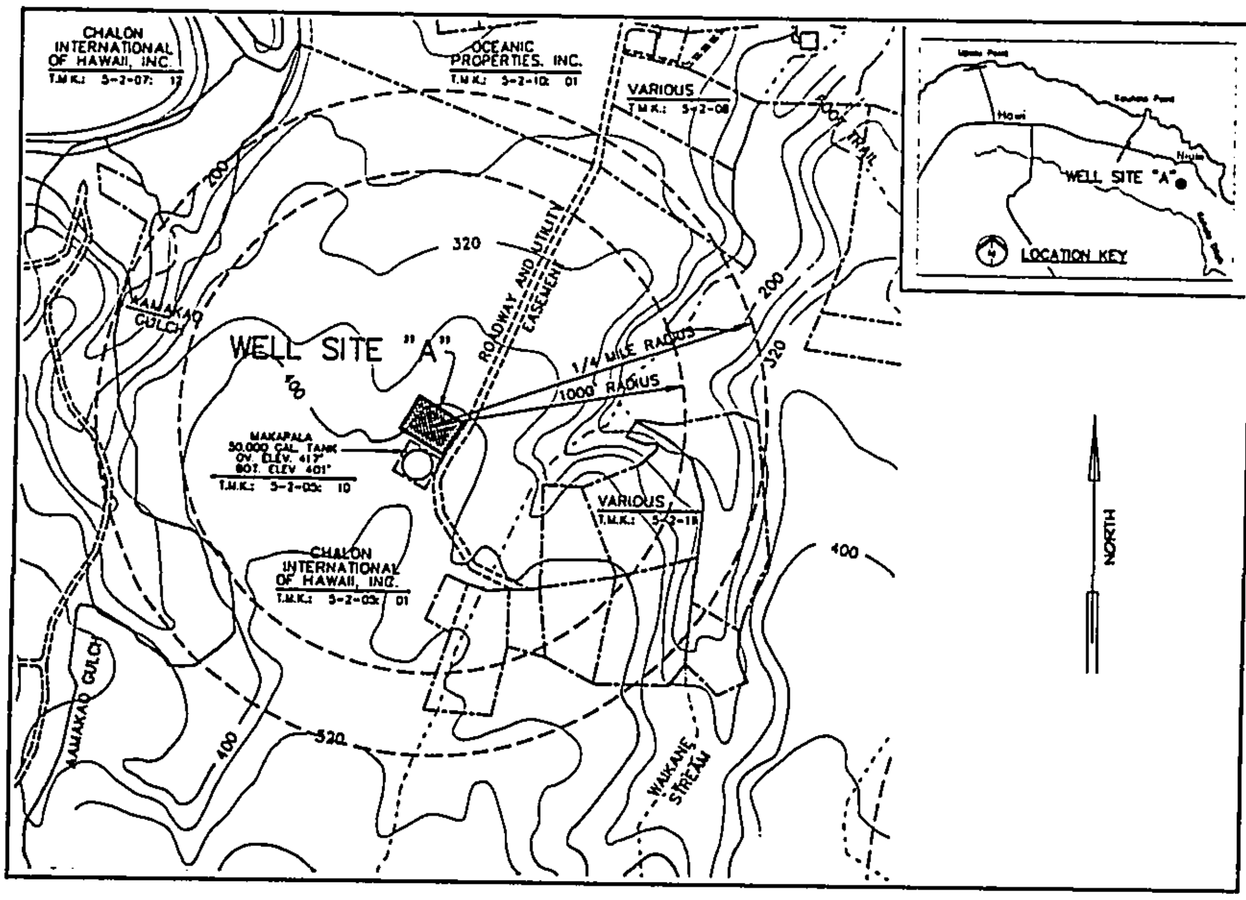

Figure 3.3-11 PHASE II - WELL SITE "A"
Map Source: Okahara & Associates, Inc.

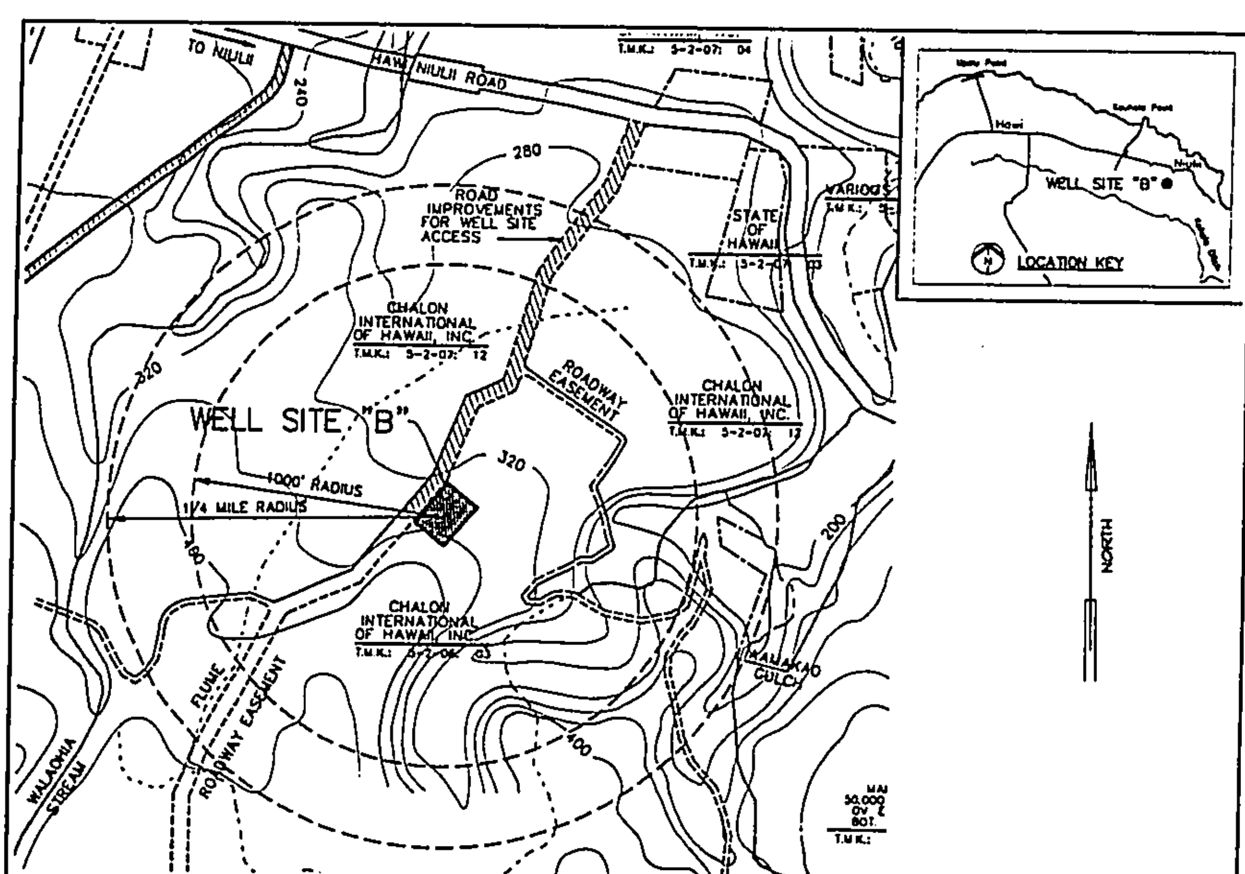

Figure 3.3-12 PHASE II - WELL SITE "B"
Map Source: Okahara & Associates, Inc.

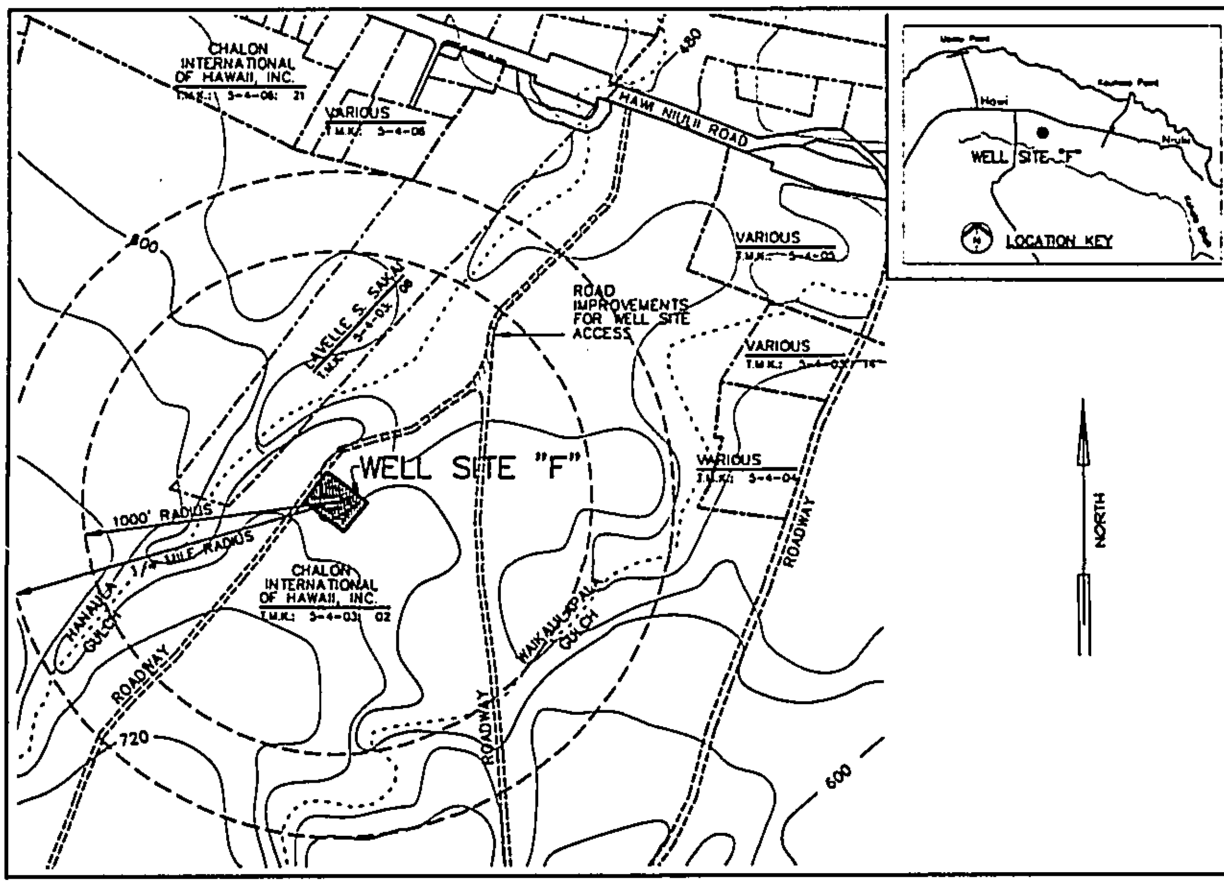

Figure 3.3-13 PHASE II - WELL SITE "F"
Map Source: Okahara & Associates, Inc.

SECTION 4
ALTERNATIVES TO THE PROPOSED PROJECT

The discussions in the following sections pertain to known alternatives to the proposed project. Alternatives considered by the Department of Water Supply were transfer of ground water from East Hawaii, desalination of brackish water, use of high-level ground water, and no action. The alternatives were not considered to have any significant advantage over the proposed project from environmental or cost standpoints.

4.1 TRANSFER OF GROUND WATER FROM EAST HAWAII

The State Department of Land and Natural Resources (DLNR) has been investigating the feasibility of recovering 20 mgd of basal ground water from the Hilo aquifer system and transmitting it to the upper Waimea region in South Kohala. The Water Resource Development and Across Island Transmission project is now in environmental review. It envisioned creating an opportunity for use of geothermal-produced electricity and to open potential agricultural areas along the pipe route.

Alternate B of the proposed project was reviewed for possibility as an alternative to the Proposed Action. Information on the proposed project was obtained from the revised draft environmental impact statement for the project.[1]

The uphill segment of the project between South Hilo and Pohakuloa Training Area (PTA) involves 9 deep wells with one 2.5 mgd pump each in the Waiakea-uka area and 38.4 miles of 42-inch diameter pressure-flow pipeline. A series of 8 booster pumps would lift the ground water from the well field to a 20 mg open reservoir at Pohakuloa Training Area. See **Figure 4.2-1** on the facing page. The pipeline follows existing roadways or powerline easements across undeveloped private and state lands in State Agricultural and Conservation Districts. Federal lands are also involved near PTA.

The downhill segment has two alternate routes. Alternate A would transport the water from PTA by gravity flow to a 140 mg open terminal reservoir at elevation 4,150 feet in the mauka Waimea region. The pipeline length of Alternate A from PTA to the terminal reservoir is 23.5 miles for a total project length of 61.9 miles.

Alternate B supplies the terminal reservoir via a loop that drops to elevation 2,700 feet, where it could be tied into the existing state and county water systems. The purpose of the loop was to allow using the proposed project to supplement the existing systems during emergencies and water shortages. The return leg of the loop requires two pump stations to boost the water to the terminal reservoir. The length of Alternate B from PTA to the terminal reservoir is 37.8 miles for a total project length of 76.2 miles.

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[1] State Department of Land and Natural Resources, DOWALD. *Revised Draft Environmental Impact Statement.* Prepared by Okahara & Associates, Inc. November 1992.

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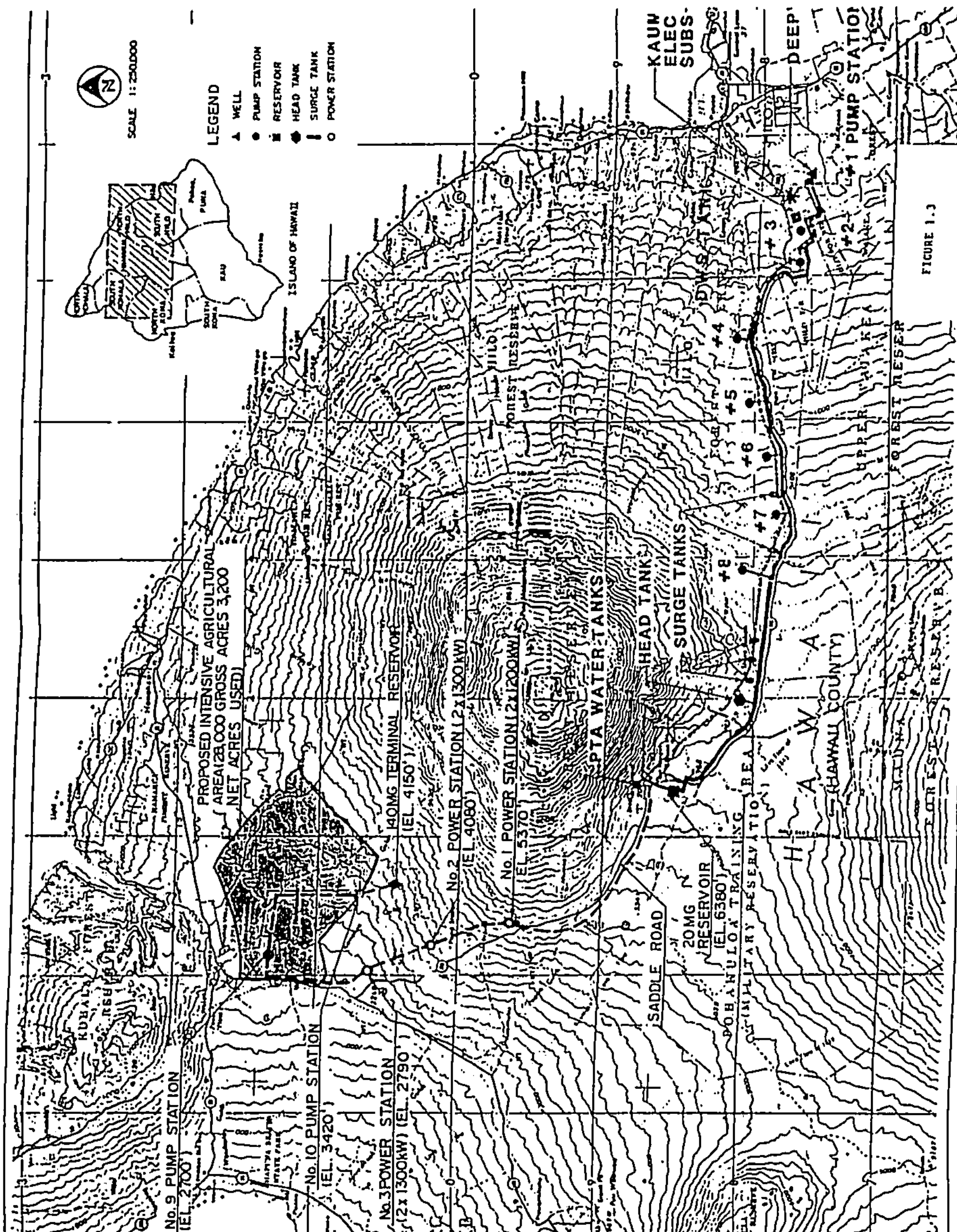

Figure 4.1.-1 GENERAL ARRANGEMENT OF PROJECT COMPONENTS
Map source: Revised DEIS-Water Development & Transmission Project, Hawaii. Nov 1992.

The project appears to have significant concerns that need to be addressed:

- Electrical power requirements are substantial (25-30 MW). Although a combination of geothermal power and hydroelectric power facilities may be possible, significant environmental and financial concerns would need to be overcome to make it happen. If public utility power is to be used additional power producing facilities, with its own environmental effects, most likely would be required.

- The construction of pipeline, booster pumps, reservoir, hydro-power generation, and other related improvements for the proposal is estimated to cost \$250 to \$312 million in 1991 dollars. An additional amount, roughly about \$30 million would be needed to transport the water to the coastal area. The project looks toward federal and state funds to implement development. Because of the tight fiscal situation in both levels of government, the probability of obtaining such funding is not encouraging.

- The potential direct environmental impacts from the system to transport the water to the coast would vary depending on the route selected. If the pipeline route follows the existing Kawaihae Road, there could be significant interruptions to traffic flow on Kawaihae Road over a relatively long pipeline construction period. The closest alternative mauka-makai route is at Waikoloa. The seven or eight pressure-breaker reservoirs along the pipeline route may or may not be considered intrusive, depending on the observer. Being on an existing highway, the pipeline route would not disturb any archaeological, botanical features or landforms. However, if one million gallon size pressure-breaker reservoirs are used they may affect landforms.

  If the pipeline route is included within the proposed mauka-makai highway right-of-way (proposed Waimea by-pass highway) the potential for adverse environmental effects appears minimal, depending on development of the Lalamilo lands. One major concern would be to assure that archaeological finds are sensitively taken cared of. As in the Kawaihae Road route, the seven or eight pressure-breaker reservoirs along the pipeline route may or may not be considered intrusive, depending on the observer. The extent of development of the Lalamilo lands would also affect the visual effect of the reservoirs on any vistas and landforms.

  Assuming that the terminal reservoirs under this alternative would be at the same locations as the proposed action, they would have similar environmental effects. The potential secondary environmental impacts would be substantially the same as described for the proposed action since the imported water would be serving the same coastal area.

- The project appears very complex and could result in relatively high cost for agricultural use water, and even for domestic use.

  The project DEIS estimates cost of water delivered at the terminus in Waimea could range from \$1.42 per 1,000 gallons to \$8.92 per 1,000 gallons, depending on the assumptions. For example, if the entire project cost is subsidized by government and power cost is \$0.07 per KWH, the water cost would be \$3.20 per 1,000 gallons. On the other hand, if the project is to repay construction funds at 8% interest rate and energy cost is $0.07 per KWH, the price increases to $7.16 per 1,000 gallons.

Water prices at Waikoloa Beach Resort and Village ranges between $3.50 and $3.75 per 1,000 gallons in 1990 dollars. The cost represents resource development and distribution costs. The price of agricultural water from the State's Waimea Irrigation System is $0.75 per 1,000 gallons. Domestic water from the County's Waimea System is priced at about $1.83 per 1,000 gallons. These latter prices for agricultural and domestic water mainly reflect distribution costs.

The route study for the proposed Kohala Water Transmission System project estimated a minimum price of $0.96 per thousand gallons would be required to cover capital and operation and maintenance costs in Phase I. The estimate for the full 20 mgd production is a minimum price of $0.67 per thousand gallons.[2]

- There appears to other issues that may require considerable time and involvement of various public and private parties to resolve. This leads to uncertainty about when water can be made available through the project. Under such conditions landowners with large water needs would likely drill their own wells and maximize water withdrawals from the Waimea or other underlying aquifer system. This would reduce the market for water from the project and negatively affect financial feasibility.

4.2 DESALINATE BRACKISH WATER

Desalination as the sole water source requires careful planning of the system design. The desalinization plant must be able to meet short-term seasonal and also longer-term variations in water demands. It must provide for storage or alternative supply for times when part or all of the desalinization capacity is out of operation due to routine maintenance, equipment failure or catastrophic plant failure.

Although brackish water would be the preferred feed water for desalination purpose, depending on its location along the Kohala coast, a 20 mgd plant could be competing with demand for brackish water for irrigation use at the resorts. For example, a 1974 research effort selected a study site in the Anaehoomalu aquifer system. Much of the irrigation water currently used by the resorts are drawn from this aquifer system.

Desalination could be advantageous if a processing plant can be constructed in increments so that capacity could be built as need developed. The transport distance to user areas would also be short and without large differences in elevation.

The State Department of Natural Resources in cooperation with the University of Hawaii Water Resources Research Center, Honolulu Board of Water Supply, and the Campbell Estate completed a 1 mgd desalination plant in Ewa in 1991. The plant uses brackish feed

[2] Hawaii County Department of Water Supply. *Kohala Coast Water Transmission Route Study, Pre-Final.* Prepared by Okahara & Associates, Inc. July 1993. Pages 13-5 and 6.

water. The unit cost of water production is estimated at about $3.00 per 1,000 gallons by the project consultant. The estimate did not include cost of storage or distribution which is usually several times greater than the cost of production by conventional means.[3] This estimated amount is approximately three times the amount estimated for the proposed Kohala Water Transmission System project. The plant is not in operation at this time.

The Kawaihae Cogeneration Partners, a private power producer group, proposes to construct a cogeneration plant in Kawaihae to produce power in conjunction with desalinization of brackish water. Firm details on the development have not been announced. The desalinization plant capacity would be less than 3 mgd.

DLNR report R50 Water Desalting in Hawaii[4] selected a location mauka of the highway across from Kiholo Bay for a desalting plant case study site. Although the study was prepared in 1974, the following conclusion may still be applicable: In situations where adequate basal or high level groundwater supplies can be developed within about 20 miles of the area of need, without exceeding 1,000 feet of pumping head, it is unlikely that desalting brackish water will provide an economically competitive alternative.

In addition to high probable operating costs of desalination, there are important environmental concerns that need to be addressed. These include: the effect of large brackish water removal on the basal water aquifer, particularly on the salinity of fresh water being withdrawn from the same aquifer; the disposal of waste products from the process; the possibly large energy needs of the process which would require fossil fuel to produce; and depending on location, the compatibility of the plant facilities with the site vicinity.

If a desalination facility is located somewhere in the coastal area and if existing highways are used as pipeline routes, the water transport system to the user areas should have minimal environmental effects. Assuming that the terminal reservoirs under this alternative would be at the same locations as the proposed action, they would have similar environmental effects as the proposed action.

The potential secondary environmental impacts would be substantially the same as described for the proposed action since the imported water would be serving the same coastal area.

4.3 USE HIGH LEVEL GROUND WATER RESOURCE

The early successes from exploration for high level ground water in upland Waimea have stimulated suggestion that this source should be explored for supplying the Kohala coastal area with water. The apparent advantage of the high-level Waimea source is shorter

3 State Commission on Water Resource Management. *Water Resources Protection Plan.* Prepared by George A.L. Yuen and Associates, Inc. June 1990. Page VII-2.

4 Hawaii State DLNR (and USDI Office of Saline Water), Division of Water and Land Development by J.M. Duncan and B.J.Garrick, Holmes and Narver, Inc. *Water Desalting in Hawaii.* Jun 1974.

transport distance from source to the coastal user areas. The potential availability of large quantity of fresh water from this high-level resource is another attraction.

The preliminary hydrogeological assessment for a proposed DWS exploratory high-level well indicated that the estimated recharge in the leeward Kohala Mountains (12 square mile area) near Waimea is voluminous enough to support development of high level groundwater supply.[5] However, it also indicated that as the aquifer is pumped, data on water levels and how they are distributed in space and time is needed to better understand the resource and its sustainable yield. The assessment describes the Waimea-Puukapu region as having two high level ground water aquifers, the shallowest about 200 to 250 below ground level at approximately 3000 feet elevation and the deepest starting about 1300 to 1600 feet below ground. Because the shallow aquifer is not as voluminous, production must be limited to 50 to 100 gpm, whereas a well in the deep aquifer could yield 700 to 1400 gpm (1 to 2 mgd).

From a development standpoint, the basic differences between the Waimea alternative and the proposed action are the type of water source, pumping depth, and transport distance. The Waimea alternative would exploit high-level ground water while the proposed North Kohala project would exploit basal groundwater source. Both sources would require pumping to withdraw the water. The Kohala wells are not as deep as the Waimea wells, about 400 feet compared to about 1600 feet. The Waimea source is far less distance to user areas than the Kohala source. However, there is considerable difference in elevation between the Waimea source area and the coastal user areas. See discussion below on magnitude of cost comparison.

In North Kohala, no significant negative impact is foreseen from the pumping. It appears that in Waimea, if high-level deep wells are the supply source there should be no negative impact from the pumping. The construction of the high-level wells in the Waimea forest area, pipeline and maintenance road through forest, and pipeline route through the built-up areas of Waimea would require careful review to assure that adverse effects are mitigable.

The effects from construction of the water transport system to the coast would vary depending on the route selected. If the pipeline route follows the existing Kawaihae Road, there could be significant interruptions to traffic flow on Kawaihae Road over a relatively long pipeline construction period. The closest alternative mauka-makai route is at Waikoloa. The seven or eight pressure-breaker reservoirs along the pipeline route may or may not be considered intrusive, depending on the observer. Being on an existing highway, the pipeline route would not disturb any archaeological, botanical features or landforms. However, if one million gallon size pressure-breaker reservoirs are used they may affect landforms.

If the pipeline route is included within the proposed mauka-makai highway right-of-way (proposed Waimea by-pass highway) the potential for adverse environmental effects appears minimal, depending on development of the Lalamilo lands. One major concern

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5 Hawaii County Department of Water Supply by Mink & Yuen, Inc. *Hydrogeological Assessment, High-Level Groundwater In Waimea-Puukapu Region, Hawaii.* Dec 1994.

would be to assure that archaeological finds are sensitively taken cared of. As in the Kawaihae Road route, the seven or eight pressure-breaker reservoirs along the pipeline route may or may not be considered intrusive, depending on the observer. The extent of development of the Lalamilo lands would also affect the visual effect of the reservoirs on any vistas and landforms.

Assuming that the terminal reservoirs under this alternative would be at the same locations as the proposed action, they would have similar environmental effects. The potential secondary environmental impacts would be substantially the same as described for the proposed action since the imported water would be serving the same coastal area.

There are significant reasons to not rely fully on this resource for supplying water to the coastal area. They include the need to gain better knowledge of the sustainable yield and reliability of this particular high-level groundwater resource, the need to have a resource to supplement surface water sources for the uplands of Waimea during drought periods, and cost of developing and operating the facilities to use the high-level sources.

More experience with high level wells is needed. The existence and developability of the deep aquifer have been proven by three production size wells drilled and tested at Waimea Country Club, Parker 1, and Puukapu. The Waimea Country Club well (500 gpm-0.72 mgd) is the only well that is currently equipped with a pump and is operating. The Parker 1 well pump (500 gpm-0.72 mgd) is currently being designed. The Puukapu well does not have an installed pump. The State plans to use the well as a standby source for the Waimea Irrigation System during droughts.

With only one well in actual operation, there is little pumping records. Mink and Yuen states that good modeling of high-level groundwater behavior in the area is apt to be crippled by ignorance of the physical boundaries of the aquifer, weakness in the hydrologic budget, and lack of an operational record against which to verify model results.[6]

Supplementary water source for upland areas is needed. (The mid-level lands down to the elevation level of the Lalamilo well field area may need to be included as part of the upland area.) The three water systems that now service the needs of upland Waimea (DWS Waimea System, DOA Waimea Irrigation System, and Parker Ranch System) all depend on surface water from the Kohala Mountain streams for their supply. Although it is normally a good source, the supply is vulnerable to vagaries of weather. As discussed on **page 2-3** the projected average future need for the DWS Waimea System alone is about 2.4 mgd or 80% of the effective yield (DWS uses 3.0 mgd for planning purpose) of the existing storage reservoirs. Additional water needs not included in the projection is anticipated, e.g., large tracts of new land recently transferred to Department of Hawaiian Home Lands by the State.

Although the draw from the Waimea water treatment plant averaged 0.9 mgd for the past three fiscal years, the system experienced an extreme outflow of 2.1 mgd during

[6] Ibid, Note 5.

the 1980-81 fiscal year. That was the year of the last prolonged drought in the Waimea area. To improve the reliability of the Waimea System, the DWS is planning to use ground water from high-level sources to supplement its surface water sources during droughts. The State's Waimea Irrigation System is also planning to use its Puukapu deep and shallow wells as supplementary sources.

Magnitude of cost comparison. A rough estimate, using costs from the proposed Kohala project, was made to assess the cost of a Waimea high-level source system.

Assumptions: 1) that sufficient resource to yield 20 mgd could be found in Waimea-Puukapu area of the Kohala Mountain slopes; 2) that deep wells would be preferable since shallow wells would have limited production capacity; 3) that a small diameter transmission line could be used; 4) that pressure breaker reservoirs would needed at 330 feet elevation intervals on the downhill transmission line; and 5) that electrical power would be available from the utility company.

Phase I	**Hawi Source**	**Waimea Source**	**Notes**
Well Development Area	$ 14,400,000	$ 20,000,000	1
Collection Reservoir	5,660,000	5,660,000	
Transmission Line	25,770,000	15,225,000	2
1.0 MG Breaker Reservoir	1,550,000	10,850,000	3
6.0 MG Terminal Reservoir	5,290,000	5,290,000	
Connection to Existing Sys.	1,750,000	0	4
Offsite Electrical	6,000,000	0	5
Total	$ 60,420,000	$ 57,025,000	
Phase II			
Well Development Area	9,290,000	15,290,000	1
Collection Reservoir	5,100,000	5,100,000	
6.0 MG Terminal Reservoir	5,220,000	5,220,000	
Total	$ 19,610,000	$ 25,610,000	
Total Phase I & II	**$ 80,030,000**	**$ 82,635,000**	

Notes to cost estimate:
1. Assume drilling cost of $800 per lf, 6 wells @ 1800 lf vs 400 lf
2. Assume 87,000 lf of 30"diam DI @ $175 per lf vs 120,000 lf of 36" diameter DI @ $215 per lf
3. Assume 6 additional 1.0 MG pressure-breaker reservoirs each at 330 ft elevation difference
4. Assume no interconnection to existing system
5. No off-site electrical required for Waimea design

From a capital cost standpoint there appears to be no major advantage of the Waimea source. The shorter pipeline distance and small diameter pipe is offset by the cost of drilling deeper wells and installing several additional pressure-breaker reservoirs.

However, there is a major operational cost difference in comparing well pumping costs. The average well depth for Waimea would be about 1800 feet compared to about 400 feet for the Hawi wells. Although the water at Hawi would need to be lifted an additional 275 feet to the collection reservoir, the Waimea pumping cost would be about 2.8 times that of the Hawi cost. This large differential is important because of the much lesser pumping cost. Maintenance cost would also be lower for the shallower Hawi wells. Both of these costs would affect water rates.

4.4 NO ACTION

The no action alternative means supplementing South Kohala coast's water supply does not occur. In this case, two basic scenarios over the next ten to fifteen years are possible:

1. The water supply for South Kohala remains at its current level for both potable and non-potable water.

2. Individual development projects, including the County DWS, develop their own water supply, through exploitation of the underlying aquifers in South Kohala but would be limited to the estimated sustainable yield of the aquifers. Upon reaching the reaching the safe withdrawal capacity of the aquifers, those projects in need of water would augment and conserve their supply. These could include the use of small scale desalinization facility, higher use of wastewater treatment plant effluent for golf course and landscape irrigation, and water savings by more efficient irrigation techniques and other conservation measures.

Given the current land ownership patterns and General Plan designations for the potential South Kohala resort properties and government plans for public properties at Kawaihae, Hapuna and Lalamilo it is unlikely that Scenario 1 would occur.

Scenario 2 is more likely to occur, although at a higher price. Development might be much slower and geographically uneven, but it would probably continue. However, given favorable market conditions, the higher cost might not be a deterrent.

The no action alternative would preclude the level of development anticipated in State and County plans for the South Kohala coast. The resort region is the major economic engine for northwest Hawaii and a significant factor for the entire county. The no action alternative would also deny the ability to promote developments that are desirable for residents such as the Hapuna regional coastal park and support community for resort workers.

Although a no action alternative in a sense may be seen as a check on quantity of growth, it might also have indirect consequences leading to growth of poorer "quality." For example, socially worthy projects such as affordable housing, Hawaiian Home Lands plans and public coastal parks may become more difficult to develop because of limited or expensive water.

SECTION 5
DESCRIPTION OF ENVIRONMENTAL SETTING

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DESCRIPTION OF ENVIRONMENTAL SETTING

5.1 REGIONAL OVERVIEW

The Island of Hawaii is the most southeastern and largest island of the Hawaiian archipelago, encompassing a land area of 4,034 square miles. Its population in 1990 was 120,317 residents, making it the second most populous county in the state. The principal industries are tourism, diversified agriculture, cattle ranching, and astronomy. Sugar, once the major industry in the island, is rapidly being phased out for economic reasons. The island is governed by the County of Hawaii and is divided into nine judicial districts. For this document northwest region means North and South Kohala. See **Figure 5.1-1.**

The northwest region has large expanses of open areas on the northern and western slopes of the Kohala Mountain, most of which are used for cattle grazing. The Parker Ranch, one of the nation's largest privately held ranch operates in the region. Chalon International of Hawaii's development plan for its vast North Kohala land holding envisions predominantly agricultural uses combined with a mix of residential, recreational, and support uses. The Puukapu and Lalamilo sections of Waimea in the uplands of South Kohala are well known for their rich harvest of vegetables and flowers, much of which are supplied to local markets and the Kohala coast resorts.

Hawi and Kapaau in North Kohala and Waimea Village in South Kohala are the primary centers of the northwest region's resident population, commercial activities, and public facilities. Except for the resort areas where numerous visitors are present, the northwest region is typical of the rural settings found in the Hawaiian Islands.

The Mauna Kea Beach, Mauna Lani and Waikoloa resorts lie along South Kohala's coast from Kaunaoa Beach to Anaehoomalu Bay in Waikoloa. A proposed addition is Nansay Hawaii's Puako residential golf community. Their proposed plans include six golf courses, residential units, golf academy and a commercial center.

Tourism has now replaced sugar as the economic engine for the island. West Hawaii with its year-round sunny and mild climate, pristine ocean waters, and expansive open spaces has seen most of the rapid growth in tourism related developments. Major resorts have focused on the South Kohala coast for large planned developments. Although an international economic slump has brought developments at these resort areas to a standstill now, the owners are looking forward to better times and are planning expansions. These resorts will require a large supply of potable and non-potable water to achieve the expansions. Since the supply will not be available from aquifers in the coastal area, it must come from another source.

The proposed project will provide the vehicle to recover and transfer water from the well fields in the Makapala-Hawi vicinity of North Kohala to the terminal reservoirs in the Kawaihae-Puako coastal areas of South Kohala.

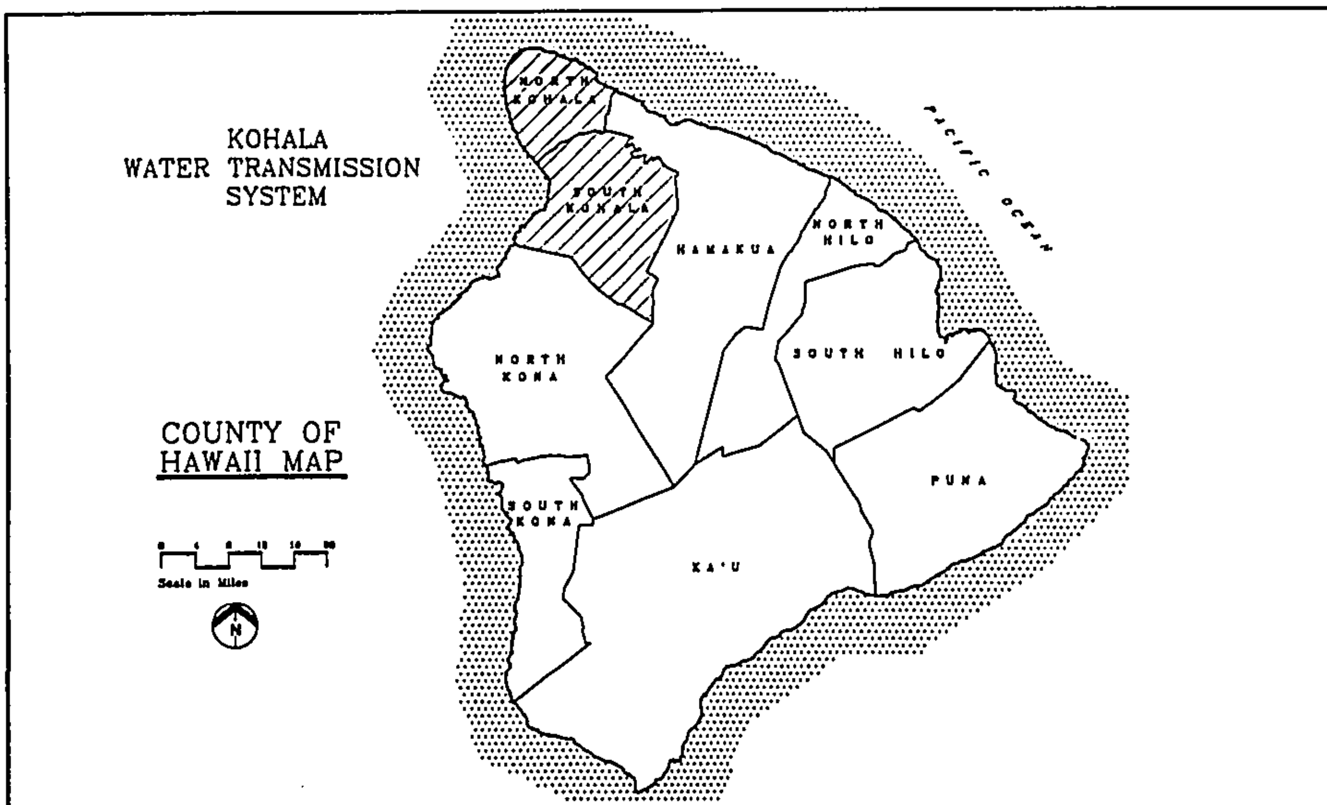

Figure 5.1-1 **NORTHWEST HAWAII REGION** Map Source: Okahara & Associates, Inc.

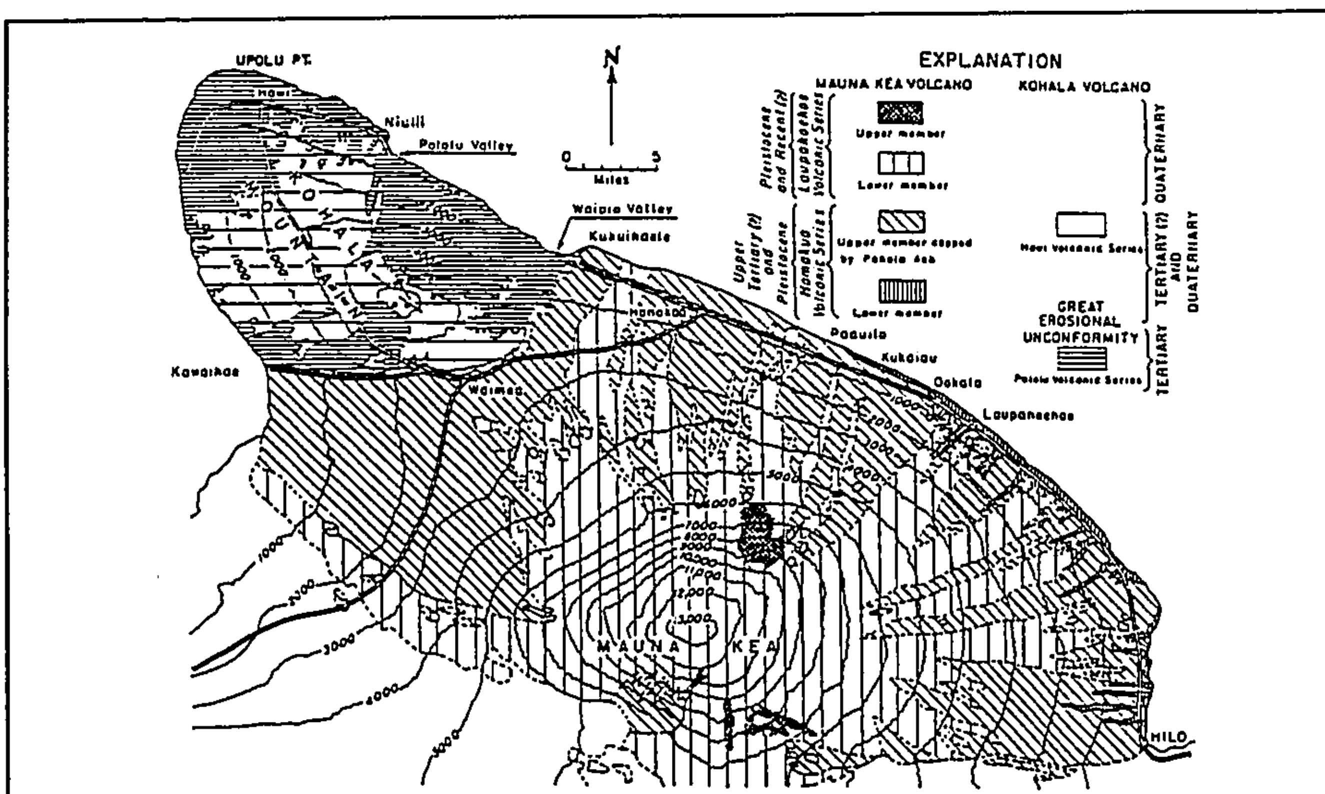

Figure 5.2-1 GENERALIZED GEOLOGIC MAP OF KOHALA AND MAUNA KEA
Map Source: Circular C14. USGS/DLNR-DOWALD. 1963.

5.2 PHYSICAL ENVIRONMENT

5.2.1 GEOLOGY

The Kohala Mountain is the oldest of the five shield volcanoes that form the Island of Hawaii. The development of the Kohala Mountain is associated with the Pololu Basalt and Hawi Volcanics. The older Pololu Basalt consisted mostly of permeable thin-bedded basaltic lava. The Hawi Volcanics series then covered much of the Pololu Basalt with thick-bedded and poorly permeable andesitic and trachytic lava flows. See **Figure 5.2-1.**

In South Kohala, the Hamakua volcanic series, capped with Pahala ash, from the Mauna Kea volcano covered the southern portion of the Polulu and Hawi volcanic series. The Hamakua series was later covered by the Laupahoehoe volcanic series.

Numerous dikes intruded the lava flows in the rift zones of Kohala Mountain. They form almost impermeable vertical barriers which cut across lava flows and often impound large quantities of ground water. Ash deposits buried in the permeable lava flows act as perching members for high-altitude perched-water bodies in parts of Kohala Mountain.

The general geology and hydrology for the four Aquifer Systems pertinent to the northwest Hawaii region described in the State's *Water Resources Protection Plan*[1] are included in **Appendix F.**

5.2.2 TOPOGRAPHY

Kohala Mountain visually dominates the region and creates an almost north to south spine that separates the region into two distinct sections. The eastern or windward side, exposed to moisture laden trades, is deeply incised by series of deep valleys and gulches with lush, green vegetation. The western or leeward slopes of Kohala Mountain, especially along the coast, are dry, sunny and sparsely vegetated. The uplands along the northern to southwestern slopes, such as in the Hawi and Waimea areas, are much cooler and wetter than the coastal area.

Between the deep valleys and gulches, the slopes on the eastern side of Kohala Mountain abruptly end at high coastal cliffs. Except for a few trails on the slopes at the top of the cliffs, the area is nearly impassable. From Niulii westward the gulches are much smaller and slopes are gentler compared to the eastern slopes. This in turn allows many distinctive views and vistas of the mountains, coastal lands, and ocean.

Large tracts of the lands on the leeward slopes of Kohala Mountain along the Akoni Pule Highway south of Upolu remain undeveloped and largely without manmade intrusions. From this highway one looks makai to the rugged lava coastline and mauka across sparsely vegetated lands to the cinder cones flanking the summit.

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1 State Commission on Water Resources Management by George A.L. Yuen and Associates, Inc. *Water Resources Protection Plan, Review Draft.* Mar 1992.

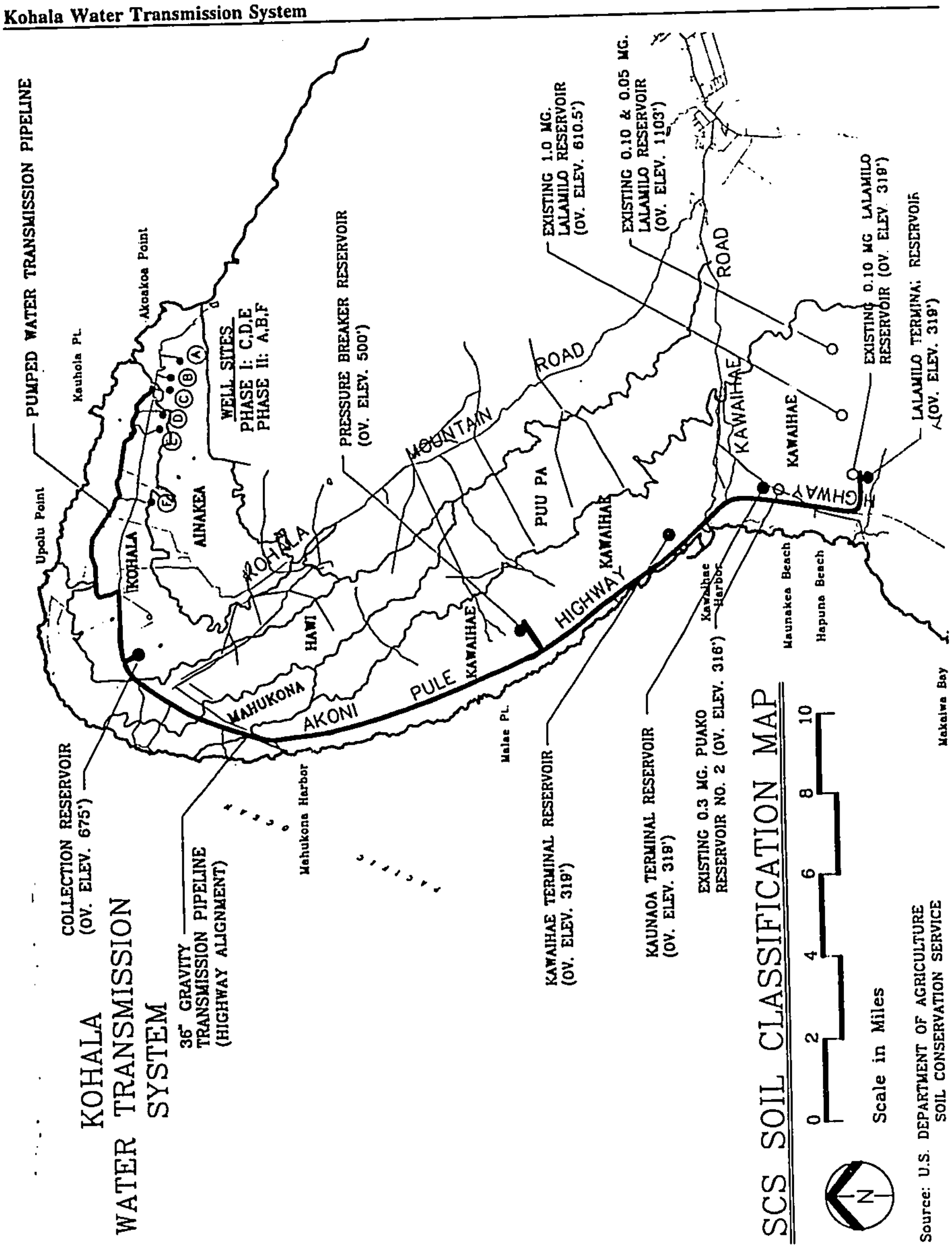


Figure 5.2-2 SCS SOIL CLASSIFICATION MAP
Map Source: Okahara & Associates, Inc.

5.2.3 SOILS

Soil associations in the northwest Hawaii region are shown on the general soils map by the U.S. Department of Agriculture, Soil Conservation Service.[2] A soil association is a landscape containing a distinctive proportional pattern of soils. There are six different soil series in the northwest Hawaii region traversed by the proposed project. The general vicinities of these soil series are shown in **Figure 5.2-2.**

The table below gives the characteristics of the soil types found in the project component sites. The soils in the shoulder area of the existing highways generally consist of imported crushed aggregate material. Native soils might be encountered where the proposed pipeline is located close to the right-of-way line. Pratt Road is not paved or oiled but is well compacted through years of heavy use by cane hauling equipment. Imported material is probably present in the road base.

Table 5.2-1 Characteristics of Soils at Component Sites

Soil Series	Map Code	Slope %	TopSoil Description	TopSoil Depth	SubSoil Depth	Bedrock Depth	Permea-bility	Runoff	Erosion Hazard
Soils in Well Sites A, B, & C and Portion of Hawi-Niulii Highway below well sites A & B									
Ainakea	AaC	3-12	silty clay loam	10"	20"	24-36"	mod-rapid	slow	slight
Soils in Well Sites D, E, F and Puakea Collection Reservoir Site									
Kohala	KhC	3-12	silty clay	14"	25"	24-36"	mod-rapid	slow	slight
Soils in Pratt Road and segment of Akoni Pule Highway south of Hikipoloa to Puakea Ranch									
Kohala	KhA	0-3	silty clay	14"	25"	39"	mod-rapid	slow	slight
Kohala	KhC	3-12	silty clay	14"	25"	39"	mod-rapid	slow-med	slight-mod
Kohala	KhD	12-20	silty clay	14"	25"	39"	mod-rapid	medium	moderate
Kohala	KhE	20-35	silty clay	14"	25"	39"	mod-rapid	rapid	severe
Soils in Akoni Pule Highway south of Puakea Ranch, Kawaihae Road, and Queen Kaahumanu Highway to Lalamilo									
Hawi	HaC	3-12	silty clay	15"	53"		moderate	slow	slight
Mahukona	MHC	3-12	silty clay loam	6"	30"	32-42"	moderate	medium	moderate
Kawaihae	KOC	6-12	very rocky very fine sandy loam	2"	33"	20-40"	moderate	medium	moderate
Soils in reservoir sites at Pressure Breaker, Kawaihae DHHL, Kaunaoa, and Lalamilo									
Kawaihae	KNC	6-12	extremely stony very fine sandy loam	2"	33"	20-40"	moderate	medium	moderate

2 U.S. Department of Agriculture, Soil Conservation Service. *Soil Survey For The Island Of Hawaii.* 1973.

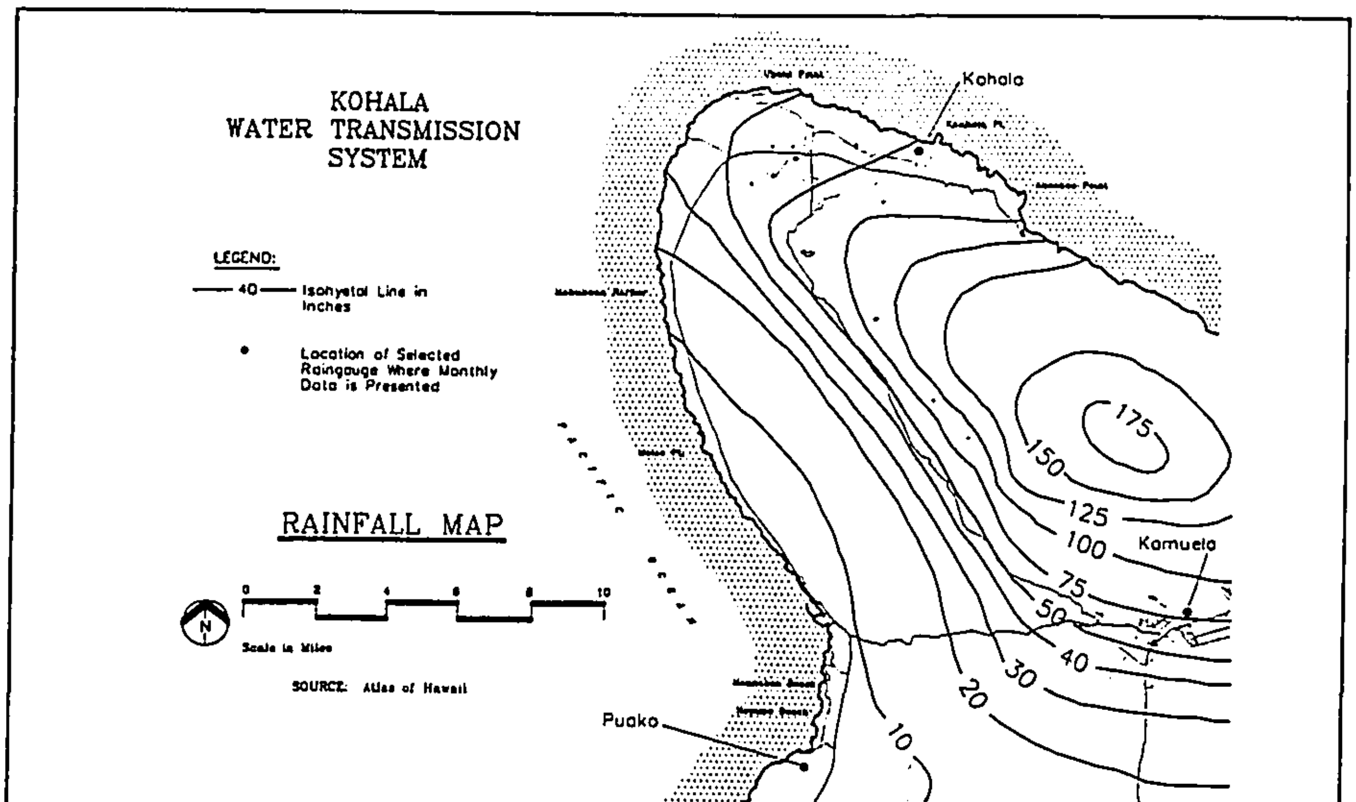


Figure 5.2-3 RAINFALL MAP Map Source: Okahara & Associates, Inc.

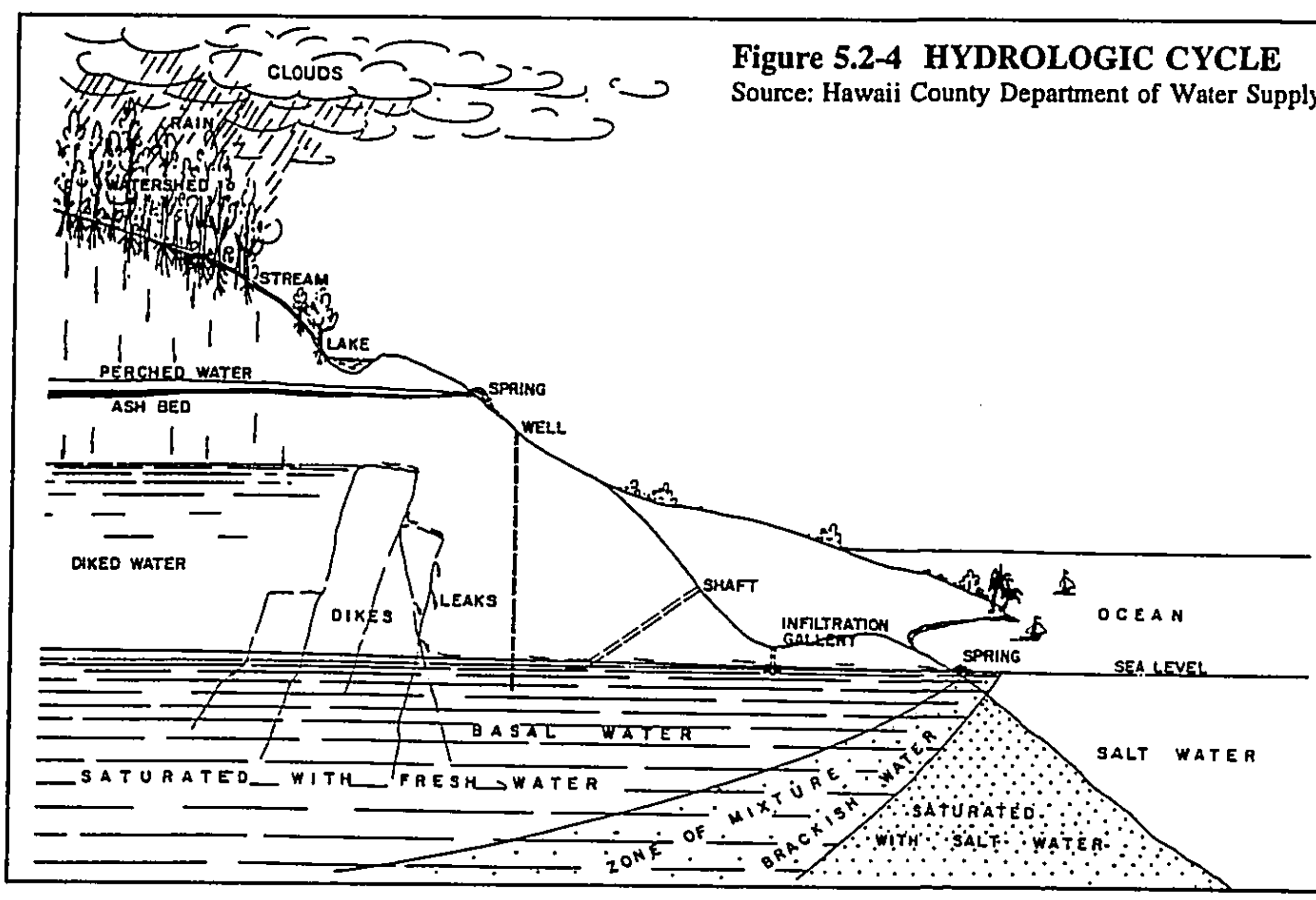


Figure 5.2-4 HYDROLOGIC CYCLE
Source: Hawaii County Department of Water Supply

5.2.4 CLIMATE

Trade winds from the northeast prevail during most of the year and account for the high average rainfall on the east or windward side of the Kohala Mountain. As the moisture laden trades rise up the eastern mountain slopes they lose much of their moisture as rain. The prevalence of trades throughout most of the year accounts for the high rainfall along the eastern side of the island. Average rainfall ranges from 75 inches along the windward coast to greater than 175 inches at the summit of Kohala Mountain. See **Figure 5.2-3.**

As the trades descend along the western or leeward slopes of the mountains, the air becomes dryer and warmer. The rainfall declines accordingly, resulting in near arid climate along the leeward coasts. Mean annual rainfall in most of these coastal areas is approximately 10 inches.

The warmest month is normally August and the coldest is February. Temperatures above 90°F are unusual except in the coastal area of South Kohala, where maximum temperatures in the low 90's are moderately common. Temperatures less than 55°F are uncommon at lower elevations. The summits of Mauna Kea and Mauna Loa frequently have snow in winter.

Trade winds prevail 90 percent of time in summer and 50 percent of the time in winter and are accompanied by a temperature inversion at about 6,500 feet in altitude. The inversion greatly influences moisture distribution in the air surrounding the island. Relative humidity below the inversion is roughly 70 to 80 percent in windward areas and 60 to 70 percent in dryer leeward areas. Above the inversion, relative humidity is generally less than 40 percent, often declining to 10 percent or less.

Although the tradewinds approach the island at fairly constant speed, the uniform flow is distorted as the winds traverse the island and combine with local winds on the mountain slopes and lowlands to form complex wind patterns. During the cooler months especially, variable winds replace the trades. The northwest region is susceptable to hurricane class storms. Lesser class storms generate winds from various directions. Over the ocean surrounding the islands, average wind speeds are highest during the summer trade wind period, exceeding 12 miles per hour 50 percent of the time. During the winter months wind speeds exceed 12 miles per hour about 40 percent of the time.

5.2.5 HYDROLOGY

The gross water supply of the island is the sum of precipitation reaching the ground surface. Some precipitation or rainfall may be lost through evapo-transpiration; it may run-off into streams and empty into the sea; or it may infiltrate the ground to become soil moisture or collect in the basal water table (or aquifers) to escape eventually to the ocean. This cycle of water movement is called the hydrological cycle. See **Figure 5.2-4** for illustration showing the cycle.

Excerpts from the State's *Water Resources Protection Plan* on the hydrology of the four aquifer systems in the region are included in **Appendix F.**

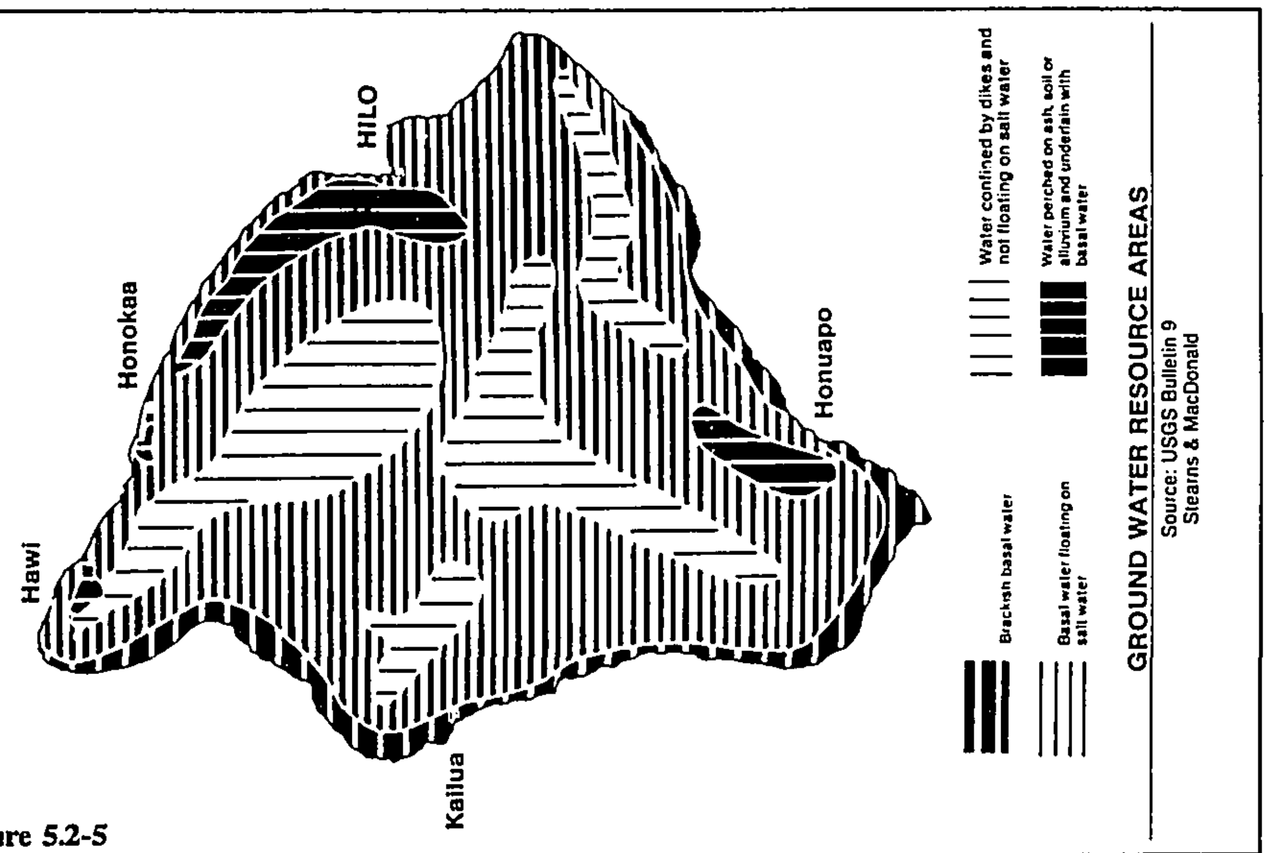


Figure 5.2-5

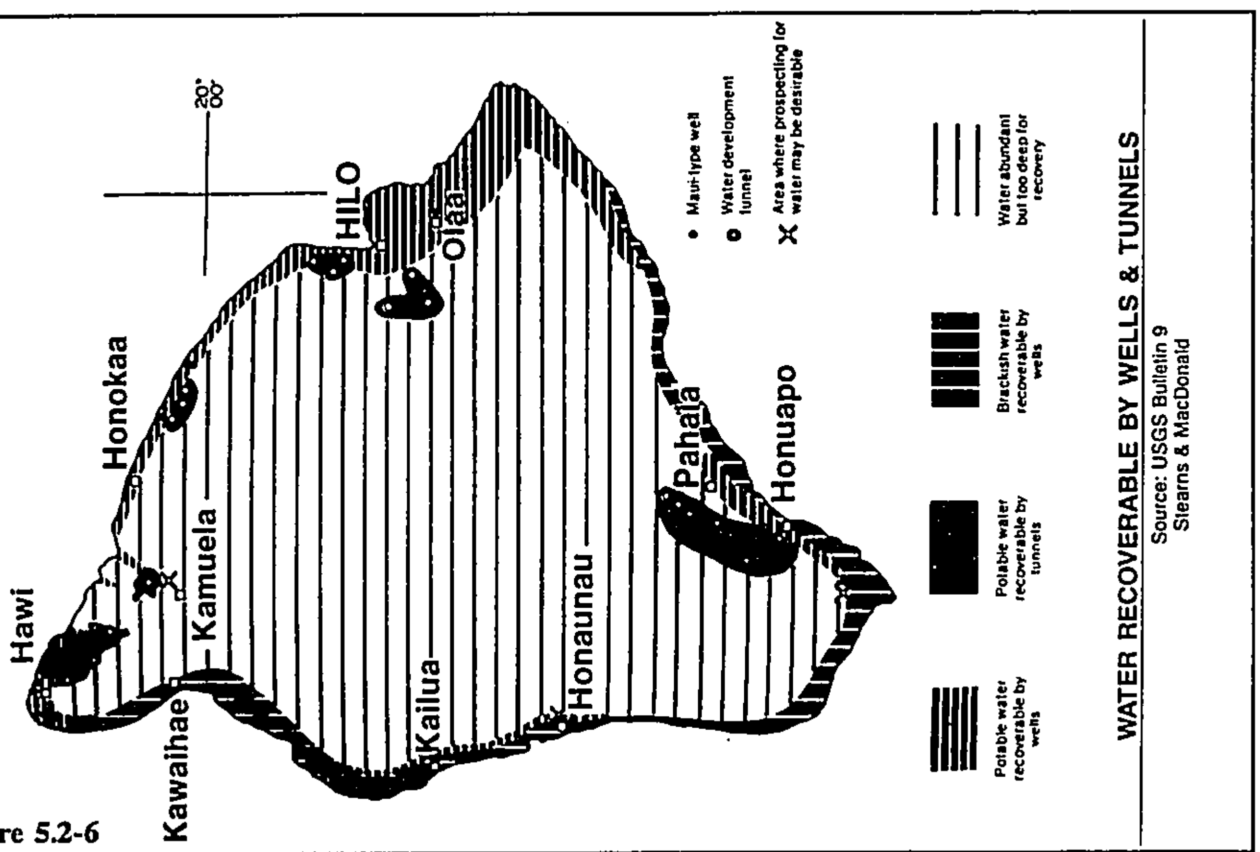


Figure 5.2-6

In Hawaii a large component of rainfall permeates the ground surface and moves down to the water table. Some of this downward flow ends up trapped between dikes or perched above impermeable levels at high elevations. However, the greatest ground water reservoir is near sea level in a fresh water lens which "floats" on sea water. Due to the difference in specific gravity between sea water and fresh water, theoretically, the lens of fresh water extends down 40 feet for every foot it rises above sea level, much like an ice cube in a glass of water. In actuality there is a zone of mixture or transition zone from sea water to fresh water. This phenomenon is known as the Ghyben-Herzberg principle. Depending on rate of rainfall and hydraulic permeability of the local geology, the basal water table rises from sea level at the shore inland on gradients of about 1 to 4 feet per mile.

Surface Water. The heaviest rainfall occurs on the eastern or windward side of the island. Because of the high permeability of much surface geology, the island has few perennial streams. These streams are found on the eastern slopes of Mauna Kea and Kohala Mountains. Some streams flow perennially in their upper reaches but lose their water to percolation well before reaching the coast. The lower reaches of such streams are subject to flash flooding during intense rainstorms.

The central part of the Kohala Mountain holds developable high level water supplies impounded by dikes. Estimated discharge from dike compartments into streams of Kohala Mountain is as much as 100 million gallons per day. Ditches such as the Lower Hamakua Ditch and Kohala Ditch were built to divert much of this discharge to the sugar plantations for irrigation and industrial uses. Although the plantations have closed, these ditches still represent significant sources for irrigation and other water uses. The Kohala Ditch, although much less used today than two decades ago, today has an estimated flow of 15 to 20 mgd, provides water for agricultural irrigation, hydroelectric generation and aquaculture uses in North Kohala. The recent closing of Hamakua Sugar Company has left the fate of the Lower Hamakua Ditch and its discharge of about 22 to 26 mgd is unclear, at this time.

Ground water is the primary source of supply for most potable water users on the island, municipal and private systems. As shown in **Figure 5.2-5**, the island has four different types of ground water: (1) brackish basal water; (2) basal water floating on salt water; (4) water confined by dikes and not floating on salt water; (4) water perched on ash, soil or alluvium and underlain with basal water. Although there appears to be an abundant supply of basal water underlying the island, **Figure 5.2-6** indicates that in most parts of the island basal water recovery is limited, primarily because the high ground elevations result in higher recovery cost.

The U.S.G.S. in its study of ground water in North Kohala[3] reported the following water budget estimate by Shade (in press). The major source of recharge to the basal part of the Hawi aquifer is from direct precipitation which amounted to 53.1 mgd on a mean annual basis. The adjacent rift zone, the Pololu Stream drainage basin and the rift zone above contributed an additional 15.3 mgd. Other sources of recharge mentioned in the report were infiltration from Kohala Ditch and injection from Hawi hydroelectric plant.

[3] See Appendix B, USGS Report, Page 13.

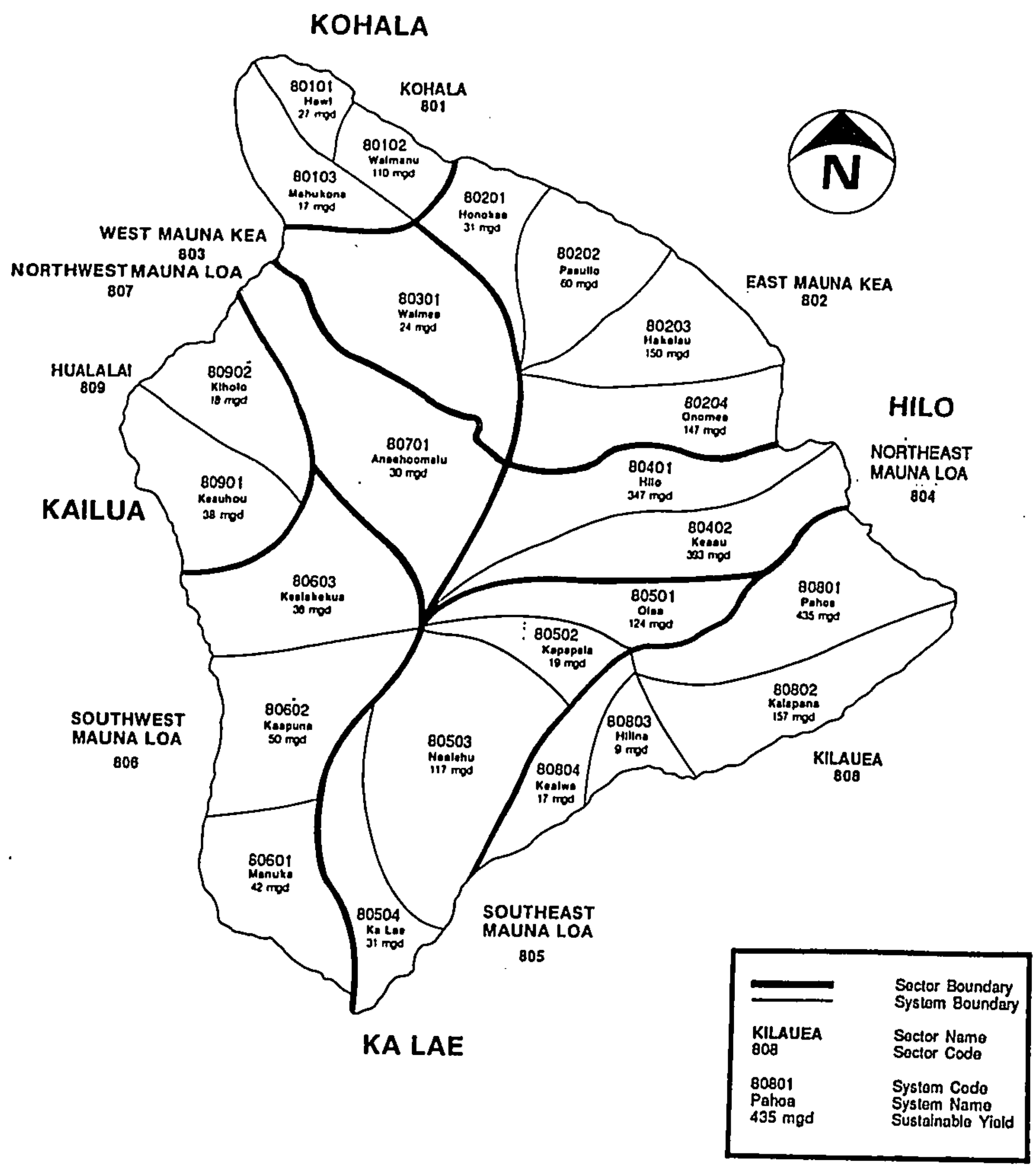


Figure 5.2-7 AQUIFER SECTORS AND SYSTEMS
Source: Kon. *Hawaii County Water Use and Development Plan, Review Draft.* 2.92.

The altitudes of water levels in the basal aquifer measured in March 1990 ranged from a high of 11.3 ft above sea level to a low of 2.5 feet. Existing recharge to and discharge from the aquifer have not changed significantly for many years. The only regularly pumped well in the basal aquifer is the DWS well (7449-02) in Hawi. Water levels measured regularly from 1972 to 1995 in shaft 7652-01 (Waikane) and periodically in well 7347-02 (Halaula) from 1986 to 1991 supports the concept that equilibrium conditions exists in the aquifer.

The study concluded that model results indicate that withdrawal of 20 mgd from the Hawi aquifer, above the existing 0.6 mgd withdrawal at the DWS Hawi well, is feasible but spacing, depth, and pumping rates of individual wells are important. If pumping is concentrated, the likelihood of saltwater intrusion is increased.

The withdrawal of 20 mgd could possibly cause some reduction of stream flow near the mouth of Pololu Stream, but because of the absence of field data concerning the hydraulic connection of this stream with the basal aquifer, the amount of reduction cannot be addressed at this time.[4]

Water samples from five of the eight test wells were analyzed for common ions. Results show that Kohala water is typical of water from Hawaiian basalt aquifers with chlorides ranging from 19 to 36 ppm. Samples from three wells showed no dissolved metals or organic compounds at concentrations exceeding USEPA maximum contaminant levels. Samples were free of significant anthropogenic organic compounds. The only organic compound reported were from well A, where toluene and xylene were found at or near level of detection. The concentration were far below USEPA limit.[5]

Estimated Sustainable Yield is defined in the State's *Water Resources Protection Plan* as the forced withdrawal of groundwater at a rate that could be sustained indefinitely without affecting either the quality of the pumped water or the rate of pumping.[6]

In Hawaii, it is a concept by which exploitation of groundwater is permitted and practiced because groundwater in the most voluminous aquifers rests on sea water. A judicious balance among input, volume of water stored in the aquifer, draft and natural leakage must be established to avoid salinization of pumped water when draft exceeds sustainable yield. See **Appendix F**, pages 121 and 122 for considerations restricting the unqualified use of sustainable yield estimates.

Excerpts from the State's Water Resources Protection Plan on the State's aquifer classification and coding scheme, and sustainable yield determination are included in **Appendix F.**

Figure 5.2-7 shows the estimated sustainable yields of aquifer systems in Hawaii Island.

4 See Appendix B, USGS Report, Page 55.

5 Ibid Note 4, Page 19.

6 Ibid Note 1, Page 97 (see excerpt in Appendix F)

5.2.6 WATER QUALITY

Coastal Waters. Section 11-54-06 Hawaii Administrative Rules (DOH) designates as Class AA the open coastal waters along the coast of northwest Hawaii, including the water areas of embayments at Puako Bay, Waiulua Bay, and Anaehoomalu Bay. An exception is Kawaihae Harbor which is designated as Class A. The objective of Class AA is to have "these waters remain in their natural pristine state as nearly as possible with an absolute minimum of pollution or alteration of water quality from any human caused source or actions." The objective of Class A waters is to have "their use for recreational purposes and aesthetic enjoyment be protected."

Streams. The *Hawaii Stream Assessment* lists ten streams in the vicinity of the proposed project area with perennial and intermittent flows.[7] Four streams are classified as having flows to the sea year-round. Six streams have year-round flows in the upper portions and intermittent flows at lower elevations. The streams are:

Code	Name	Location	Resource Ranking (O=outstanding	S=substantial	M=moderate)
Streams with flow to the sea year-round					
8-1-03	Kumakua	Hawi			
8-1-12	Aamakao	Makapala	Aquatic-O	Cultural-O	Recreational-S
8-1-13	Niulii	Niulii		Cultural-O	Recreational-M
8-1-14	Akoakoa	Akoakoa		Cultural-O	Recreational-S
Streams with flow year-round in the upper portions and intermittently at lower elevations					
8-1-06	Hanaula	Honomakao			
8-1-07	Hapahapai	Kapaau			
8-1-08	Pali Akamoa	Kapaau			
8-1-09	Wainaia	Halaula			
8-1-10	Unnamed				
8-1-11	Halawa	Halawa		Cultural-O	

Potable Water. The water quality of potable water sources in the region varies. The County water systems in North Kohala rely on a combination of ground and surface water supplies. The ground water is from one well in Hawi. Well water tests indicate good water quality. The surface water supply comes from tunnel sources and is chlorinated before distribution. No water quality problems have been encountered. In South Kohala, the upland areas are served by the County's Waimea System. That system diverts its raw water supply from the Kohala Mountain streams. The raw water is filtered and chlorinated before distribution. The treated water meets all Department of Health requirements. However, the water is occasionally discolored from vegetation in the watershed. The coastal area is served by the County's Kawaihae-Lalamilo-Puako System. Ground water from the Lalamilo wells is used in this system. Well water tests indicate good quality water.

[7] State Commission on Water Resource Management by Hawaii Cooperative Park Service Unit-US National Park Service. *Hawaii Stream Assessment* (DLNR Report R84). December 1990. Page 24 & 266.

5.2.7 AIR QUALITY

There are no apparent sources of industrial or agricultural air pollution in the vicinity of the well and reservoir sites. Because these sites are in agricultural or open grazing lands, natural fugitive dust might occasionally occur during very windy days.

The commonly called "vog" or volcanic haze from the eruptions at Kilauea Volcano can drift north along the coast as far as Kawaihae, especially during periods of south winds. This natural emission has been the source of occasional air pollution on the island for over a decade.

The highway corridor is subject to air pollution from vehicle exhaust emission and spillage from vehicles traveling on the highways. Vehicle exhaust emissions on the coastal highways normally dissipate quickly because of the brisk winds that prevail during most of the year.

5.2.8 NOISE LEVEL

An attraction of the northwest region is its rural ambience and relative quietness. Vehicular traffic along the highways produces the usual traffic noise. Other than noise from vehicular generated noise, there appears to be no urban or industrial activities in the project area that would generate noises at nuisance level. Measurements taken in the residential areas nearest to the well sites showed ambient background noise level averaged about 42 to 46 dBA in the late afternoon, and was influenced by the natural sounds of birds, animals and foliage movement with the wind. Very early morning measurements were similar at 43 to 45 dBA, primarily due to foliage movement with the wind. Minimum readings during period of calm winds measured 37 dBA. Based on these measurements, the existing natural background ambient noise levels at the residences near the well sites are estimated to be approximately 40 to 45 Ldn (Ldn is the day-night average sound level used by federal agencies to assess environmental noise).

5.2.9 NATURAL HAZARDS

The U.S. Geological Survey classifies general areas of the island into volcanic hazard zones and discusses seismic and tsunami hazards in an informative booklet on Hawaii Island.[8]

Volcanic. The booklet shows approximate lava flow hazard zones for the island. North Kohala falls in Zone 9 which is the least hazardous zone on the island and includes areas that did not have any eruption in the past 60,000 years. South Kohala essentially falls in Zone 8 which is the next least hazardous zone and includes areas with only a few percent of its land covered by lava in the past 10,000 years.

Seismic. According to Heliker "although the Island of Hawaii experiences thousands of earthquakes each year; most are so small they can only be detected by instruments,

[8] U.S. Geological Survey by Christina Heliker, U.S.G.S. Volcanic and Seismic Hazards on the Island of Hawaii.

Figure 5.2-9 FEDERAL FLOOD INSURANCE RATE MAP
Map source: FIRM Hawaii County Panels 137 and 139

but some are strong enough to be felt, and a few cause minor-to-moderate damage. Most of Hawaii's earthquakes are directly related to volcanic activity and caused by magma moving beneath the earth's surface." The northwest region has not had any damaging earthquakes since 1868. From a building code standpoint, the Island of Hawaii is classified as Earthquake Risk Zone 3 on an ascending risk scale of 1 to 4.

Tsunami. Heliker explains tsunamis as "large, rapidly moving ocean waves triggered by a major disturbance of the ocean floor, which is usually caused by an earthquake but sometimes can be produced by a submarine landslide or a volcanic eruption. About 50 tsunamis have been reported in the Hawaiian Islands since the early 1800's." The tsunami of 1946, which originated in the Aleutian Islands, had a wave height of 55 feet at Pololu Valley in North Kohala. The well sites, pipelines, and reservoir sites are all located above this elevation.

Flooding. According to the Federal Flood Insurance Rate Map (FIRM), the sites for the project components, excepting a short segment of the Kawaihae Road across the Kawaihae Harbor, are all located within Zone X (Other Areas), defined as areas located outside a 500-year flood plain. One 700-feet segment and 250-feet segment of Kawaihae Road are in Zone X (Other Flood Areas), defined as areas of 500-year flood, areas of 100-year flood with average depths of less than 1 foot or with drainage areas less than 1 square mile. Between these two Zone X segments, there is a 200-feet segment at Makeahua Gulch in Zone A (Areas Inundated by 100-year flood), defined as areas where no base flood elevations have been determined. See **Figure 5.2-9.**

5.2.10 INFRASTRUCTURE AND PUBLIC SERVICES

This section contains descriptions of existing infrastructure in the region that may be directly affected by the proposed project. Those infrastructure and public services that may be affected by secondary growth resulting from the proposed project are described in **Appendix A** *Socio-Economic Impact Analysis.*

Roadway Systems. Two State highways connect North and South Kohala. The Kohala Mountain Road traverses the mauka slopes of Kohala Mountain between Kamuela and Hawi. The Akoni Pule Highway follows the coastline between Kawaihae and Mahukona then rises inland to Hawi. The Hawi-Niulii Highway is the only paved highway serving the communities east of Hawi. These three highways are used as the spine by most of the collector streets that serve the North Kohala communities.

- Kohala Mountain Road is a two-lane roadway with an 18-foot pavement. Although the pavement is in good condition, it is an old roadway and has several narrow bridges, curves and narrow shoulders.

- Hawi-Niulii Highway is a two-lane roadway with an 18-foot pavement and where most of the commercial outlets between Hawi and Niulii have frontage. Parking for many stores is adjacent to the roadway shoulders. *The beginning segment of the pumped water collector pipeline in the Makalapa vicinity is located in this highway.*

- Pratt Road is a private road that runs almost parallel to the Hawi-Niulii Highway from the Halawa-Makapala area to Upolu. This unpaved field road was used by the former sugar plantation for hauling cane and heavy equipment. Currently, Chalon International Hawaii and its lessees use the road to access their lands. *The pumped water collector pipeline, between Halawa and Kahei, will be located within Pratt Road.*

- The Akoni Pule Highway is a two-lane highway with 24-foot pavement and 8-foot wide shoulders. *The end segment of the pumped water collector pipeline from Kahei area to the collector reservoirs near Puakea Ranch will be located along this highway. The 36-inch gravity flow transmission pipeline from the collection reservoirs to Kawaihae will also be located in this highway.*

The South Kohala coast is served by Akoni Pule Highway, Kawaihae Road and Queen Kaahumanu Highway. All are parts of the State highway system. The Akoni Pule Highway connects Hawi to Kawaihae. Two large developments – the existing Kohala Ranches and Estate subdivision and the proposed Hawaiian Home Lands' Kawaihae project – have their makai access on Akoni Pule Highway. The Kawaihae Road is the primary mauka-makai route between Kawaihae and Waimea. The Queen Kaahumanu Highway connects Kawaihae to Kailua-Kona.

- The Akoni Pule Highway within South Kohala continues as a two-lane roadway with 24-foot pavement and 8-foot shoulders. It changes to the Kawaihae Road, a 22-foot pavement roadway, at Kawaihae. As Kawaihae Road continues south it intersects with the Queen Kaahumanu Highway near Waikui, then continues mauka to Kamuela where it ends at the intersection with Kohala Mountain Road and Mamalahoa Highway. *The 36-inch gravity flow pipeline on Akoni Pule Highway continues on Kawaihae Road to the intersection with Queen Kaahumanu Highway.*

- The Queen Kaahumanu Highway is the major arterial between South Kohala and North Kona. It has two 12-foot lanes with 8-foot shoulders. The access points to the Kona and Kohala resorts and recreational areas are from this highway. *The 36-inch gravity flow pipeline continues in this highway from the intersection with Kawaihae Road to the Puako vicinity where it turns mauka to the Lalamilo terminal reservoir.*

Water Systems. The potable water needs of the coastal areas of North and South Kohala are served by four public and two private water systems. In North Kohala the area between Upolu and Makapala is served by three County water systems. The Kohala Ranches and Estates subdivisions in the west coast of North Kohala is served by the private Kohala Ranch Water Company. The South Kohala coast is served by the County DWS and the private Waikoloa Water Company.

- The Kaauhuhu-Kokoiki System (mauka) serves the upper Kaauhuhu Homesteads and Kokoiki area above Kohala Ditch. The source of water for this system is Lindsey Tunnel with supplementary water from the Hawi well. In FY 1993-94 the average daily consumption was 124,000 gallons.

- The Hawi-Kokoiki-Kynnersly-Kapaau System (makai) serves the area along the main highway between Kapaau and lower Kokoiki to the former Loran Station in Upolu. The Watt Tunnel and Hapahapai Tunnel normally supply the system. Supplementary water is provided by the Hawi well. The former Makapala-Keokea System service area is now included in this system. The combined systems consumed an average of 309,000 gpd in fiscal year 1993-94.

- The Halawa-Halaula System serves residents in the former Kohala sugar mill area. The primary water source for this system is Bond Tunnel No. 1. Supplementary water is provided through the Hawi System when necessary. In FY 1993-94, this system consumed an average of 91,000 gpd.

- The private Kohala Ranch Water Company services the Kohala Ranches and Estate subdivisions. The system's water supply is provided by two deep wells located on Kohala Ranch land.

- The County's Kawaihae-Lalamilo-Puako System's service area extends from the Mauna Lani Resort at the southern end to DHHL's industrial subdivision in Kawaihae. This system serves the Mauna Lani, Mauna Kea Beach and South Kohala resorts, Puako area, Kawaihae Harbor and village area, and DHHL industrial subdivision. The system is supplied with ground water from the Lalamilo wells. In fiscal year 1993-94, the system consumed an average of 2.8 mgd.

- The private Waikoloa Water Company provides potable water to the Waikoloa Beach Resort and the Waikoloa Village areas. The company maintains three deep wells in Waikoloa. The system's current average consumption is 3.2 mgd.

The non-potable and irrigation water needs of the coastal areas of North and South Kohala are provided by four private systems. In North Kohala, Chalon International of Hawaii provides raw surface water from its Kohala Ditch system for irrigation, hydroelectric, and aquaculture uses. In South Kohala, the three existing resorts—Mauna Kea, Mauna Lani, and Waikoloa—each operate their own brackish ground water system for golf course and landscape irrigation. There are presently nineteen brackish water irrigation wells in operation. They are situated at lower elevations, mostly adjacent to Kaahumanu Highway. See **Figure 2.2-4** for map showing the location of operating wells in the South Kohala coastal area.

Wastewater. In the northwest Hawaii region, the Department of Health's critical wastewater disposal area (CWDA) line is defined as 1,000 feet from the shoreline or at 100 foot elevation, whichever distance is greater from the shoreline. New cesspools may not be installed for domestic waste disposal within the CWDA. Hawaii Administrative Rules §11-62-32 requires an individual wastewater system to have a minimum distance of 1000 feet from a potable drinking water well. In addition, Hawaii Administrative Rule §11-23-09 requires any new injection well to be at least one-quarter mile from any part of a drinking water source.

There is no municipal wastewater system in North Kohala. Cesspools are the commonly used method for domestic waste disposal. New cesspools can be installed in any location that is not within a CWDA area and is beyond the minimum distances described above.

The South Kohala coast resorts all operate their own private wastewater treatment and effluent disposal systems. As part of their water conservation effort, the resorts are working toward greater use of effluent from the treatment plants for golf course and other irrigation.

Solid Waste. The County operates solid waste transfer stations in Waimea, Puako, Kaauhuhu and Halaula. The compacted solid wastes from these stations are hauled to the recently opened Pu'u Anahulu landfill just south of the North and South Kohala boundary.

Power and Communication Systems. Electrical service in the region is provided by Hawaii Electric Light Company (HELCO). Power from HELCO's Waimea plant is carried to the Maliu, Hawi, and Kohala sub-stations through an overhead 34 KV transmission line that runs along the Kohala Mountain Road. Supplementary energy generated by the Kahua Ranch wind farm and Hawi hydroelectric power plant is fed into the grid through this line.

The South Kohala coast receives its power through overhead 69 KV and 12 KV lines from HELCO's plant in Waimea. The minor power needs of the proposed project components in the coastal area can be accommodated by the existing system.

Telephone services in the region are provided by Hawaiian Telephone Company (HTCO). Central switching station functions for the region are handled through the Kailua-Kona station. There are no CATV facilities in the region. However, the resorts have their own CATV facilities.

5.3 ARCHAEOLOGICAL / CULTURAL RESOURCES

The information in this section is from an archeological inventory survey conducted for the proposed project by Scientific Consultant Services, Inc. See **Appendix D.**

Although several listed historic sites are located near the project corridor, none of them will be significantly affected by the proposed project. These sites include the Bond complex, Kamehameha Statue, Kohala Sugar District, Hawi Commercial District, Pu'ukohola and Mailekini Heiau, and John Young's home.

A total of five archaeological sites were identified during the field work. Three of the site were small scatters of marine shell (Sites 19,774, 19,777, and 19,778), one site was a platform (Site 19,775), and one site was a complex of features comprised of at least three enclosures and a small paved area (Site 19,776).

Research conducted at Chalon International, including interviews with land managers and field checks, confirmed that all of the well locations and their associated access roads were located in areas highly disturbed by sugarcane production. This is also true of the Collection Reservoir Site, the Kapa'au Booster Station, the Kapa'au Reservoir Site, the Kynnersley Booster Pump Station, the Hawi Booster Pump Station, and the pipeline route that follows the cane haul road known as Pratt Road. South of the Collection Reservoir Site sugarcane agriculture appears to have played a lesser role in modifying the landscape within the project area.

The pipeline route located along Akoni Pule Highway has also been highly disturbed by the construction of that highway. The only areas along the highway requiring close inspection were the gullies that the highway crossed. No significant cultural remains were found in these gullies which were generally quite disturbed by the highway construction.

Three sites were identified along the access road to the Pressure Breaker Reservoir. Site 19,774 was a midden scatter not associated with any surface architecture or recognized trail. Such midden scatters were expected in the barren settlement zone.

The presence of the platform (site 19,775) and the habitation complex (site 19,776) were somewhat surprising. The location of site 19,776 on the edge of a gully suggests that sufficient water may have been present in the gulch to support the residence. Insufficient work has been carried out at his site to allow this to be more than conjecture at this point.

Sites 19,777 and 19,778, identified along the access road to Lalamilo Terminal Reservoir were both midden scatters. Again, such scatters are expected in the barren zone and fit the settlement model. No surface architecture or trails were associated with either site.

Sufficient work has been completed at sites 19,774, 19,777, and 19,778 that they can be considered no longer significant. Site 19,775, a probable burial platform, should be preserved by slightly realigning the access road to the north to avoid impacting the feature. Site 19,776 is situated outside of the proposed access road corridor and should not be in any danger from project activities.

The author of the survey also recommended that an archaeological monitor be present when the access roads to the Pressure Breaker Reservoir and the Kawaihae Terminal Reservoir are constructed. Because of possible realignment during construction the present of a monitor would facilitate the construction. This is especially important along the access road for the Kawaihae Terminal Reservoir since several features (Allen 1987) are recorded near, but not in, the proposed access road.

5.4 BIOLOGICAL RESOURCES

The information in this section is from a biological survey conducted for the proposed project by Lani Stemmerman and Rexford Palmer. See **Appendix D** for the survey report.

The biological survey of the proposed project area did not locate any endangered or candidate endangered species that legally require planning consideration. The proposed well field is situated on land once in sugar cultivation, and the proposed pipeline is

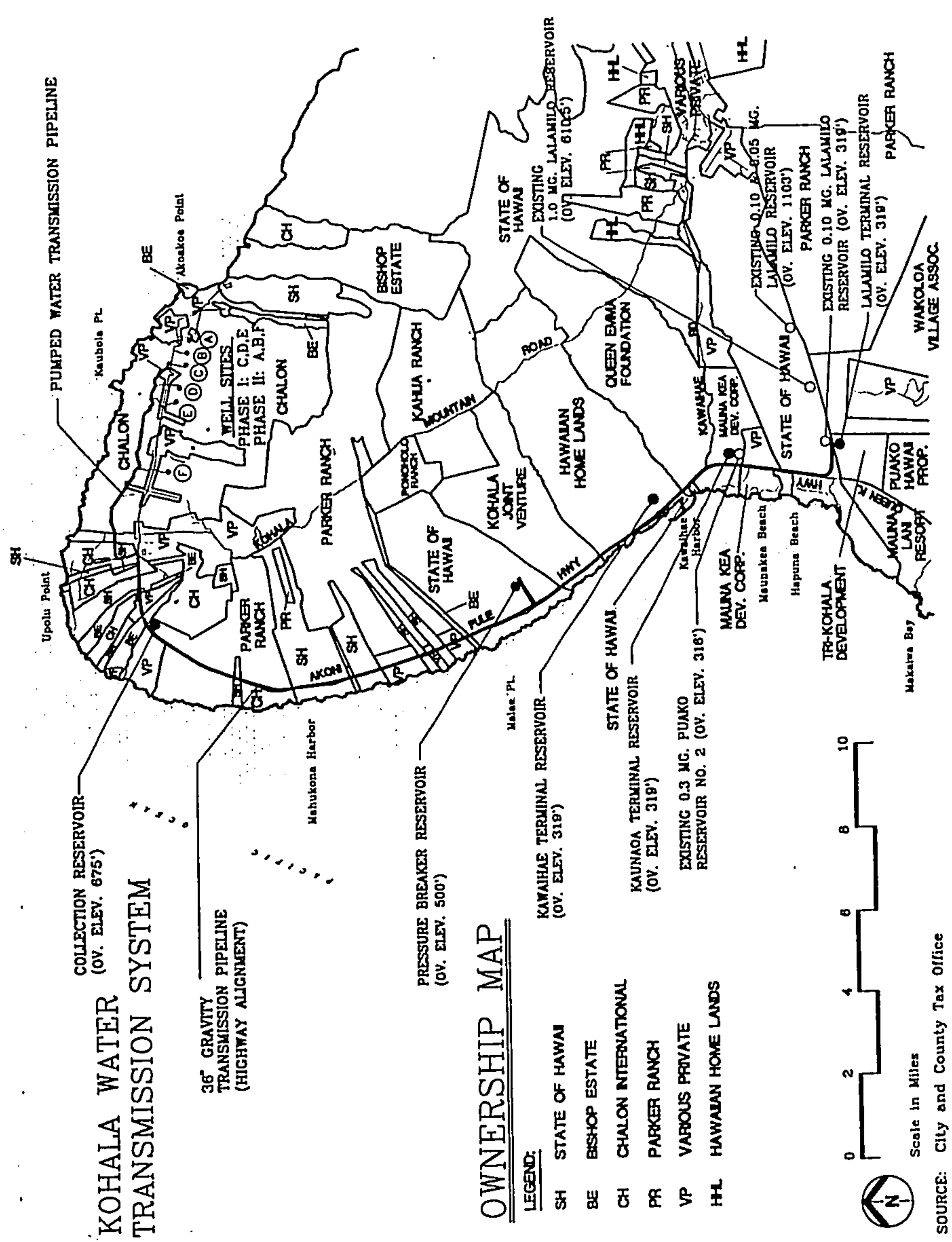


Figure 5.5-1 OWNERSHIP MAP
Map Source: Okahara & Associates, Inc.

located on the road shoulder or in the road for much of the route. Thus, prior to the project, most of the native biological communities that would be affected have already been disturbed.

Plant species: Roughly 260 plant species were identified in the project area. The species diversity was highest in the relatively wet northern portion of the project. However, native species were proportionately greater in the less disturbed and drier southern part of the project. No endangered or candidate endangered plant species were located. Patches of native grass, identified as *Eragrostis variabilis* (Hitchcock 1922) grow at the terminal reservoir site near Puako and on the makai side of the Akoni Pule Highway just south of the ten mile marker. While this species is not legally protected, relatively intact patches of native plants in the Hawaiian lowlands are rare. The revised location of the Phase II terminal reservoir is on the south side of the existing reservoir and avoids the patches of native grasslands.

Bird species native to region that were detected include the 'Io, which is common in the North Kohala region, the plover, and ruddy turnstone which are common annual migrant species, and the pueo. The 'Io is an endangered species widespread on the island of Hawai'i, but it is highly unlikely that there could be any direct impact of the proposed project on this or any other native birds since the project is largely restricted to pastures and already modified edges of existing roads.

Other vertebrate species seen during the survey include mongoose, domestic and feral cats, dogs, livestock, and poultry. Geckos, skinks, toads, rats, mice, and feral goats also occur in the project area. None of these species require planning consideration. The Hawaiian bat may fly over the project area, but Kohala roadsides and pastures are not considered the prime habitat for this endangered species.

Stream fauna were not surveyed doing the biological survey because of the lack of impact to stream habitat from the proposed action.

Wetland. Although the present survey does not constitute an Army Corps of Engineers wetland determination, direct project effects on wetlands are not anticipated.

5.5 LAND OWNERSHIP

Ownership of sites for project components are as follows (see **Section 3.7** for maps):

- The six Well Sites and access roadways are on lands owned by the Chalon International Inc. of Hawaii.
- A large segment of the Pumped Water Collector Pipeline is on Pratt Road, which is owned by Chalon International Inc. of Hawaii.
- The Collection Reservoir site and access roadway are on land owned by Parker Ranch.
- The Pressure-Breaker Reservoir site and access roadway are on land owned by State of Hawaii.

- The Kawaihae Terminal Reservoir site and access roadway are on land owned by the Department of Hawaiian Home Lands.
- The Kaunaoa Terminal Reservoir site and access roadway are on land owned by Mauna Kea Properties.
- The Tri-Kohala Terminal Reservoir site and access roadway are on land owned by Tri-Kohala Development.

Research conducted for this EIS at the Hawaii County Planning Department indicated that approximately 50 parcels with shoreline or near shoreline frontage are present between Upolu Point area and the Kawaihae Hawaiian Homes boundary. **See Figure 5.5-1.** At least seven of these belong to the State of Hawaii, including several parcels with large acreage and substantial shoreline frontage. Parker Ranch and Chalon International are owners of another large fraction of acreage/frontage. The remaining parcels vary between one and several hundred acres.

The lands between the Kawaihae Hawaiian Homes tract and Waikoloa Resort and Village are mostly in large tracts except for the Puako and Kawaihae Village areas that have many small privately held parcels. The major landowners include the Queen Emma Foundation, Mauna Kea Properties, Mauna Lani Resort, State of Hawaii, Tri-Kohala Development, and Nansay Hawaii Puako Properties.

5.6 SOCIO-ECONOMIC ENVIRONMENT

North and South Kohala are the setting of the Kohala Water Transmission System, and they would experience the majority of impacts. In the century preceding 1970, the economic and social mainstays were sugar plantations in North Kohala and cattle ranching in South Kohala. Kohala became an ethnically diverse collection of small towns and farmsteads highly dependent on a few large agricultural enterprises. Most of landscape remained in open space, providing a resource for local residents and a striking backdrop for the resorts to come.

The last twenty-five years have seen a transition from an agrarian base to one dominated by the visitor industry, which now provides over 4,000 jobs, mostly at the five major resort hotels. The visitor industry began an economic and social transformation that now involves all of Kohala and continues to accelerate. Population increased almost 150% between 1970 and 1990, and today stands at over 14,000. Other key trends include economic diversification, immigration of mainlanders, and the opening of new lands for settlement.

The water made available by the Kohala Water Transmission System would continue many of these trends. It would generate social and economic impacts of two types: *direct or primary,* related to construction and operation of the water system, and *secondary,* related to the development induced by the increase in water supply.

The Socioeconomic Impact Assessment (see **Appendix A**) conducted for this EIS attempted to predict the nature and extent of development based on two scenarios: the **Historical Trends**, which simply projected past trends into the future, and the **As-Planned** scenario, which used projections supplied by private and public sector planning studies for the region.

In both scenarios, development would be concentrated in coastal South Kohala, where government policy supports the creation of infrastructure necessary to support planned needs. Private developers would be able to implement their plans for resort hotels and housing within the areas served by the water system. Development plans for the Department of Hawaiian Homes Lands (DHHL) Kawaihae project would also be furthered by the presence of water. The provision of water is a key element in the unfolding of the development concepts envisioned for Kohala in the Hawaii County General Plan, in the West Hawaii Plan, and more generally in the Hawaii State Plan. However, the fact that the pipeline of necessity runs through coastal North Kohala may encourage urban development of this area, where many parcels are currently not zoned for such land uses.

In the **Historical Trends** scenario, it is expected that as many as 3,600 new hotel rooms would be created by the year 2020, along with approximately the same number of resort residential units. If development unfolds according to **As-Planned** projections, only 450 hotel rooms would be developed, while over 12,000 residential units would be created, 65 percent of them located in the Kawaihae DHHL project.

Starting with these assumptions concerning the path of future development, the SIA made a series of calculations to estimate construction activity, jobs, indirect economic impacts, government revenues and expenditures, population growth, change in social composition and conditions, and impacts to recreation, open space and cultural resources.

See **Appendix A - Socio-Economic Impact Assessment**, beginning on page 8 for discussions on Existing Economic Conditions which covers State Economy, Hawaii County Economy, and Regional Economic Setting.

See **Appendix A - Socio-Economic Impact Assessment**, beginning on page 14 for discussions on Social Characteristics which covers Population and Settlement Patterns, Socio-economics (page 19), Socio-cultural (page 20), Indicators of Social Well-Being (page 23), Community Identity, Values, and Visitor Interaction (page 25), Outdoor Recreational Resources (page 32), and Public Services and Infrastructure (page 34).

See **Section 9** for discussions on probable socio-economic impacts of the proposed action.

SECTION 6
RELATIONSHIP TO LAND USE PLANS, POLICIES AND CONTROLS

SECTION 7
RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

SECTION 8
IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

SECTION 6
RELATIONSHIP TO LAND USE PLANS, POLICIES AND CONTROLS

Planning for any major public works project merits review of public policy. There may be a multitude of agencies with some sort of interest in or jurisdiction over a particular project, with policies that may be inconsistent or even in conflict. It is often only through analysis of a specific project's consistency that the level of concordance among various policies comes to light.

This section lists important plans and policies by agency or document and discusses their relationship to the proposed project. The concluding section considers the collective implications of the plans and policies and attempts to assess the project in the context of the "big picture."

6.1 HAWAII STATE PLAN

The Hawaii State Plan was adopted in 1978 and most recently revised in 1991 (HRS, Chapter 226, as amended). The Plan establishes a set of goals, objectives and policies that are meant to guide the State's long-run growth and development activities. The proposed project is consistent with State goals and objectives that call for increases in employment, income and job choices, and a growing, diversified economic base extending to the neighbor islands.

6.1.1 Hawaii State Plan - Water

The sections of the Hawaii State Plan most relevant to the direct impacts of the proposed project are centered on the theme of water. The following objectives and policies are taken from the section dealing with water (Section 226-16, as amended, HRS).

Objectives and Policies for Facility Systems - Water

Section 226-16(a): Planning for the State's facility systems with regard to water shall be directed towards achievement of the objective of the provision of water to adequately accommodate domestic, agricultural, commercial, industrial, recreational, and other needs within resource capacities.

Section 226-16(b): To achieve the facility systems water objective, it shall be the policy of this State to:

Section 226-16(b)(1): Coordinate development of land use activities with existing and potential water supply.

Section 226-16(b)(2): Support research and development of alternative methods to meet future water requirements well in advance of anticipated needs.

Section 226-16(b)(3): Reclaim and encourage the productive use of runoff water and wastewater discharges.

Section 226-16(b)(4): Assist in improving the quality, efficiency, service, and storage capabilities of water systems for domestic and agricultural use.

Section 226-16(b)(5): Support water supply services to areas experiencing critical water problems.

Section 226-16(b)(6): Promote water conservation programs and practices in government, private industry, and the general public to help ensure adequate water to meet long-term needs.

Discussion: Succinctly put, it is the policy of the State to encourage the most efficient use of water supporting planned development. Of relevance to the proposed project are the implications for supporting development plans in both North and South Kohala, as well as the issue of efficient use of water resources.

Projections of potable ground water use for North Kohala indicate that local use approaching sustainable yield for the abundant groundwater resources of the North Kohala is unlikely (see **Appendix F**) Therefore, the loss of 20 mgd from the North Kohala aquifer system does not preclude the full, planned development of North Kohala. Transferring this quantity of water to South Kohala would enable completion of the level of development anticipated in State and County plans for the South Kohala resort region.

Potable water in the South Kohala region is used for a number of purposes: domestic use, commercial uses e.g., hotels, restaurants, residences, and landscape irrigation. Because water is a critical and scarce element, resort hotels are working on a number of water conservation measures. Golf courses use little potable water but instead use brackish ground water. Some courses are using a blend of treated wastewater effluent and brackish water. Short of curtailing water use to levels that would preclude the lush ambience that plays a major role in attracting tourists to the resorts, there are few conservation measures with potential for large water savings. Supporting additional development thus implies importing large quantities of water.

6.1.2 Relationship to Secondary Impacts of Proposed Project

In addition to the issue of water systems it is also important to examine the Hawaii State Plan in relation to the secondary impacts of the proposed project–encouraging business and population growth in South Kohala.

The three themes that express the basic purpose of the Hawaii State Plan are *individual and family self-sufficiency, social and economic mobility* and *community or social well-being*. In general, it can be said that the proposed action is generally consistent with State goals and objectives that call for increases in employment, income and job choices, and a growing, diversified economic base extending to the neighbor islands. The following sections analyze the relationship of the proposed project selected State Plan goals, objectives, policies and priority guidelines.

Objectives and Policies for Population

Section 226-5(b)(1): Manage population growth statewide in a manner that provides increased opportunities for Hawaii's people to pursue their physical, social, and economic aspirations while recognizing the unique needs of each county.

Section 226-5(b)(2): Encourage an increase in economic activities and employment opportunities on the neighbor islands consistent with community needs and desires.

Section 226-5(b)(3): Promote increased opportunities for Hawaii's people to pursue their socio-economic aspirations throughout the islands.

Section 226-5(b)(7): Plan the development and availability of water resources in a coordinated manner so as to provide for the desired levels of growth in each geographic area.

Discussion: The growth of the region is certainly in conformance with existing State and County land use policies specifically concerned with this region (see Sections 6.4 to 6.6). The development of the South Kohala resort region remains a key element of State and County planning because the resorts are the major economic engine for the region and a significant factor for the entire county. Although it is certainly true that the basic motive behind every resort is profit for developers and operators, government planning and support of this development has focussed on the jobs, tax revenues, economic multiplier effects, and cultural side benefits for residents. As discussed in **Section 9.2**, average income, job diversity, opportunities for mobility and advancement, road access to coastal areas, and cultural activity choices have all increased in South and North Kohala over the last two decades, largely as a result of the resort industry. In creating a magnet for jobs, the resort region has also induced population growth of over 300 percent in the last thirty years. Part of this growth reflects the retention of young workers formerly drawn elsewhere for employment opportunities.

Such benefits have not come without costs: some formerly isolated cultural recreational spots are now overrun or adversely affected by the presence of tourists; the monopoly on the economy formerly held by the plantations has been to some degree simply replaced by the visitor industry; not all employees are satisfied with the types of jobs offered by the resort industry; and many residents are concerned about socioeconomic polarization of Kohala into two classes, wealthy mainlanders/Asian nationals and a local underclass.

Nevertheless, strong community support for resort development (under conditions appropriate for the community) has been consistently evident in Kohala. Voters have steadily endorsed pro-development candidates in local elections and expressed positive feelings about resorts in surveys and interviews throughout the last two decades. Because the proposed project would tend to support the increase of economic opportunities for the region, it appears to be consistent with calls in the Hawaii State Plan for promotion of a level and nature of development desirable for residents.

Objectives and Policies for the Economy - in General

Section 226-6(a)(1): Increased and diversified employment opportunities to achieve full employment, increased income and job choice, and improved living standards for Hawaii's people.

Section 226-6(a)(2): A steadily growing and diversified economic base that is not overly dependent on a few industries.

Discussion: The secondary economic impacts of the proposed project would increase employment opportunities for residents of North and South Kohala, as well as Hamakua, which has suffered severe economic dislocation since the closure of the sugar plantations.

The question of economic diversification is problematic. An increase in the number of resort hotels would dramatically increase jobs but would tend to decrease economic diversity and increase dependence on the visitor industry. Current developer plans specifying little hotel growth but a great increase in resort housing would produce fewer direct jobs but spawn a more diversified secondary economy, particularly in the service sector (see **Section 9.2**).

Objectives and Policies for the Economy - Agriculture

Section 226-7(b)(6): Assure the availability of agriculturally suitable lands with adequate water to accommodate present and future needs.

Discussion: Neither the direct (pipeline-reservoir) nor the secondary (urbanization of parts of South Kohala) impacts of the proposed project would remove agriculturally important land from use or the potential for use. The price of developing potable ground water exceeds the ability of agricultural users to pay and therefore the use of this water will not negatively impact any agriculture. If anything, the secondary impacts will have a tendency to stimulate the market for local crops.

Objectives and Policies for the Physical Environment - Land-based, Shoreline and Marine Resources

Section 226-11(a)(2): Effective protection of Hawaii's unique and fragile environmental resources.

Section 226-11(b)(3): Take into account the physical attributes of areas when planning and designing activities and facilities.

Section 226-11(b)(9): Promote increased accessibility and prudent use of inland and shoreline areas for public recreational, educational, and scientific purposes.

Discussion: Biological inventories performed for this EIS indicate that the direct effect of the pipeline and reservoirs on biological resources will be minimal. No candidate or listed threatened or endangered species or their habitat will be negatively impacted (see **Section 5.4**).

In general, the development of the resort industry in South Kohala has opened up significant parts of the coastline for public, vehicular access in addition to opening and transforming the coastline for resort purposes. Given State and County policies and existing public sensitivity about the importance of public access, this trend is expected to be an integral part of all future coastal developments.

As this once-wilderness area continues to develop, State and County agencies will need to closely monitor private and public shoreline use to ensure that the resource is not over-taxed by crowding, litter, pollution or incompatible uses.

Objectives and Policies for the Physical Environment - Scenic, Natural Beauty, and Historic Resources

Section 226-12(b)(1):	Promote the preservation and restoration of significant natural and historic resources.
Section 226-12(b)(3):	Promote the preservation of views and vistas to enhance the visual and aesthetic enjoyment of mountains, ocean, scenic landscapes, and other natural features.
Section 226-12(b)(4):	Protect those special areas, structures and elements that are an integral and functional part of Hawaii's ethnic and cultural heritage.

Discussion: Archaeological studies and view analyses performed for this EIS indicate that the direct effect of the pipeline and reservoirs on historic and scenic resources will be minimal (see **Section 5.3**). Several reservoirs have been re-sited during the design process in order to minimize or mitigate scenic impacts (see **Section 3.4**).

Special Management Area and other State and County review processes analyze and suggest mitigation measures for impacts relating to scenery and natural beauty for resorts built near the coast, where the greatest potential for impact on scenic resources exists.

Objectives and Policies for the Physical Environment - Land, Air and Water Quality

Section 226-13(b)(2):	Promote the proper management of Hawaii's land and water resources.
Section 226-13(b)(3):	Promote effective measures to achieve desired quality in Hawaii's surface, ground and coastal waters.
Section 226-13(b)(7):	Encourage urban developments in close proximity to existing facilities and services.

Discussion: Best management practices as required by State Department of Health and County grading permits are expected to mitigate any negative impacts on water quality from construction to essentially zero.

Studies of the impact of both the withdrawal of 20 mgd of ground water which will decrease the discharge of groundwater at the shoreline in North Kohala, and increase discharge in some areas of South Kohala. The studies revealed there appears to no potential for negative impacts to marine ecosystems in either North or South Kohala from the diversion of the groundwater (See **Section 3.4** and **Appendix C**). No significant deterioration of coastal water quality, air quality or land would be expected from properly regulated urbanization in South Kohala.

Objectives and Policies for Socio-Cultural Advancement - Housing

Section 226-19(a)(1):	Greater opportunities for Hawaii's people to secure reasonably priced, safe, sanitary, livable homes in suitable environments that satisfactorily accommodate the needs and desires of families and individuals.
Section 226-19(b)(2):	Stimulate and promote feasible approaches that increase housing choices for low-income, moderate-income, and gap-group households.
Section 226-19(b)(7):	Foster a variety of lifestyles traditional to Hawaii though the design and maintenance of neighborhoods that reflect the culture and values of the community.

Discussion: It is expected that virtually all market homes or lots planned for the resort areas will be significantly more expensive than what the average Hawaii resident can afford. The experience of the past decade in Kohala indicates that the creation of affordable housing, whether through market or government-mandated or sponsored programs lags behind the needs of residents drawn to the area by resort jobs. Agreements between government and business concerns may be necessary to insure development of adequate affordable homes.

The potential that residential development at Hawaiian Homes lands in Kawaihae may benefit from the provision of water from this project would supply a source of affordable homes for residents who qualify for the homestead lots. This development would also avoid skewing of socioeconomic makeup of Kohala abnormally towards wealthy, part-time, non-local residents.

Objectives and Policies for Socio-Cultural Advancement - Leisure

Section 226-23(b)(6):	Assure the availability of sufficient resources to provide for future cultural, artistic and recreational needs.

Discussion: The expansion of the South Kohala resort area can be expected to continue the broadening of the range of activities currently available in South Kohala.

Objectives and Policies for Socio-Cultural Advancement - Culture

Section 226-25(b)(2): Support activities and conditions that promote cultural values, customs, and arts that enrich the lifestyles of Hawaii's people and which are sensitive and responsive to family and community needs.

Discussion: A significant outgrowth of the resort industry has been the support and revival of traditional and contemporary Hawaiian arts, crafts and customs. At the same time, however, the "Americanization" of this formerly isolated region which was occurring anyway has been accelerated by the growth of the resort industry and increasing income and exposure to a upper middle-class and wealthy individuals from around the world. The desirability of the resulting balance between isolated tradition and a cultural renaissance that takes place in a context of increasing alienation from traditions in everyday life can only be judged by each individual.

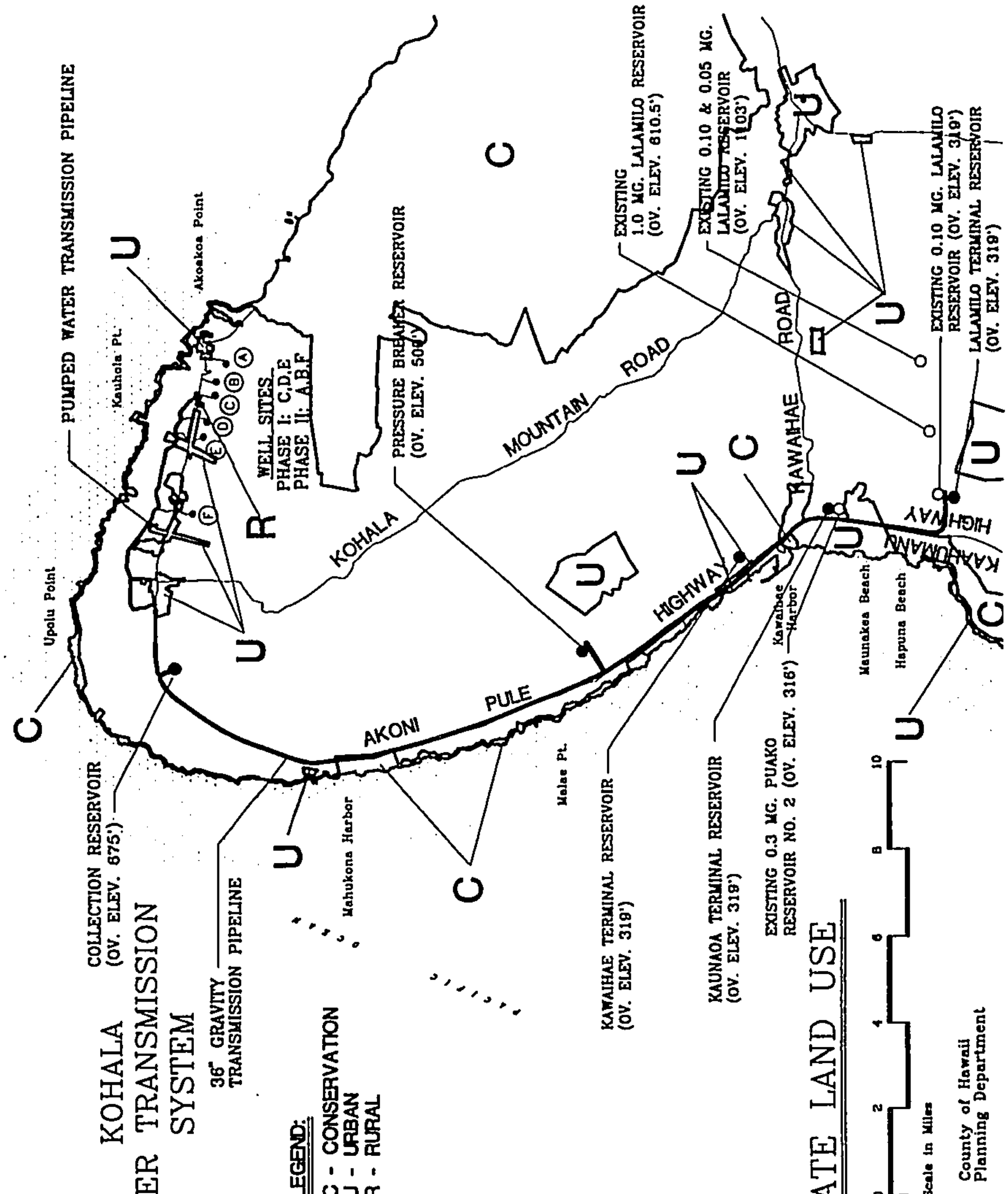


Figure 6.2-1 STATE LAND USE - NORTHWEST HAWAII
Map Source: Okahara & Associates, Inc.

6.2 STATE LAND USE LAW

All land in the State of Hawaii is classified into one of four land use categories -- Urban, Rural, Agriculture, or Conservation -- by the State Land Use Commission, pursuant to Chapter 205, HRS. The areas directly affected by the project (wells, pipelines, reservoirs, etc.) fall almost completely within the Agriculture district, with limited areas of Urban classification in the towns of North Kohala and the resort area of South Kohala. A very small corner of a parcel designated Conservation (Lapakahi State Park) may be impacted by the pipeline right-of-way. If so, the appropriate Conservation District Use Permits (CDUP) will be sought. No Petition to Amend State Land Use District Boundaries is anticipated or necessary for the project. See **Figure 6.2-1.**

Secondary impacts will induce development in areas primarily designated as Urban, although lands in the Agricultural District may also experience more development opportunities or pressure as a result of water availability.

6.3 COASTAL ZONE & SPECIAL MANAGEMENT AREA

The objectives and policies of the Hawaii Coastal Zone Management (CZM) Program are included in Chapter 205A, HRS. All of the island of Hawaii lies within the CZM. Only one small segment of the main pipeline (as it crosses Honokoa Gulch, near Kawaihae) may fall within the Special Management Area as defined by the County of Hawaii. This segment of the project may require a Special Management Area Use Permit.

The relevant objectives and policies of Chapter 205A are presented below, followed by a brief discussion of the relationship of the objectives to the proposed project.

Objective 2: Protect, preserve and where desirable, restore those natural and man-made historic and prehistoric resources in the coastal zone management area that are significant in Hawaiian and American history and culture.

Policy 2a: Identify and analyze significant archaeological resources.

Objective 3: Protect, preserve, and where desirable, restore or improve the quality of coastal scenic and open space resources.

Policy 3a: Identify valued and scenic resources in the coastal zone management area.

Policy 3b: Ensure that new developments are compatible with their visual environment by designing and locating such developments to minimize the alteration of natural landforms and existing public views to and along the shoreline.

Policy 3d: Encourage those developments which are not coastal dependent to locate in inland areas.

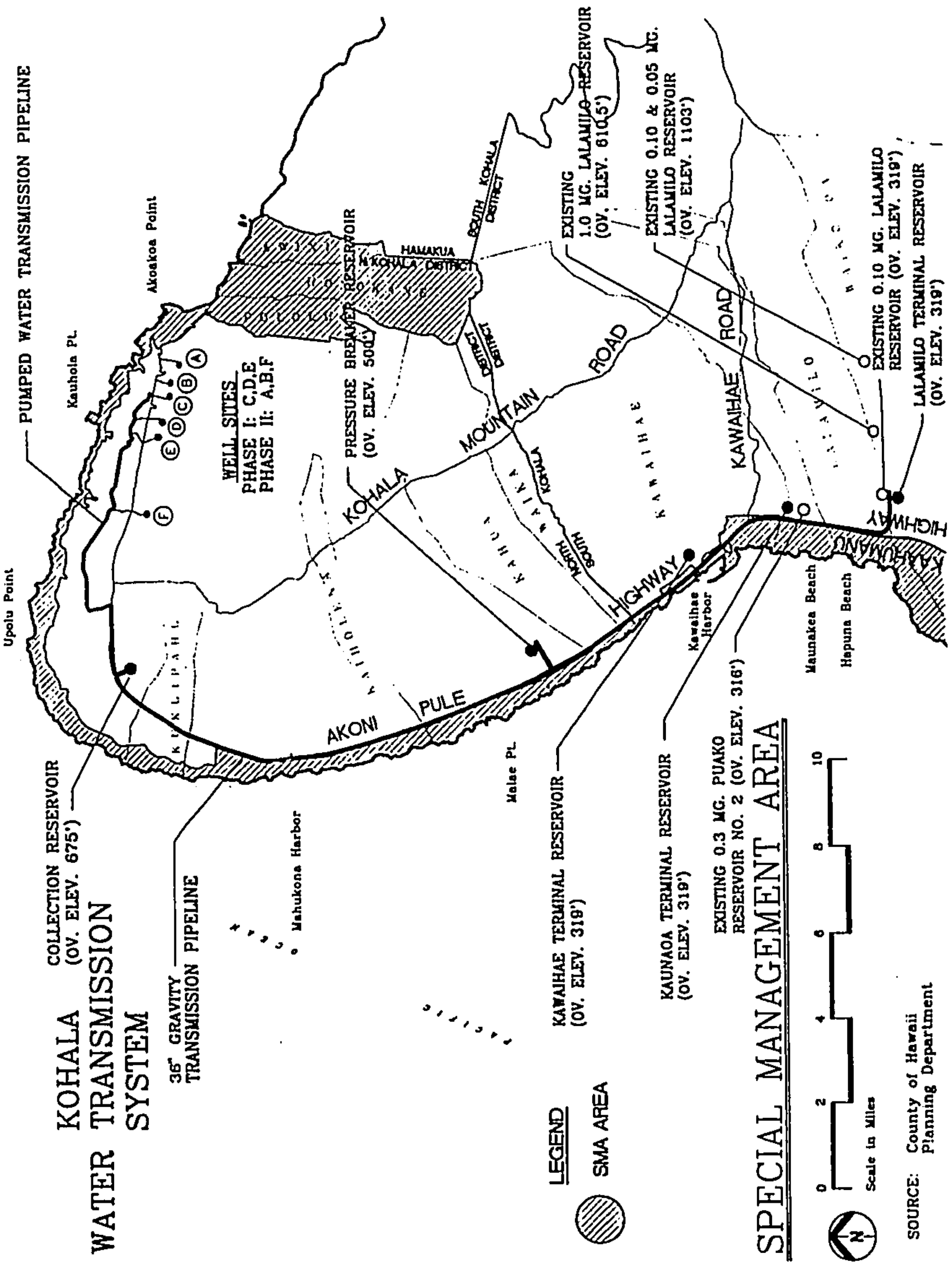


Figure 6.3-1 SPECIAL MANAGEMENT AREA
Map Source: Okahara & Associates, Inc.

Objective 4:	Protect valuable coastal ecosystems from disruption and minimize adverse impacts on all coastal ecosystems.
Policy 4b:	Preserve valuable coastal ecosystems of significant biological or economic importance.
Objective 6:	Reduce hazard to life and property from tsunami, storm waves, stream flooding, erosion and subsidence.
Policy 6b:	Control development in areas subject to storm wave, tsunami, flood, erosion, and subsidence hazard.
Policy 6c:	Ensure that developments comply with requirements of the Federal Flood Insurance Program.

Discussion: An inventory survey of archaeological resources has been accomplished by a professional archaeologist in coordination with the State Historic Preservation Division (see **Section 5.3**).

Regarding scenic impacts, most of the areas through which the project passes through will be unaffected because the pipeline will be buried. Design engineers have taken considerable effort to site reservoirs in such a way as to minimize or mitigate scenic impact (see **Section 3.4**). As a result, the scenic values of the coastal zone in North and South Kohala should not be affected directly by the project. The route of the pipeline follows the coast only in those areas in which the highway is adjacent to the coast.

The secondary impacts - growth associated with the availability of water - doubtless have the potential to significantly affect archaeological resources, scenic views, and coastal ecosystems in the area. These impacts are discussed in general terms throughout the EIS, particularly in **Section 9.3**. The specific impacts and mitigation measures necessary to minimize these impacts cannot be evaluated until actual developments are proposed. Regulatory review by State, Federal and County agencies will address such issues at the appropriate time.

No coastal hazards threaten the direct project area. Requirements of the Federal Flood Insurance Program are reviewed as part of the construction and development process and compliance is to be expected (see **Section 5.2.9**).

6.4 WEST HAWAII REGIONAL PLAN

The West Hawaii Regional Plan (Hawaii Office of State Planning 1989) represents an attempt to coordinate planning efforts among State agencies that have programs, facilities and other interests in North Kona, South Kohala and North Kohala. The basic purposes are to respond more effectively to emerging needs and critical problems, coordinate Capital Improvements within a regional planning framework, and provide guidance in State land use decision-making processes.

The following contains a listing and discussion of key strategies and actions designed to address particular planning problems in the region.

Planning for Resort Development

Strategy: Cluster resorts in "Resort Destination Nodes" of Mauna Kea, Mauna Lani/Waikoloa, Kaupulehu/Kona Village/Kukio, and Keahole-Keauhou.

Actions: Develop concept of Resort Destination Nodes as employment centers;
Provide economic incentives for private sector involvement in financing and enveloping social and physical infrastructure systems.

Discussion: The provision of water to the South Kohala resort region is a rational step in assuring proper infrastructure for an identified resort node. However, resort development along the pipeline route in areas of South and North Kohala that are not included in these nodes may be brought one step closer to fruition by the availability of water. It must be emphasized that considerable input and approvals from both State and County government would be necessary before any such development would be possible.

The financing of the proposed project is being accomplished partly through pre-construction facilities development charge agreements made between the County Department of Water Supply and large landowners with appropriate zoning in the service area. Such an approach minimizes taxpayer or ratepayer expense or risk in developing the new system and fulfills exactly the action desired by OSP.

Support Communities

Strategy: Designate and develop appropriate primary and secondary support communities to house employees working at Resort Destination Nodes.

Actions: Target major areas for government-assisted support communities at Kealakehe, Signal Puako, Waikoloa, Lalamilo, and Kawaihae.
Where feasible, coordinate development efforts with the private sector and other governmental agency developments.

Discussion: The fulfillment of this objective will be enhanced but not enabled by the availability of water. As mentioned in the discussion of the Hawaii State Plan, agreements between government and business concerns may be necessary to insure development of adequate affordable homes

Outdoor Recreation Resources

Strategy: Support an improved and expanded recreation delivery system in the region in order to meet a greater diversity of recreation needs and provide a wider range of recreation opportunities. Priority should be given to prime swimming beaches and other areas with a variety of recreation resources.

Actions: Establish more public parks or park reserves in places with high outdoor recreation resource potential [including] Hapuna Beach State Recreation Area expansion to Wailea Beach.

Discussion: The provision of additional water will help enable the planned expansion of Hapuna Beach State Park.

State-Owned Lands

Strategy: Optimize the use of State-owned lands.
Actions: Support implementation of the Department of Hawaiian Home Lands' development plans for its lands.

Discussion: The proposed project offers a critical element - water supply - for the development of the Hawaiian Home Lands at Kawaihae. It must again be emphasized, however, that water is a necessary, but not sufficient, ingredient for this development.

Water Quality

Strategy: Ensure that the high quality of groundwater is maintained. Ensure that the high quality of the region's nearshore and coastal waters is maintained as asset for recreation, the economy, and natural biological systems.

Actions: Expand the Department of Health's water quality monitoring program to include toxic monitoring, biomonitoring, and biosurveys.

Discussion: Monitoring conditions attached to well permits for the project will ensure that withdrawal of ground water does not result in any degradation of the aquifer. Studies conducted for this EIS indicate that no significant deterioration of coastal water quality is to be expected from the diversion of water from North to South Kohala. (see **Section 3.4** and **Appendix C**). However, continual monitoring of pollutants, nutrients and biological resources should be implemented in order to correct potential problems before there is significant damage.

Public Infrastructure - Water Systems

Strategy: Provide timely development of water sources to coincide with growth needs and ensure consistency with the County's water use and development plan and the State Water Code.

Discussion: The proposed project would support needs created by planned development in a timely manner.

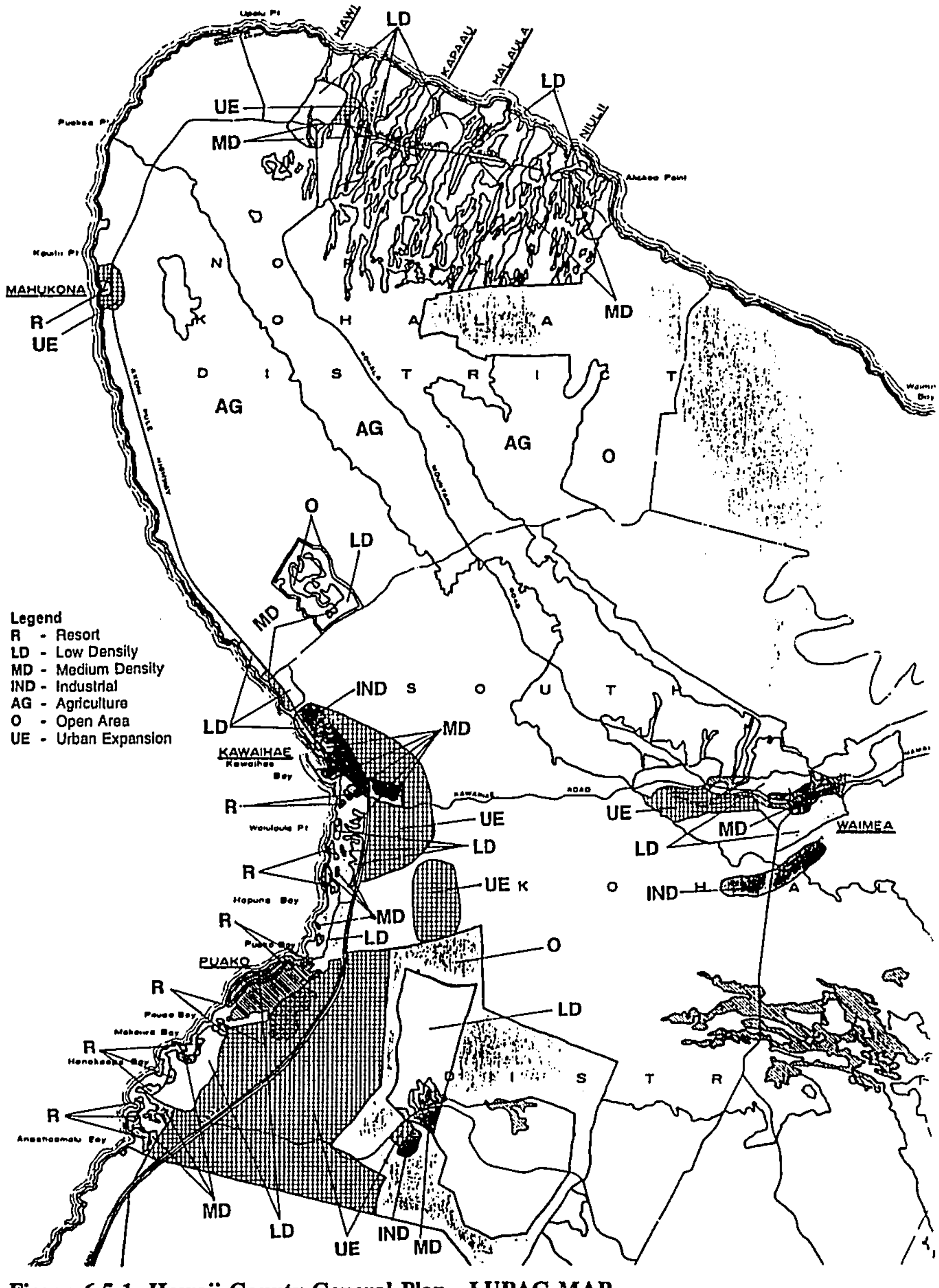


Figure 6.5-1 Hawaii County General Plan - LUPAG MAP
Map Source: Hawaii County General Plan 11.89

6.5 HAWAII COUNTY GENERAL PLAN

The General Plan for the County of Hawaii is a policy document expressing the broad goals and policies for the long-range development of the Island of Hawaii. The plan was adopted by ordinance in 1989. The General Plan is organized into thirteen elements, with policies, objectives, ordinance in 1989. standards, and principles for each. There are also discussions of the specific applicability of each element to the nine judicial districts comprising the County of Hawaii.

6.5.1 General Plan Goals and Policies

Section Four of the General Plan includes a discussion of general goals. The following goals and policies are relevant to the proposed project:

A. Economic:

- Economic development shall be in balance with the physical and social environments of the island of Hawaii.
- The County shall provide an economic environment which allows new, expanded, or improved economic opportunities tat are compatible with the County's natural and social environment.

J. (1) Water:

- Water systems and improvements shall promote the County's desired land use development pattern.
- Water system improvements should be first installed in areas which have established needs and characteristics, such as occupied dwellings and other uses, or in areas adjacent to them if there is need for urban expansion, or to further the expansion of the agricultural industry.

M. (6) Resort:

- Maintain an orderly development of the visitor industry.
- Provide for resort development that maximizes conveniences for its users and optimizes the benefits derived by the residents of the County.

Discussion: The context of the South Kohala resort region in County planning and the role of water infrastructure is discussed at length in this chapter. The justification for upgrading service to existing North Kohala residents is self-evident. The increase in water volume for South Kohala conforms with the policy supporting urban expansion in areas adjacent to existing urban areas.

Residents in other parts of the County unserved by water systems (e.g., much of Puna, South Kona and Ka`u) may believe that only after their needs are met should urban expansion needs be addressed. Some have expressed the opinion that if water is available it should come their way first. However, the impediment to providing water has been and continues to be financing, not water availability. In Puna, for example, there is an enormous groundwater resource capable of satisfying the districts needs ten times over.

But there is no party - resident, former developer, community association, or government - that will commit to pay the enormous infrastructure costs necessary to provide water to every house and farm lot. In the case of the proposed project, facilities charges levied in advance on water users will finance most of the project.

6.5.2 Courses Of Action For North And South Kohala

Section 5 of the General Plan identifies courses of action necessary to promote County policies and objectives on a district-by-district basis. Recommendations for South and North Kohala Districts include the following:

North Kohala

1. Economic:
- Resort facilities compatible with the physical, social and economic goals of the residents of the district should be encouraged.

5a. Water:
- Explore further sources for future needs.
- Improve and replace inadequate distribution mains and storage facilities.

South Kohala

1. Economic:
- Resort development in the district shall be in an orderly fashion and shall be consistent with the physical and social goals of the people of the areas.

5a. Water:
- Further efforts should be made to develop adequate quantities and acceptable quality of basal ground water at appropriately placed sites mauka of the shoreline.

8f. Resort:
- Adequate access, sewer and water systems, and other basic amenities shall be provided in all areas where higher density uses are allowed.

Discussion: The proposed project would upgrade the water system for North Kohala, by providing an all-ground water system that would improve supply reliability and most efficiently meet safe drinking water regulations. In that the project would support projected demand increases from resort users, the project would also satisfy water infrastructure goals for South Kohala.

6.5.3 LUPAG Map

The Land Use Pattern Allocation Guide (LUPAG) map component of the General Plan is a graphic representation of the Plan's goals, policies, and standards as well as of the physical relationship between land uses. It also establishes the basic urban and non-urban form for areas within the planned public and cultural facilities, public utilities and safety features, and transportation corridors. The provision of a public water system to appropriately zoned properties may encourage land use matching the LUPAG maps. See **Figure 6.5-1.**

6.6 COUNTY ZONING

County zoning is diverse for the numerous parcels containing the various components of the proposed project. The majority of the lands are designated as Agricultural-20 acres (A-20a). Agricultural zoning of different acreages, unplanned, and various urban zone designations are also present.

Section 25 of the Hawaii County Code states the following:

(a) Communication, transmission, and power lines of public and private utilities and governmental agencies are permitted uses within any district.

(b) Substations used by public utilities for the purpose of furnishing telephone, gas, electricity or water shall be permitted uses where the Planning Director finds that the same are not hazardous, dangerous, or a nuisance to surrounding areas and has granted plan approval therefor.

During the course of the permitting process, the Planning Director will review the location and context of the facilities to verify consistency with the above provisions.

6.7 NORTHWEST HAWAII OPEN SPACE AND COMMUNITY DEVELOPMENT PLAN

The public draft report for this plan (Townscape, Inc. 1992) is meant to serve as the basis for a Community Development Plan (CDP) setting forth policies and programs for open space, land use and infrastructure development for the period from 1993 to 2005. The final draft of this report, which may contain extensive revisions to the public draft, has not yet appeared as of the writing of this document. After development of the final draft, the Plan may be adopted by ordinance by the County of Hawaii, at which time the policies would have a legal basis.

Until such time, the recommendations in the report are appropriate only as possible guidelines for future development. However, it is relevant to note several highlights of the Plans and Recommendations section (Part 3) of the Draft Plan:

- The basic objective is to establish a balance between open space preservation and well-planned growth and development.
- The extensive open spaces and diverse natural and cultural resources of the Northwest Hawaii areas must be recognized and protected.
- Well-planned and well-designed growth of resorts and recreational facilities, and moderate, steady growth of the visitor industry are essential to the economic health and prosperity of the region.

- The planning and development of liveable residential communities and of affordable family housing must also be a top priority.

- The planned, organized, phased implementation of regional infrastructure systems must be a central part of the Plan.

The proposed project is explicitly listed as the primary avenue of fulfilling the demand for water the Plan anticipates (on the order of 40 mgd).

6.8 CONCLUSIONS

State and County policy clearly supports the development of water system infrastructure as necessary to support existing and planned needs. The provision of water is a key element in the unfolding of the development concepts envisioned for Kohala in the Hawaii County General Plan, in the West Hawaii Plan, and more generally in the Hawaii State Plan. Most of the supporting elements, such as road infrastructure, land ownership, and appropriate State Land Use Districts and County zoning are in place. Private developers will be able to implement their plans for resorts within the areas served by the water system. Development plans for the Department of Hawaiian Homes Lands Kawaihae project would also be furthered by the presence of water.

A number of policies emphasize not only the need for support of economic development but also the importance of community involvement in determining the level and nature of development, as well as the importance of safeguarding natural and cultural resources. Assuring that the rate of population growth does not exceed reasonable levels is an implicit element of such concerns.

The availability of domestic water has become an increasingly important factor in determining when, where and how growth should occur. However, it has generally been the policy in planning for public facilities in the State of Hawaii that agencies and commissions charged with determining the broader patterns of land use - such as the Office of State Planning, the State Land Use Commission, and the County Planning Departments and Commissions - are the bodies best suited for regulating and influencing whether, how, when and where population growth shall occur. The Board of Water Supply is entrusted with ensuring that the entire public is served with a safe, and reliable system delivering adequate amounts of water - and not with determining growth policy.

Essentially, the only assurance that public policy calling for sensitive, community-minded development will occur is the continual involvement of the public in development decisions. It is through the cumulative effects of individual developments - not through the broad action of water supply - that the character of Kohala in the future will be determined.

SECTION 7
RELATIONSHIP BETWEEN SHORT TERM USES AND ENHANCEMENT AND MAINTENANCE OF LONG TERM PRODUCTIVITY

The purpose of the proposed Kohala Water Transmission System project is to provide a high quality and reliable potable water supply that would meet the estimated future needs of North Kohala and coastal area of South Kohala, including the Hawaiian homestead tract in Kawaihae. An adequate potable water supply would be essential to carrying out the physical and economic growth envisioned for the northwest Hawaii region in State and County plans and policies.

Jeopardy to long term productivity is a relevant concern for several physical and social resources in the project area, including:

- Aquifer;
- Coastal water quality;
- Scenery; and
- Recreational resources.

Aquifer. The characteristics of the aquifer from which the proposed project will draw water are discussed in detail in **Appendix B.** To summarize, the USGS study modeling results clearly show that withdrawal of 20 mgd of ground water above the existing withdrawal at the DWS Hawi well is possible from the basal part of the Hawi aquifer, if pumping centers are spaced adequately apart and well depths are limited. According to the design engineers, results of USGS modeling of the location, depth and pumping rate of the proposed wells are within acceptable limits.

The water budget for the study area was estimated by the USGS (Shade, in press). The recharge to the basal part of the Hawi aquifer is derived mainly from direct infiltration of precipitation. It accounted for 53.1 mgd on a mean annual basis. Recharge from the adjacent rift zone and the Pololu drainage basin and adjacent rift zone contribute 15.3 mgd to the aquifer.[1] The recharge would be continuous and replenish the basal water withdrawn by the project. Thus, the proposed project pumpage would not jeopardize the long term productivity of the Hawi aquifer.

The DWS will carry out a monitoring program to evaluate effects of the pumpage on the aquifer. If any negative effect on the aquifer is detected mitigation measure will be initiated immediately.

The USGS study also stated that the pumping could cause some reduction of stream flow near the mouth of Pololu Stream. However, the absence of field data concerning the hydraulic connection of this stream with the basal aquifer precluded estimating the size

[1] See Appendix B, USGS report page 13.

of the streamflow. The Department of Water Supply will arrange with USGS to have the issue addressed and, if there is any reduction in streamflow, the resulting data can be used to assess the impact on Pololu Stream and formulate appropriate mitigation measures.

Coastal water quality. Studies conducted for this DEIS (**Section 3.4 and Appendix C**) indicate no apparent potential for negative impacts to marine ecosystems in either North or South Kohala from the projected changes in ground water flux from the Kohala Water Transmission System project. Thus, no long term productivity losses are anticipated relative to the abundance of marine algae (limu) in the coastal areas of North Kohala and reef corals in South Kohala.

Scenery. The preservation of scenic drives, corridors and vistas is an integral part of State and County plans and planning process. Preservation is vital for not only the local population but also the long-term attractiveness of the visitor industry, and it is therefore in the interest of resort developers to preserve and enhance scenic beauty of the area. As described in **Section 3.4**, because the leeward slopes of the region is largely void of large built-up structural intrusions, the designers have taken considerable effort to site components such as the collection and pressure-breaker reservoirs in a way to minimize scenic impact. As result, the scenic values of the leeward coastal area should not be adversely affected by the proposed project.

Recreational resources. The long term productivity of recreational resources can be diminished if the level of exploitation exceeds the ability of the resource to continue to provide satisfactory service. Local residents require relatively uncrowded locations for many local recreational practices, including surfing and fishing - although visitors may not object to crowds. Examples of potential conflict include surfing beaches which become too crowded for local use. Many recreational resources of the Kohala area are still relatively untapped (e.g., hiking trails), but most sandy beaches already experience use. Careful planning and regulation by government agencies will be necessary to ensure maintenance of the productivity of Kohala's coastal recreational resources.

SECTION 8
IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

8.1 PROPOSED WATER SYSTEM

The planning, design, and construction of the proposed water system project would irretrievably commit capital, building materials, labor, and energy from petroleum or fossil derived fuel.

The operation of the completed water system would irretrievably commit capital, labor and energy from petroleum or fossil derived fuel. The basal water withdrawal from the Hawi Aquifer System will not result in an irreversible and irretrievable commitment of basal water resource since it is considered a renewable resource that is continually replenished by rainfall.

8.2 SECONDARY DEVELOPMENTS

The physical development that would occur in the Kohala region due to the availability of water would require the irreversible and irretrievable commitment of a number of resources, the primary natural resource being land for resorts and related developments and government agency developments. In addition, these various developments would require capital, material, labor and energy to plan, build, and operate the facilities. The facilities would also consume petroleum-derived fuels, which represents an irretrievable commitment of resources.

Most of the lands in the proposed water system's service area that would be involved in resort and DHHL developments have very limited range of potential uses, mainly because of soil type. Large sections are either barren lava covered land or composed of very rocky or extremely stony sandy loam soil (Kawaihae soil series-see **Section 5.2.3**). Thus, from a practical standpoint, the commitment of the lands for secondary developments would have minimal or no adverse affect on potential uses.

The impact of using these resources should, however, be weighed against the economic benefits to the residents of the County and State and the consequences resulting from taking no action.

SECTION 9
PROBABLE IMPACTS

SECTION 10
PROBABLE UNAVOIDABLE
ADVERSE ENVIRONMENTAL EFFECTS

SECTION 11
PROPOSED MITIGATION
MEASURES TO MINIMIZE IMPACTS

SECTION 12
SUMMARY OF
UNRESOLVED ISSUES

SECTION 9
PROBABLE IMPACTS OF PROPOSED PROJECT

This section discusses probable impacts of the proposed project as primary (direct) impacts or secondary impacts.

- Primary (direct) impacts are the effects on the environment resulting directly from planning, design, and construction activities for the proposed project. These impacts are further divided into short-term (temporary) construction related impacts and long-term system operation related impacts.

- Secondary impacts are the effects associated with anticipated developments and growth that occur in the region due to the availability of water. The terms indirect and induced refer to effects of activities that are generated in the community by the "ripple" effect of the anticipated developments in the region.

9.1 PROBABLE PRIMARY IMPACTS

9.1.1 PROJECT CONSTRUCTION RELATED IMPACTS

- There will be intermittent and temporary impacts on air quality, noise level, and traffic during the two-year construction period for Phase I and one-year of Phase II. These construction related impacts are not expected to be significant.

- There would also be minor displacement of vegetation and some alterations to landforms from earthwork necessary to construct the improvements.

- No disturbances are anticipated to any archaeological/cultural sites or significant biological resources including wetland sites.

- There would be substantial positive economic and fiscal impacts from project construction activities.

Air Quality. There may be temporary degradation of air quality from increase in vehicular and construction equipment emissions. There will be a larger than normal number of vehicles transporting workers and material to and from work sites. Heavy construction equipment will be operating at the well and reservoir sites and pipeline laying locations. Although best management practices would be used to control dust, fugitive dust could occur on windy days during clearing and grading at work sites.

Noise Level. The increased number of vehicles and construction equipment operating during construction work hours could result in higher noise levels than normal in the vicinity of the work sites. There would be trucks hauling material for the wells and water lines, heavy equipment grading well and reservoir sites and drilling wells.

Traffic Flow. Increased traffic from heavy trucks hauling material to and from work sites, probably insignificant at most times, may cause occasional inconveniences for local motorists. In Phase I, pipelines from the wells would cross the Hawi-Niulii Highway at three locations to connect to the collector pipeline on Pratt Road. Also, pipelines would be installed on the Hawi-Niulii Highway, Kynnersely Road, and Kapaau Road to interconnect the proposed and existing systems. In Phase II, pipelines would be installed from the well sites to and along the Hawi-Niulii Highway from Makapala to Halawa. These activities may occasionally cause traffic interruptions during work hours.

Because of the higher speed limits on the State highways between Hawi and Lalamilo, normal traffic flow during construction hours at locations where pipeline installation is occurring may be slowed or interrupted for traffic safety. However, because the average daily traffic along this route is low compared to its capacity and construction would occur mostly in the road shoulder, no excessive interruptions to traffic flow is expected.

Water Quality. The project is not expected to directly affect any streams or marine waters (see **page 9-4** Water Resources for effect of pumping at Pololu Stream mouth). Thus, no significant direct impact to water quality is anticipated. Although the construction contract will require best management practices to be followed in controlling stormwater and other non-point sources, diligent effort will be necessary to avoid potential stream or marine water pollution problems.

Landforms. Clearing, grading, and paving (where required by road grade) of the access roadways to the well and reservoir sites would alter the terrain permanently but not significantly. The reservoirs sites are being selected carefully to minimize landform alterations. The concrete reservoir structure would alter the topography of the sites permanently. See **Section 7.1.2** for discussion on visual aspects of these reservoirs. Pipeline trench excavations would temporarily alter the existing terrain until they are backfilled and returned to their original grade and condition.

Well Site Location. There are two Department of Health (DOH) rules that would affect lands in the vicinity of the wells (see **Section 3.7** for maps of well sites). They are the individual wastewater disposal system and underground injection rules. In North Kohala, DOH rules allow the use of cesspools for residential wastewater disposal, provided there is a minimum horizontal distance of 1,000 feet between a cesspool and the nearest well.[1] This requirement should have minimal effect on parcels within the 1,000 feet radius zone since residential construction is not anticipated in the parcels.

DOH underground injection rules require that where an injection well is allowed, such as a drainage well for storm water, it must be sited at least one-quarter mile from any part of a drinking water source.[2] These drainage facilities are generally located in roadways or commercial/industrial use lots, the impact of this regulation appears minimal in the vicinity of the proposed wells sites.

[1] Reference: §11-62-05 HAR, CWDA and §11-62-32 HAR, Spacing of IWS.

[2] Reference: §11-23-09 HAR Siting and pre-construction requirements.

Archaeological Resources. The archaeological survey identified five archaeological sites. Sufficient descriptive and data recovery work has been completed on three sites that they can be considered no longer significant. One site is outside the project area. The fifth site, Site 19,775, which was recommended for preservation will not be impacted since the access roadway corridor to the reservoir site will be realigned to avoid the feature.

Biological Resources. A biological survey of the project area indicates that the direct impact of the proposed project would be minimal. The survey did not locate any endangered, or candidate endangered species that legally require planning consideration.

Economic. (See **Appendix A, from page 43**) Primary economic impacts begin with the $60.4 million in 1993 dollars for construction cost for Phase I of the proposed project. Construction of Phase II would expend an additional $19.6 million (1993 dollars).

The total job generation during construction is estimated to be 1,480 full-time jobs during two-year Phase I and 480 full-time jobs during the one-year Phase II. Of the total 1,960 jobs generated, 914 or 46.6 percent would be on the island.

Phase I project construction is estimated to produce $50.3 million in income earnings by construction workers and those employed in construction industry support activities. During Phase II, the construction expenditure of $19.6 million would result in $16.3 million of income to construction workers and those working in construction industry support activities.

Fiscal. (See **Appendix A, from page 58**) Tax revenue income to the State during the construction phase of the project would result from general excise tax on direct cost of construction and income tax on earnings by construction workers. Revenue from excise taxes is estimated to be $2.4 million for Phase I and $0.8 million from Phase II. Income tax revenue is estimated at $3.7 million for Phase I and $1.2 million for Phase II.

9.1.2 SYSTEM OPERATION RELATED IMPACTS

- The operation of the system is anticipated to have minimal environmental effects.
- Once construction is completed, the physical condition of the project area would essentially be returned to or near preconstruction conditions, except at the well sites and collection and pressure-breaker reservoir sites.
- The well sites would have a permanent control building and above ground pump appurtenances. The three Phase I sites would also have temporary power generators and fuel storage vaults. See **Table 3.7-3** for safeguards against stored fuel leakage. The visual impacts of these above ground facilities would be reduced with appropriate landscaping and earth-tone finishes. The potential noise and air quality effects of the power generators are discussed below.
- The potential visual effect of the reservoirs are discussed below.

Water Resources. The USGS concluded from its study of the Hawi aquifer that the modeling results clearly show that the withdrawal of 20 mgd of basal ground water above the existing withdrawal at the DWS Hawi well is possible, if pumping centers are spaced adequately apart and well depths are limited.[3] The DWS foresees pumpage starting at 5 or 6 mgd and building up to 10 mgd in 10 to 15 years, depending on how projected demands develop. This gradual build-up of pumpage will allow the Department time to evaluate the behavior of the aquifer from the pumping over several years. The study also stated that the pumping could cause some reduction of streamflow near the mouth Pololu Stream. The DWS will arrange with USGS to obtain the required field data to find out if there is a hydraulic connection between the stream and the aquifer, and if there is, to estimate the size of the possible reduction in streamflow.

Water Quality. Studies were conducted to determine the potential impact on marine environment of decreasing discharge of groundwater at the shoreline in North Kohala, and increasing discharge in some areas of South Kohala. The results revealed that there appears to be no potential for negative impacts to marine ecosystems in either North or South Kohala from the diversion of the groundwater. See **Appendix C** for study report.

Air Quality. The proposed diesel generator units at the well sites are considered relatively small sources of air pollution. Atmospheric dispersion modeling results indicate that nitrogen oxides emissions from an individual generator unit could potentially exceed ambient air quality standards if a discharge plenum or rooftop stack is used. On the other hand, the dispersion modeling results show that maximum impacts would be well within ambient air quality standards if the generator stack height conforms with good engineering practice. Odorous compounds will likely be present in the generator exhaust gases at low concentrations, but these should not be detectable at or beyond the well site boundaries. See **Appendix E** for air quality study report.

Noise. The proposed well pumps are of submersible type and pump noise would not be audible. The portable diesel-fueled power generator stationed at each well site to power the deep well pumps would be enclosed in a quiet suite with estimated noise levels of 72 dBA at 50 feet distance. The predicted noise level of the generators at the nearest existing residence (between 1,200 to 1,400 feet from well site) range from 32 to 46 dBA. Under worst case conditions, generator noise levels may exceed the State DOH nighttime limit of 45 dBA for residences on Oahu, and will probably be audible above the lower nighttime background ambient noise levels of 37 to 45 dBA. See **Appendix E** for noise study report.

Visual. The relocation of the collection reservoirs to a site mauka of and about 2,000 feet inland from Akoni Pule Highway in the vicinity of Puakea Ranch should minimize its visual presence, particularly to motorist driving along the highway. Similarly, the relocation of the pressure-breaker reservoir to a site about 4,000 feet mauka of Akoni Pule Highway and about 2,400 feet north of Kohala Ranches boundary should minimize its visual presence for both motorists and residents of Kohala Ranches. Grading work for the reservoir structures would disturb the natural terrain.

[3] See Appendix B, USGS report, pages 52 and 55.

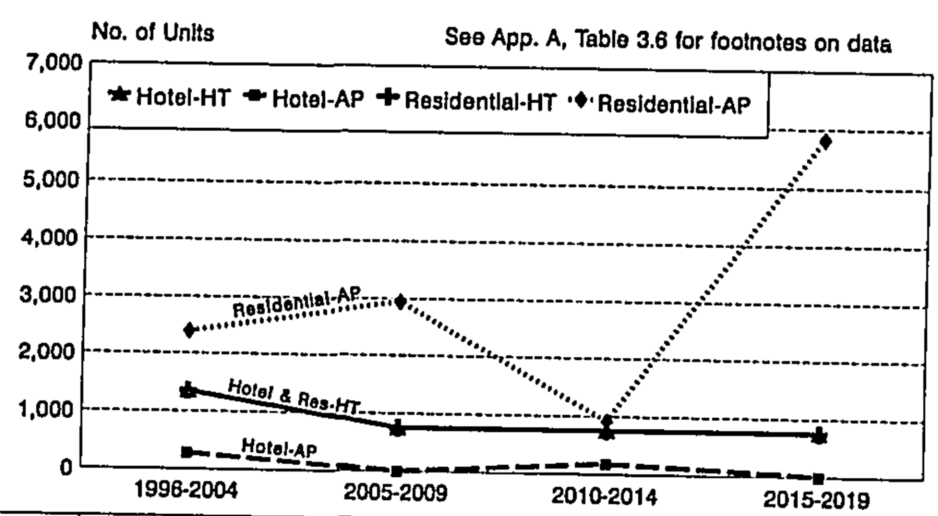
9.2 PROBABLE SECONDARY IMPACTS

9.2.1 ECONOMIC AND FISCAL IMPACTS

The reader is encouraged to review the economic and fiscal impact assessment beginning on **page 49 of Appendix A.** The following section primarily summarizes parts of the statistical data given in the assessment in graphic format.

Economic Impacts. In view of the complexity and difficulty in deriving absolute numbers for future developments, the socio-economic analysis assessed potential socio-economic impacts for a high-low range of probable development. One end of the range is based on historical trends and the other end on private and public sector planned projections. See **page 46 of Appendix A** for discussion on assumptions regarding future economic development due to water availability. The two scenarios are referred to as ***Historical-Trend*** and **As-Planned. Figure 9.2-1** below presents the numerical assumptions on which the employment and expenditure data for the charts on the following pages are based. The figures for the **As-Planned** scenario are estimates obtained by the Department of Water Supply from affected large property owners in the water service area and Department of Hawaiian Home Lands' master plan for the Kawaihae project.

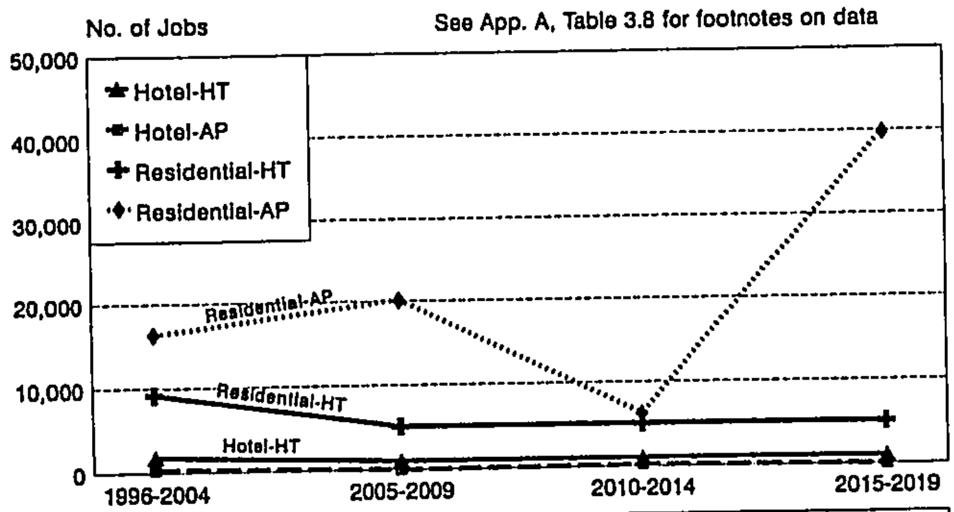
Figure 9.2-1 Secondary Impact-Kohala Water Transmission System
RANGE OF HOTEL AND RESIDENTIAL DEVELOPMENT SCENARIO



	1996-2004	2005-2009	2010-2014	2015-2019
Hotel-HT	1,350	750	750	750
Hotel-AP	275	0	175	0
Residential-HT	1,350	750	750	750
Residential-AP	2,393	2,942	916	5,822

HT = Historical Trend AP = As Planned
Note: The values for Hotel-HT and Residential-HT fall on the same graphic line.

Figure 9.2-2 Secondary Impact-Kohala Water Transmission System
PROJECTED EMPLOYMENT - HOTEL AND RESIDENTIAL CONSTRUCTION
(Sum of Direct and Indirect/Induced Employment)



Hotel-HT	1,816	1,009	1,009	1,009
Hotel-AP	371	0	237	0
Residential-HT	9,217	5,121	5,121	5,121
Residential-AP	16,339	20,087	6,253	39,749

HT = Historical Trend AP = As Planned

Figure 9.2-3 Secondary Impact-Kohala Water Transmission System
PROJECTED CUMULATIVE EMPLOYMENT - RESORT HOTEL OPERATION
(Sum of Direct, Indirect and Induced Employment)

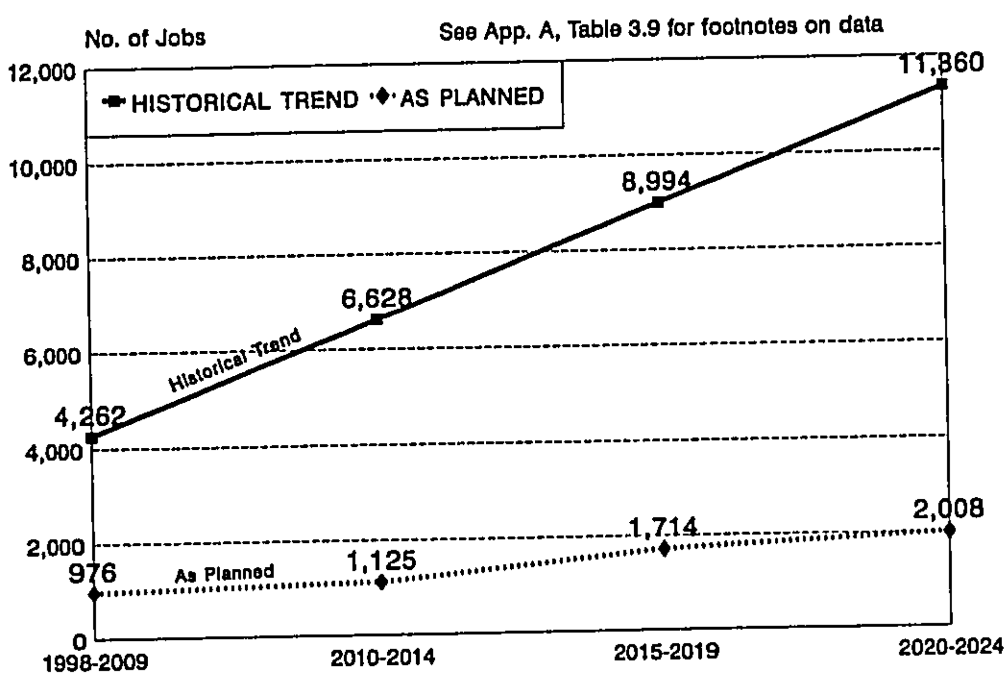
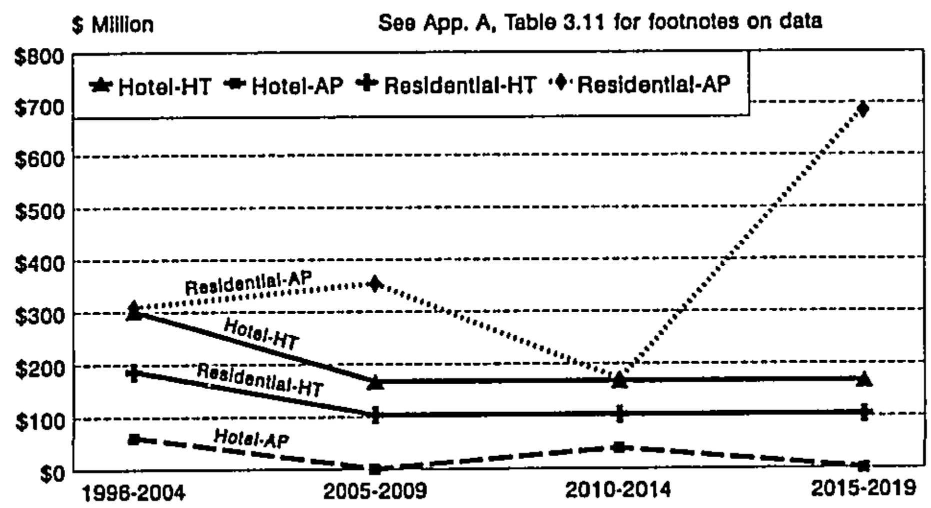


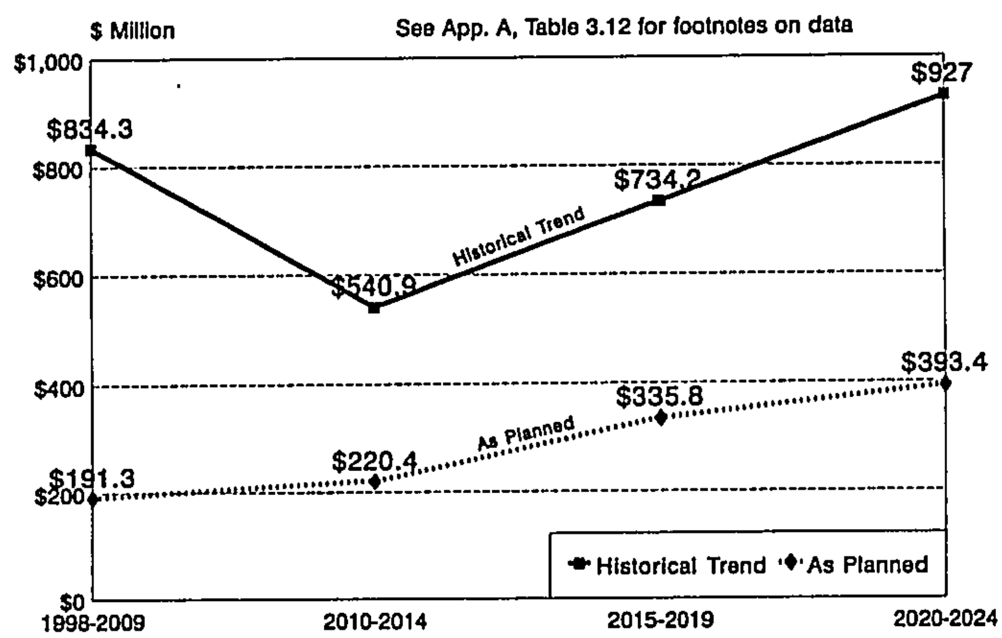
Figure 9.2-5 Secondary Impact-Kohala Water Transmission System
PROJECTED INCOME FROM RESORT CONSTRUCTION
(Sum of Direct and Indirect/Induced Income)



	1998-2004	2005-2009	2010-2014	2015-2019
Hotel-HT	$301.7	$167.5	$167.5	$167.5
Hotel-AP	$61.6	$0	$39.4	$0
Residential-HT	$187.3	$104.1	$104.1	$104.1
Residential-AP	$309.2	$353.6	$169.4	$684.4

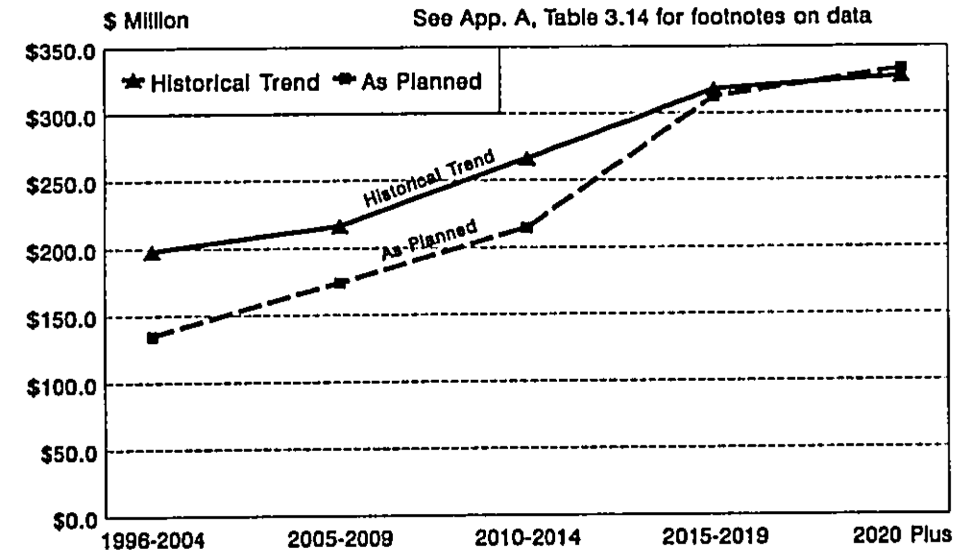
HT = Historical Trend AP = As Planned

Figure 9.2-6 Secondary Impact-Kohala Water Transmission System
PROJECTED INCOME FROM RESORT HOTEL OPERATION
(Sum of Direct and Indirect/Induced Income)



HT = Historical Trend AP = As Planned

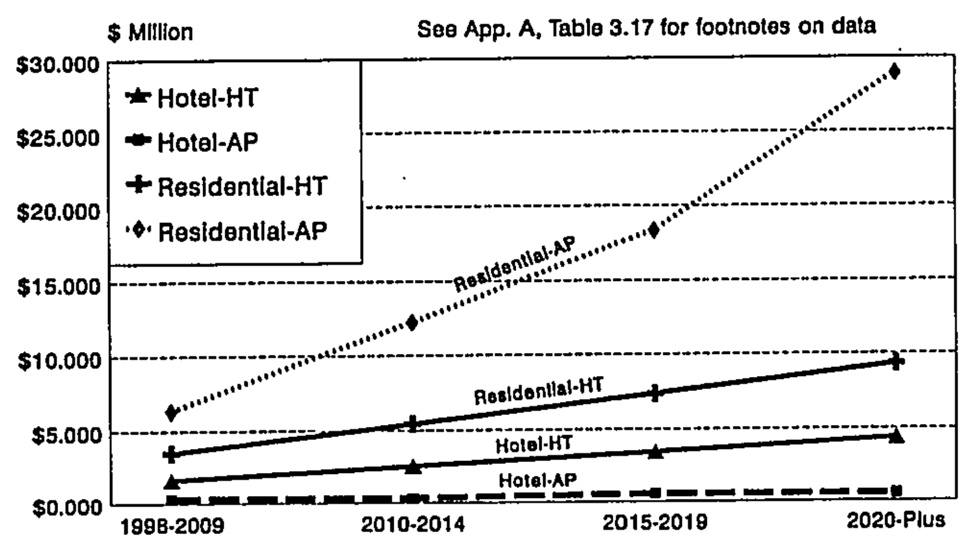
Figure 9.2-7 Secondary Impact - Kohala Water Transmission System
PROJECTED NET INCREASE IN EXCISE AND INCOME TAX REVENUE FROM RESORT CONSTRUCTION AND OPERATION



	1996-2004	2005-2009	2010-2014	2015-2019	2020 Plus
Historical Trend	$198.2	$216.3	$266.3	$318.3	$327.7
As Planned	$134.9	$174.0	$214.8	$312.7	$333.2

HT = Historical Trend AP = As Planned

Figure 9.2-8 Secondary Impact-Kohala Water Transmission System
ANNUAL STATE EXPENDITURES DUE TO DEVELOPMENTS



	1998-2009	2010-2014	2015-2019	2020-Plus
Hotel-HT	$1.638	$2.547	$3.457	$4.368
Hotel-AP	$0.334	$0.334	$0.545	$0.545
Residential-HT	$3.498	$5.442	$7.385	$9.329
Residential-AP	$6.351	$12.253	$18.355	$28.920

HT = Historical Trend AP = As Planned

Fiscal Impacts - Methodology (See Appendix A, page 57) In general the fiscal benefit/cost ratio (FBCR) computations are based on a series of economic assumptions. In this study, the principal assumptions are the values for two major factors: 1) the number of hotels and resort housing units that may be built over the next twenty to thirty years time horizon; and 2) increases in the number of visitors and new residents to the state of Hawaii (in migration) and to the island of Hawaii because of such developments.

On the first assumption, there are two build-out scenarios, namely the Historical and As-Planned. For each scenario, a benefit/cost ratio is computed for every five year interval. These ratios are then averaged to arrive at a single FBCR ratio.

A discussion on the FBCR for cumulative effects of the resort developments is presented in Appendix A, beginning on page 60.

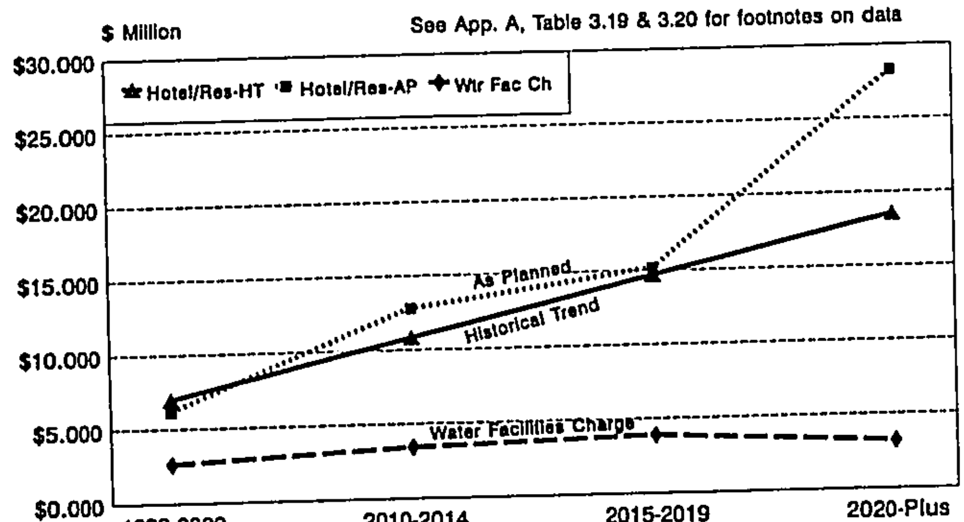
State Fiscal Impacts. (See Appendix A, page 58) Tax revenue during the construction of the resorts would result from general excise tax on direct cost of construction and from income tax revenue from earnings by construction workers. During resort operations, excise taxes would be generated from visitor spending. In addition, there would be income tax and other taxes generated as part-time and full-time employees pay income taxes, excise taxes, inheritance tax and other taxes. At the same time that employment activities are taking place, the State expends funds to operate support programs (see **Appendix A, Table 3.15** for State expenditure activities). These income and expenditure estimates were then applied to derive a fiscal cost/benefit ratio.

Table 9.2-1
PROJECTED NET TAX REVENUE/EXPENDITURE TO THE STATE FROM DEVELOPMENT IN THE WATER SERVICE AREA
Data Source: Table 3.18, Appendix A-page 64

	1996 to 2004	2005 to 2009	2010 to 2014	2015 to 2019	2020 & beyond
Historical Trend Scenario					
Revenue	198.2	216.3	266.3	316.3	327.7
Expenditure	36.0	25.7	39.9	54.2	68.5
Revenue/Expenditure Ratio	**4.3**	**8.4**	**6.7**	**5.9**	**4.8**
As-Planned Scenario					
Revenue	134.9	174.0	214.6	312.7	333.2
Expenditure	46.8	33.4	62.9	94.5	191.2
Revenue/Expenditure Ratio	**3.0**	**5.2**	**3.4**	**3.3**	**1.7**

Note: Assumes all planned construction for period "2015 Plus" ends by year 2019.

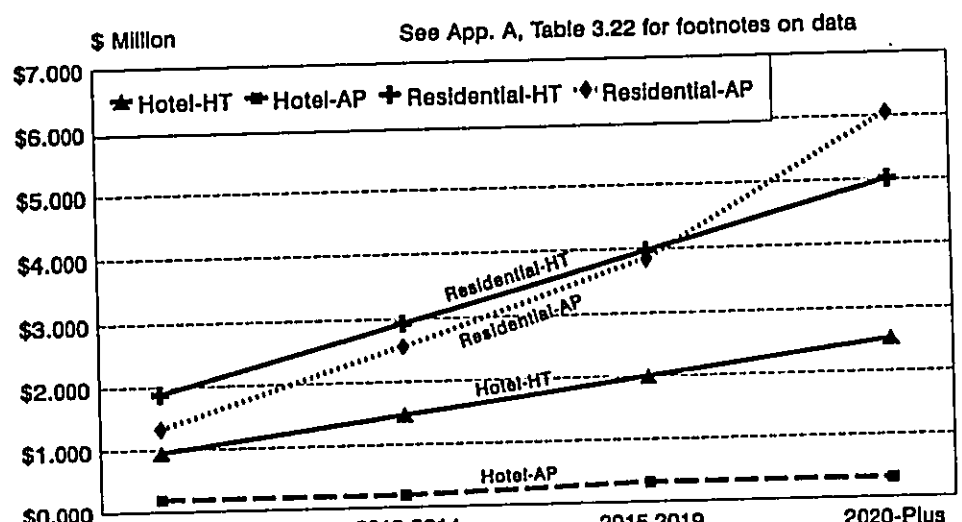
Figure 9.2-9 Secondary Impact-Kohala Water Transmission System
PROJECTED ANNUAL REVENUES TO COUNTY FROM
PROPERTY TAX AND WATER FACILITY CHARGE



	1998-2009	2010-2014	2015-2019	2020-Plus
Hotel/Res-HT	$6.962	$10.830	$14.698	$18.565
Hotel/Res-AP	$6.185	$12.805	$15.191	$28.291
Wtr Fac Ch	$2.618	$3.440	$3.888	$3.200

Hotel/Res-HT = Hotel/Residential-Historical Trend   Hotel/Res-AP = Hotel/Residential-As Planned

Figure 9.2-10 Secondary Impact-Kohala Water Transmission System
ANNUAL COUNTY EXPENDITURES DUE TO DEVELOPMENT



	1998-2009	2010-2014	2015-2019	2020-Plus
Hotel-HT	$0.946	$1.472	$1.998	$2.524
Hotel-AP	$0.193	$0.193	$0.315	$0.315
Residential-HT	$1.881	$2.926	$3.971	$5.017
Residential-AP	$1.328	$2.563	$3.840	$6.050

HT = Historical Trend   AP = As Planned

County Government Fiscal Impacts. The expected county revenues and county expenditures due to secondary growth are shown in **Figure 9.2-9** and **Figure 9.2-10** on the facing page. Expected county revenue is generated primarily from the property tax levied on the new resort development and from water facility charges.

Table 9.2-2
PROJECTED NET TAX REVENUE/EXPENDITURE TO THE COUNTY FROM DEVELOPMENT IN THE PROJECT'S WATER SERVICE AREA
Data Source: Table 3.23, Appendix A-page 69

		1998 to 2009	2010 to 2014	2015 to 2019	2020 & beyond
Historical Trend Scenario					
Revenue	$ million	114.964	71.350	92.930	108.825
Expenditure		33.924	21.990	29.845	37.705
Revenue/Expenditure Ratio		**3.4**	**3.2**	**3.1**	**2.9**
As-Planned Scenario					
Revenue		105.640	81.225	95.395	160.915
Expenditure		18.252	13.780	20.775	31.825
Revenue/Expenditure Ratio		**5.8**	**5.9**	**4.6**	**5.1**

Note: The assumption is all planned construction for period "2015 Plus" ends by year 2019.

Summary of Economic Impacts

Economically, the proposed project would provide substantial benefit to Kohala, the County of Hawaii and the State of Hawaii. The $66 million in income and $3 million in State revenues associated with construction of the proposed pipeline project alone represent a sizeable benefit.

More important, however, are the secondary economic impacts that would be produced by resort construction and operation, by housing construction, and by visitor and resident spending. When direct and indirect impacts are totalled, between 1,000 and 6,000 permanent jobs would be generated by the year 2010 and between 2,000 to 11,000 by year 2020. These figures do not include resort and housing construction, which are expected to require as many as 20,000 labor years. Benefit/cost ratios of over 4:1 would be associated with state and county revenues, which are projected to rise to over $300 million and $70 million, respectively, by the year 2020 under the Historical Trend scenario.

Adverse economic impacts are essentially limited to property tax increases, which could be mitigated for targeted individuals by County policies.

9.2.2 SOCIAL IMPACTS

The reader is encouraged to fully review the section on social impacts which begins on **page 70 of Appendix A.**

Impacts to Population.
The **As-Planned** and **Historical Trend** scenarios entail very different population impacts. In the former, population increase would be derived primarily from in-migration to Kohala by those filling jobs generated directly or indirectly from resort hotels. In the latter scenario, new residents to the resort areas and the Kawaihae DHHL project account for most of the population increase, with a secondary boost from direct (but mostly indirect and induced) jobs generated as a result of new communities. The maximum/minimum estimates **(As-Planned/Historical Trend)** given in the table described below reflect this distinction.

The relationship between jobs and population increase is conceptually simple but exceedingly difficult to calculate with any certainty. A large number of unknown factors influence these numbers, including: current and future demographic characteristics of Kohala; unemployment rates in Kohala over the next 25 years; availability and attractiveness of alternative employment opportunities; population growth in adjacent districts, along with unemployment in these areas and willingness/ability of those residents to commute to Kohala jobs. The list of assumptions is so extensive and resulting uncertainty factor so large that any calculation of population increase because of jobs should be judged with a great deal of caution (see **Appendix A, Table 3.27**).

The total potential increase in resident population and visitor population as a result of the proposed project is shown in the following **Table 9.2-3.** Although figures for two scenarios are presented, any combination of the two scenarios is possible. Visitor population is much higher, particularly in relation to the resident population increase, in the **Historical Trend** scenario. It is in such situations, where visitors are contributing greatly to state excise taxes but also imposing a burden on public services such as roads and recreational facilities. In the **As-Planned** scenario such visitor population impacts are relatively modest.

Table 9.2-3
POTENTIAL INCREASE IN RESIDENT POPULATION AND VISITOR POPULATION AS A RESULT OF PROJECT

Source of Growth	As-Planned		Historical Trend	
Ref: Appendix A, Tables 3.28 and 3.29	Yr-2010	Yr-2020	Yr-2010	Yr-2020
New residents of resort area	1,150	2,712	938	1,875
New residents of Kawaihae DHHL	11,025	23,625	0	0
New residents of drawn by employment	0	0	4,750	9,065
Total increase in resident population	**12,175**	**26,337**	**5,688**	**10,940**
Additional visitor population	**1,745**	**3,853**	**3,120**	**6,240**

Impacts to Housing.
As with labor and population, the impacts of housing are quite distinct between the **As-Planned** and **Historical-Trend** scenarios. In the former, housing is a "built-in" component of most projects, including both the resort and the DHHL Kawaihae project. Although some growth in housing stock might be required for employees of jobs not filled by existing or project-related households, the magnitude is within the range to be expected as an extension of current trends (see **Appendix A, Table 3.33**), which has created over four thousand units in the twenty years.

If the **Historical-Trend** continues the jobs generated by resort hotels will lead to an increase in the number of households and a consequent demand for housing. As revealed in **Appendix A, Table 3.27**, more than 5,000 new households could relocate to Kohala as a result of jobs generated by the secondary effects of the water project. This would create a demand for roughly double the current inventory of housing.

In the **Historical-Trend** scenario, there would be a strong demand for housing composed largely of single-family homes situated reasonably near the resort complex. Affordable housing in the coastal region has not been produced, and given a lack of incentive or conditions, might continue to be lacking. In its absence, the result would be an increase in the number of commuters inside and outside of Kohala.

Impacts to Public Services and Infrastructure.
Roads. The estimated project-related increase in resident and visitor population means a de facto population of between 25,000 and 50,000. This equates roughly to a doubling or tripling of traffic on Kohala Roads, based on 1990 de facto population of near 18,000. Although roads in most of Kohala are far from crowded today, this magnitude of increase could create traffic problems on certain highways, especially State Route 19 from Honokaa through Waimea and Kawaihae Junction to Kailua-Kona.

In the **As-Planned** scenario, many local roads needed to serve housing developments are integral parts of the Master Plans, thus reducing public impacts. The Master Plan for the Kawaihae DHHL project includes planning for internal roadways and external connections. An Akoni Pule Bypass, which would route traffic away from Kawaihae Harbor and replace Kawaihae Road as the main linkage to Waimea and Queen Kaahumanu Highway, is an integral part of the circulation system. Another component is a mauka-makai "spine" road designated to be the main roadway in the community and ultimately to provide a connection to the Kohala Mountain Road. Roads in all resort communities would also undoubtedly be privately planned and financed.

Utilities. Secondary growth associated with the project will lead to a substantial increase in demand for electrical, phone, and cable service. Expansion of the former will require extra generating capacity from HELCO. Assuming a population growth of 12,000 to 25,000 residents, a minimum additional capacity on the order of 12 to 25 MW might be necessary. Some of this capacity might be derived from on-site power generation. The fate of a proposal for a power plant in Kawaihae will probably be determined by pending litigation. Other potential sources include a proposed Keahole Power Station and diesel-oil facility at Honokaa on the site of the former sugar mill.

Sewage and Solid Waste. Secondary growth will induce a need for sewage treatment plants, particularly in the coastal areas of South Kohala but also along any portions of the North Kohala coastline that may experience increased development. The impacts from such systems are primarily physical and are covered in a separate section on the marine environment.

Because the landfill is at Pu'u Anahulu is relatively recent, it is expected to accommodate solid waste needs for West Hawaii well into the future, particularly if East Hawaii is able to resolve its landfill capacity problems. Additional solid waste transfer stations will be required, particularly in large communities such as the DHHL Kawaihae project. Resort developments are normally required to contract for rubbish services and this can be expected to continue.

Schools and Libraries. The Kawaihae DHHL project, which accounts for most of the demand growth for schools and libraries in the **As-Planned** scenario, has a Master Plan that includes a full range of community facilities including three elementary schools and an intermediate school. In the **Historical Trends** scenario, schools and libraries would require more planning. Based on projected population increases of between approximately 10,000 and 18,000 at least one more high school and several intermediate schools, elementary schools and public libraries would be required.

Fire and Police Protection. The Kawaihae DHHL Master Plan includes a "Town Center" with provisions for a police and fire station. If the **Historical Trends** scenario is fulfilled, these public facilities would have to be expanded by the County of Hawaii. Although, as with schools, the ultimate distribution of service communities would determine the best location, Kawaihae is well situated to provide the hub for public safety services.

Government Agency Offices. The proposed "Town Center" planned for the Kawaihae DHHL project includes a community activity center, a post office, and community support services. Under the **Historical Trend** scenario, expansion of services would probably follow the same pattern as for schools and public safety facilities. The Northwest Hawaii region, with a total projected population of perhaps 40,000 by the year 2020, would perhaps merit its own satellite County government central offices. Alternately, decentralized small centers could offer the most needed government services in strategic locations throughout Kohala. The north Hawaii Community Hospital, slated for opening in 1996, would contribute greatly to the anticipated medical needs of the region.

Impacts to Outdoor Recreation.

Substantial impact to the public use and enjoyment of land would occur as a result of further development in Kohala. The resulting total or component impacts are difficult to classify as either beneficial or adverse, because such judgement is largely a matter of the attitudes of individuals (see **section 3.3.4.2-Appendix A** for discussion of impacts).

Impacts to Socioeconomic/Ethnic Structure of Community.

Depending how development actually unfolds, a number of trends—some with the net effect of cancelling each other out—may occur.

With the **As-Planned** scenario, two quite distinct processes would unfold. For one, the growth of resort housing would bring to Kohala a social trend already seen in condominium-laden West Maui and Kona, where an essentially bi-modal population structure exists: well-off, older Caucasians from the mainland one pole and a mostly middle-class, mixed-ethnic group at the other.

At the same time, however, the creation of 3,000-7,000 Hawaiian households at the DHHL development in Kawaihae would create the largest Hawaiian enclave in the County. If all units were built as planned and the average household size expected in similar settlements of these types were achieved, an addition of some 3,000 new resort residents (mostly Caucasians) and some 24,000 new DHHL residents (mostly Hawaiians) would result by 2020. to some extent, the outcome would create a Kohala in which the two most numerous ethnic groups currently—Hawaiians and Caucasians—would come to make up even larger proportions of the population.

The growth of DHHL housing and the resort industry in close proximity would match jobs with job-seekers. The hotel worker survey (cited in Appendix A - CRI and Datametric Research 1987) found that Hawaiians and part-Hawaiians constituted about one-third of the workforce at both the Westin Mauna Kea and the Mauna Lani Bay—the largest single ethnic group at either hotel.

Under the **Historical Trend** scenario, hotel construction would dominate and although there would be a great rise in the de facto population of mainland vacationers, many of them wealthy, there would be far fewer new residents in resort housing. The socio-economic polarization and reduction of ethnic diversity discussed for the first scenario would probably also occur, but in a less pronounced manner, as an extension of trends that have been dominant in Kohala for the last twenty years. Direct visitor industry jobs —as opposed to the more diverse indirect and induced jobs that would dominate under the first scenario—would increase the dependence of the economy on tourism and involve a larger proportion of the local population in the visitor industry lifestyle and culture.

Community members expressed a diversity of opinion about these processes. The overwhelming response, however, was a feeling of concern about polarization and the impact of hotel jobs on a rural population's identity and self-esteem (see **Appendix A**, page 97 for examples of opinion).

Impacts to Social Well-Being and Lifestyle/Community Values.

Social Well Being. The **Historical Trend** scenario assumes an augmentation of the resort hotel economy and lifestyle that is currently present in Kohala. There are those who assume that social disorders will increase as a result of lifestyle more dependent on tourism. There is no question that absolute incidence of crime and other disorders have increased when resorts are built and more people are present, but there is little evidence that crime rates have increased as a result of the resort lifestyle. It has also been demonstrated that many social problems are associated with unemployment and underemployment. This in no way indicates that resorts prevent crime, but it does illustrate the complexity of the cause-effect relationship, if there is one.

In the **As-Planned** scenario, population growth is primarily a product of the Kawaihae DHHL project, the impacts of construction on the economy and to some extent resort homes. Whether the rates of social disorder will decline, increase or stay stable in relation to the trends in such rates for other areas of the State and County is virtually impossible to predict.

Community Values and Lifestyle. In the experience of most residents of Kohala, as evidenced in surveys and the generally friendly reception given to visitors, the last fifteen years has shown that an economy largely based on the visitor industry can be compatible with the rural lifestyle and values of Kohala. Family, social group and community-wide values have indeed changed, but to what extent this is a function of the visitor industry is difficult to determine.

Community respondents to questionnaires were concerned about impacts to the existing community values and identity in Kohala, particularly as they concerned preservation of Hawaiian values, visitor industry jobs, and wilderness and coastal areas.

Impacts of Added Development Opportunities/Pressures.
Public comments received in scoping meetings, interviews and questionnaire responses included numerous concerns about the consequences of *unintended* development opportunities/pressures. Several individuals stated that although the project might be intended as a "highway" to transfer water to South Kohala, it would also inadvertently open up large sections of the North Kohala coast, which are currently without any water service, for development. Some contended that in fact this might be the hidden addenda of the project.

In response to such comments, the Hawaii County Water Department of Water Supply (DWS) stated that the policy for allowing or recommending water hookups consisted of the following factors:

- If the requested use of water is legally permissible under existing zoning, then the hookup shall be permissible. If the zoning is not appropriate, then no hookup will be allowed.

- The DWS does not recommend for or against rezoning applications. In response to written requests from the Planning Department in the course of rezoning applications, it is DWS policy to state whether or not the existing water system can be expected to accommodate the amount of water that will be required if the property is rezoned and water is requested.

Some community members in turn responded that any surplus of the system would tend to elicit rezoning applications from owners of property along the pipeline route seeking windfall from the potential increase in property value. Some of these parcels might be in turn developed according to permissible zoning, resulting in development not now envisioned by zoning or the Hawaii County General Plan.

A number of land use regulations currently limit the extent of development options available for most of the parcels. Most proposed development of the parcels would require at least two or more levels of review, involving environmental studies, public hearings, and administrative or legislative approval. Because of the multiplicity of factors involved, it is impossible to predict which if any landowners may choose to undertake the process necessary to develop a parcel.

CUMULATIVE SECONDARY IMPACTS OF THE PROJECT.

Throughout the text, note has been taken of the fact that the Kohala Water Transmission System project is only one stimulus for development in Kohala. Innumerable smaller projects and several larger projects are likely to add population, jobs and housing, and may also transform the economic and social composition of the area in ways that augment or cancel out trends that would result from the proposed project.

The quantification, or even description, of projects that may occur over the next 25 years is problematic. Smaller projects are not liable to a great of advance planning or public review. General conceptual plans for larger projects may be available, but the scope and nature of such projects are notoriously subject to substantial modification according to financial or social factors.

For this reason, the authors of the Socio-Economic Impact Assessment have attempted to estimate the net impact of the proposed project in its various aspects–employment, fiscal, demographic, housing–and to frame this impact where possible in the context of larger trends.

Concerning population, where a number of projections exist, some clear comparisons are possible. As discussed in Section 3.3.1.3, depending on the scenario and the particular projection used, the proposed project may account for as little as 50 percent or as much as 140 percent of predicted population growth. Other types of impacts are more difficult to predict without specific information such as firm and reliable projections of job-counts or housing units, which are lacking.

In the absence of viable, large-scale agriculture or industry prospects for Kohala, the most significant influence in the economy and population over the next two decades in this region will probably be the growth of resort hotels and housing. Several major development schemes and a number of smaller projects are expected to have significant economic and social impacts in Kohala over the next two decades. The following list is a general description of the most prominent proposed projects, using information provided in the Draft Northwest Hawaii Open Space and Development Plan (Townscape, Inc. 1992). It must be cautioned that although many projects have estimated figures for housing or hotel units, these figures are often speculative and subject to change.

Chalon International, Inc.

- Mahukona Lodge: 240 hotel rooms, and as many as 150 one-acre agr. lots with golf course
- Kohala Plantation West: 40 single-family lots with golf course

Chalon International, Inc. (continuation)

- Ainakea Village: 70 single-family lots
- Hawi Makai: 500 lots
- Kukuipahu Mauka and Makai: 100 single-family lots with golf course

Kohala Ranch

- Resort Community: 962 single-family lots and 528 multi-family units

Waikoloa Development Corporation

- Waikoloa Village: 12,000 single-family lots; 1,000 multi-family units; 1,100 larger lots
- Waikoloa Beach: 1,200 hotel units; 1,000 single-family lots; 1,600 multi-family units

Other

- Parker 2020: 626 single-family lots; 418 multi-family units; 37 larger lots
- Kohala Makai: 416 multi-family units
- Kahua Shores: 300 single and multi-family units

A number of smaller projects are also planned. According to calculations by Townscape, Inc., projects with the necessary approvals for development account for approximately 31,000 units in northern North Kona and Kohala. Of this number, possibly as many as 20,000 housing units and 1,500 hotel units are essentially unrelated to the proposed water project.[4]

Furthermore, additional conceptual projects with little if any development entitlements might swell these numbers even further. If a significant proportion of such planned and conceptual projects were implemented, the consequences would dwarf the secondary impacts of the Kohala Water Transmission System. Tens of thousands of jobs and perhaps billions in government revenue might result. Population in Kohala could conceivably exceed 50,000 as a result of all plans unfolding. However, it is far from clear to what extent these plans will be fulfilled and according to what timetable. Many lack zoning and other entitlements, and some also lack financing or markets. It is too early to know the context of the impacts of the proposed project in terms of cumulative future growth. It will be the duty of State and County government to monitor this context and adjust goals and policy, plan for infrastructure, and impose development conditions as necessary.

[4] Hawaii County Planning Department by Townscape Inc. Northwest Hawaii Open Space and Development Plan, Draft. Nov, 1992. Page 114.

SECTION 10
PROBABLE UNAVOIDABLE
ADVERSE ENVIRONMENTAL EFFECTS

10.1 SUMMARY OF UNAVOIDABLE ADVERSE EFFECTS

10.1.1 DIRECT IMPACTS

Direct impacts from the construction and operation of the proposed Kohala Water Transmission System are generally temporary or benign. Short-term adverse impacts during construction that are unavoidable include clearing of vegetation, alteration of terrain, and the generation of noise, dust, and emissions from equipment and generally, are not significant. Each well site would have a small control building and well shaft mounts and piping. Three of the Phase I well sites may have temporary on-site diesel fueled power generators and fuel storage vaults. All potential adverse effects from the units will be mitigated. The collection and pressure-breaker reservoirs on the western slopes of Kohala Mountain may be seen by some people as visual intrusions in an area generally devoid of man-made objects. Otherwise, once construction is completed, the project area would essentially be returned to near preconstruction conditions.

10.1.2 SECONDARY IMPACTS

The secondary impacts of the project are derived from the developments made possible by the water system. The precise nature of such future development cannot be accurately ascertained, and therefore must be estimated.

The Socioeconomic Assessment conducted for this EIS attempted to predict the nature and extent of development based on two scenarios: the **Historical Trends**, which simply projected past trends into the future, and the **As-Planned** scenario, which used projections supplied by private and public sector planning studies for the region (see **Section 9.2**).

Starting with these assumptions concerning the path of future development, a series of calculations were made to estimate construction activity, jobs, indirect economic impacts, government revenues and expenditures, population growth, change in social composition and conditions, and impacts to recreation, open space and cultural resources.

The majority of impacts would be considered by most parties to be beneficial, such as provision of jobs, a favorable benefit-cost ratio for government revenues and expenditures, and the contribution towards the fulfillment of the Department of Hawaiian Home Lands settlement plans. Other impacts might be considered neutral, such as population growth, which in itself may cause few direct effects but engenders a number of desirable and undesirable side-effects. Still others are mixed, i.e., beneficial or adverse depending upon the standpoint or taste of the observer, such as changing the ethnic makeup or encouraging heretofore development opportunities in areas for which this was heretofore impractical.

The following impacts would be considered by most observers to be adverse:

- Potential for pollution of coastal waters;
- Potential for increased polarization of Kohala population into two social groups based on income, which might also coincide with ethnic and cultural identity;
- Potential for crowding of recreational areas;
- Potential for social change that might promote the decay of traditional Hawaiian culture and values;
- Potential for government infrastructure to fall behind demand created by project-driven population growth;

It may be argued that all of these potentially adverse effects are wholly or largely mitigable through government regulation of development activities that employ water from the proposed project. For example, exactions on resort residential housing developments may be imposed to help create or pay for public recreational areas or community infrastructure. Proper siting of coastal developments and strict regulations on non-point source water pollution may negate pollution impacts. Also, depending on the exact course of development, several of these effects may fail to occur altogether. If the Kawaihae Hawaiian Homes project manages to approaches its settlement goals, there is the potential for a net benefit to the preservation of Hawaiian culture.

10.2 RATIONALE FOR PROCEEDING NOTWITHSTANDING UNAVOIDABLE EFFECTS

10.2.1 DIRECT IMPACTS

The effects of construction-related impacts, although unavoidable, are not significant and following best management practices during construction should mitigate the minimal negative effects.

The collection and pressure-breaker reservoirs are essential components of the water system. Although it is not possible to completely avoid seeing the reservoirs in the landscape from all viewpoints, the mitigation measures proposed in **Section 11** would greatly reduce the intrusiveness of the reservoirs from most viewing points, especially from along Akoni Pule Highway. With the mitigation measures in place, the benefits that can be derived from the water system is viewed as a positive trade-off for the unavoidable effect of the reservoirs on certain vistas.

10.2.2 SECONDARY IMPACTS

All adverse secondary impacts are potentially mitigable, and therefore the project could proceed without substantial harm to the physical or social environment.

SECTION 11
PROPOSED MITIGATION MEASURES
TO MINIMIZE IMPACTS

11.1 MITIGATION MEASURES FOR PRIMARY IMPACTS

Although there may be several primary impacts during the construction of the proposed project, they would be generally temporary and not significant. The Department of Water Supply (DWS) would require that all construction activity abide by best management practices to avoid adverse environmental impacts. Proposed mitigation measures to avoid or minimize specific impacts are discussed below.

Archaeological Resources. *Of the five sites identified in the archaeological inventory* survey only one was potentially affected by project activities. Site 19,775, a probable burial platform, was recommended for preservation by realigning the access road to the north to avoid impacting the feature. The access roadway will be realigned to avoid the feature and provide an acceptable buffer. In addition, to facilitate any alignment changes during construction of the access roadway for the pressure breaker reservoir and Kawaihae terminal reservoir, the DWS will have an archaeological monitor present to avoid impacting any archaeological features.

Water Resource. The DWS foresees the system pumping beginning at 5 or 6 mgd and building up to 10 mgd in 10 to 15 years. Although no negative effects are expected, to assure that the water withdrawal is not adversely affecting the aquifer the DWS will closely monitor water levels and quality and other elements during the Phase I operation. The monitoring records would be essential in determining if any corrective action is necessary to assure that the integrity of the aquifer is being maintained.

Visual. Although the placement of the collection and pressure-breaker reservoirs in open pasture areas is unavoidable, the design has been sensitive to visual aspects. The collection reservoir site has been relocated from makai to mauka of Akoni Pule Highway. The site is now located approximately 2,000 feet mauka from the highway and nestled between two puu's. This mauka location avoids silhouetting the reservoir structure in the ocean and skyline views. The pressure breaker reservoir has been relocated further north placing it approximately 2,400 feet from the Kohala Ranch subdivision and 4,000 feet from the highway. This location would intrude less on the views of the neighboring homes. Both reservoirs would have minimal visibility from the highway. To soften their appearance in the region's vistas, the reservoir structures would be finished in earth tone colors and the site appropriately landscaped.

Noise Level. In view of the proximity of the well sites to residential areas, the generator enclosure or surround will be designed to have sufficient quieting measures to keep the noise level of the diesel-fueled power generators at equal to or lower than the ambient background noise at the nearest residential areas during the most quiet hours, before sunrise. The proposed submersible type pumps for use in the wells will not produce any audible noise at the surface.

Air Quality. The allowable range of emissions from a source is regulated by the Department of Health under its clean air regulations. The appropriate class of permit will be obtained by the DWS to operate the diesel-fueled generators. The conditions of the permit and use of good engineering design practice, as recommended in the air quality study for this DEIS, would mitigate adverse effects of the emissions from the diesel fueled generators.

11.2 MITIGATION MEASURES FOR SECONDARY IMPACTS

Mitigation for Population. The adverse impacts of population growth are usually indirect rather than direct. Increased population may lead to pressure on scarce resources, undesirable changes in social conditions, and decreasing access to public facilities and services. More specific information regarding these impacts, their implications, and the mitigation planned for negative impacts are discussed in the sections which follow.

Mitigation for Housing. The West Hawaii Regional Plan (Hawaii Office of State Planning 1989), which was designed to coordinate planning efforts among State agencies, laid out State policy for housing associated with the development of resorts. Included in policies pertaining to resort development were strategies to cluster resorts in "Resort Destination Nodes" of Mauna Kea and Mauna Lani/Waikoloa within Kohala. These nodes would serve as employment centers around which the State and County could focus efforts to provide economic incentives for private sector involvement in financing and enveloping social and physical infrastructure systems. This would include active designation and development of primary and secondary support communities to house employees working at Resort Destination Nodes.

The fulfillment of this objective will be enhanced but not enabled by the availability of water. Agreements between government and business concerns may be necessary to insure development of adequate affordable homes.

Mitigation for Public Services. It is essential for the maintenance of adequate public services and facilities in growing regions that State and County agencies carefully track potential growth. The proposed project has substantial potential to greatly increase demand for these. It is beyond the scope of this document to recommend individual projects for consideration. Subdivision and other permit conditions imposed by the County and State would determine the degree to which necessary infrastructure to support the developments would be provided by the individual landowners/developers.

In general, it is important to recognize and recommend to agencies such as the Hawaii County Council, the State Department of Transportation and others that planning for significant increases in demand be encouraged. Tracking of predicted versus actual magnitude and distribution of development using Geographic Information System (GIS) technology is also recommended.

Mitigation for Recreation. The potential for outdoor recreation expansion and improvement in Kohala is very great. The following actions are recommended.

- Accelerated expansion of Hapuna Beach State Recreation Area to anticipate demand.
- Creation of new coastal state parks, e.g., Pololu/Akoakoa State Park.
- Expansion of County coastal parks (such as Kapa'a Beach Park) to take pressure off other recreational areas.
- Encouragement of public park creation in all private sector projects of sufficiently large size.
- Vigorous action by the County and State to ensure access rights to and along the coastline consistent with State law. All private development projects should be evaluated for consistency with long-term access and trail programs at State and County levels.
- Actions to safeguard native Hawaiian gathering, fishing and hunting rights from direct or indirect encroachment because of continued development.

Mitigation Measures for Social/Community Impacts. Mitigation measures sometimes suggested for socioeconomic impacts are complex, controversial and often unrealistic. For the purposes of this document, it is simply suggested that whenever government agencies consider permitting conditions for the proposed developments in Kohala, that due consideration is given to the following:

- Policies that encourage the creation of jobs desired by Kohala residents, to be filled primarily by Kohala residents, in order to conserve to some degree the existing structure and generational continuity of Kohala.
- Support of affordable housing in order to retain housing opportunities for Kohala residents.
- The impacts of gated housing communities on the larger community.
- The involvement of all interest groups, and in particular the Hawaiian community, in planning decisions that will affect economic, social and land use patterns of Kohala.
- Continuing and expanded emphasis on Hawaiian culture in Kohala resorts.

SECTION 12
SUMMARY OF UNRESOLVED ISSUES

2.1 ENVIRONMENTAL ISSUES

There are two environmental issues that are not resolved at this time. The following are brief descriptions of the issues and proposed actions toward their resolution.

Issue: The future potable water need for the North Kohala area lying generally Hawi side of Mahukona is estimated to be 4.3 mgd. The USGS water resources study for the Hawi aquifer system concluded that it is feasible to withdraw 20 mgd from the aquifer. This amount is in addition to the existing 0.6 mgd capacity of the DWS Hawi well. Since the Hawi well would be part of the source to supply the 4.3 mgd need, the net amount to meet future needs would be 3.7 mgd (round to 4 mgd). Although general data appears to suggest good possibility of withdrawing such amount, more definitive determination is necessary.

Proposed action: The Department of Water Supply will arrange with the USGS to apply the numerical model used for the Hawi aquifer study to determine the feasibility of withdrawing the additional 4 mgd of basal water from the Hawi aquifer. The feasibility study would include establishing parameters for well location, spacing, depth, and pumping rates. The determination will guide the Department of Water Supply in deciding if any adjustment should be made to the proposed capacity of Phase II.

Issue: The USGS water resources study of the Hawi aquifer system pointed out that it is possible that pumping of the Hawi aquifer could cause some reduction of streamflow near the mouth of Pololu Stream. But, because of a lack of field data concerning the hydraulic connection of the stream with the basal aquifer, the magnitude of the reduction could not be addressed.

Proposed action: The Department of Water Supply will arrange with the USGS to obtain the necessary field data to determine if there is a hydraulic connection between Pololu Stream near its mouth and the basal aquifer and, if there is, to estimate the size of the possible reduction in streamflow in Pololu Stream near its mouth. The size of streamflow reduction, if any, would allow an assessment of the potential impact on Pololu Stream. If any negative impact is found, appropriate measures can be formed to mitigate the impact.

2.2 PROJECT IMPLEMENTATION

The following tasks must be completed before project construction can proceed.

Financing. The exact method and terms for financing Phase I of project construction must be decided and approved by the Hawaii County Council. The Department of Water Supply and Hawaii County Administration will prepare and submit a project financing proposal to the Council. In view of weak current economic conditions, the financial plan may need to await stronger economic time for completion and approval by the County Council. As part of the review and approval process, the County Council would be holding public meetings and hearings on the issue. Start of project construction will be dependent on timing of approval of the financial plan and securing of funding.

Land Acquisition. Several parcels of land and easements must be acquired for well and reservoir sites and pipeline corridors. Preliminary discussions with affected property owners are going on and the required acquisitions are expected to be completed before the start of construction. No major easement or land acquisition costs are anticipated.

Permits. Several permits must be obtained before construction and operation can proceed. The permits are listed in **Section 1.9**. Additional permits that are not listed may be required depending on findings during engineering design and preparation for project construction.

SECTION 13
PARTIES CONSULTED AND PARTICIPANTS IN STATEMENT PREPARATION

SECTION 14
REPRODUCTIONS OF COMMENTS AND RESPONSES

SECTION 13
CONSULTED PARTIES AND
DEIS PREPARATION PARTICIPANTS

13.1 PARTIES CONSULTED

The Draft Environmental Impact Statement (DEIS) for the proposed Kohala Water Transmission System was initially published in OEQC Bulletin dated July 8, 1995. The 45-day public review and comment period ended on August 22, 1995. Copies of the DEIS were mailed or forwarded on July 5, 1995 to the public agencies and private parties listed below. Those from whom comments were received are marked with one asterisk. Those whose comments were received and required responses are marked with two asterisk. Copies of all written comments received and responses made during the consultation period are included in **Section 14**. In addition to distributing copies of the DEIS, the Department of Water Supply held a community information meeting on the DEIS on July 19, 1995 at the Kohala High School Cafeteria.

13.1.1 FEDERAL AGENCIES

U.S. Department of Agriculture, Soil Conservation Service
U.S. Army Corp of Engineers, Pacific Ocean Division*
U.S. Army Support Command, Hawaii
U.S. Coast Guard, 14th District
U.S. Fish and Wildlife Service
U.S. Environmental Protection Agency, Region IX
U.S. National Park Service, Puukohola Heiau Historic Site
U.S. Geological Survey, Water Resources Division
U.S. Pearl Harbor Naval Base

13.1.2 STATE AGENCIES

Senator Malama Solomon, West Hawaii
Representative Dwight Takamine, Northwest Hawaii
Department of Agriculture
Department of Hawaiian Home Lands
UH Hilo, Marine Options Program
DBED, State Land Use Commission*
DBED, State Energy Office*
DLNR State Historic Preservation Division*
Department of Transportation*
Housing and Finance Development Corporation*
Department of Accounting and General Services*
Department of Health*

Office of Environmental Quality Control **
Office of Hawaiian Affairs**
Office of State Planning**
Office of Civil Defense, DOD**
Department of Land & Natural Resources**
UHM, Environmental Center**
UHM, Water Resources Research Center**

13.1.3 HAWAII COUNTY AGENCIES

County Council
Councilman John Ray**
Office of Mayor
Board of Water Supply
Planning Department**
Public Works Department
Police Department**

13.1.4 DEVELOPERS - ORGANIZATIONS - INDIVIDUALS

Bernice Pauahi Bishop Estate
Bond Estate
Chalon International Hawaii
Kohala Joint Venture
Mauna Kea Properties
Mauna Lani Resort
Parker Ranch
Puako Hawaii Properties
Queen Emma Foundation**
Tri-Kohala Development Company
Waikoloa Land Company
Hawaiian Electric Company
Hawi Agriculture & Energy Corporation**
Kohala Nursery
Aboriginal Native Hawaiian Association**
American Lung Association
Conc. Kohala Ranch Property Owners
E Mau Na Ala Hele**
Friends of Puako Reef**
H.I. Economic Development Board**
Hui Lihikai
Kawaihae Community Association
Kawaihae HHH Comunity Association**
Kona-Kohala Chamber of Commerce
Kohala By The Sea Community Assoc.
Kohala Coast Resort Association
Life Of The Land**
North Kohala Community Association
North Kohala Hawaiian Civic Club
Native Hawaiian Advisory Council
Puako Community Association
Waimea Community Association
Waimea Community Council
West Hawaii Sierra Club
Norman Ah Nee
William Ahyou Akau
Ken Boche
Bert Block
Jim Bryan
Anthony Carvalho
Shane Ching
Wallace Ching
Maurice Fujimoto
Mark Goodini**
Rick Gordon
Matt Grady
Gary Grosshuesch
Rev. John Hoover
Kai Kaholokai

Ana Nawahine Kahoopii**
Kaipo Kamalani
Rick LeBus-Kaniho
Mike Merle
Andrew Morgan
Dana Moss
Barrie Moss & Ken Boche
Larry Neff
Debra Noa*
Fred Orita
Henry Pasco
Roland Patel
Lesley Patton
Tom Quinlan
Henry H. Ross**
David Rotstein**
George & Alexa Russell
John Scovel
Albert Sing
Kehaulani Spencer-Boyd
Clyde Sproat
Leon A. Thevenin**
Jim Trump
Noelani Whittington
Toni Whittington
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13.2 DEIS PREPARATION PARTICIPANTS

The following firms and individuals were involved in the preparation of this DEIS.

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Wallace Oki, P.E.

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Geometrician Associates . . . . Socio-economic impact analysis
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Scientific Consultant Services, Inc.. . . . . Archaeological inventory survey
Robert L. Spear, Ph.D.

Lani Stemmermann & Rexford Palmer . . . . Biological resources survey
Lani Stemmerman, Ph.D.
Rexford Palmer, Ph.D.

Tom Nance Water Resource Engineering . . . . . Marine environment study
Tom Nance, P.E.

Marine Research Consultants . . . . Marine environment study
Steven Dollar, Ph.D.

Y. Ebisu & Associates . . . . Diesel generator noise study
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B.D. Neal & Associates . . . . Diesel generator air quality study
Barry D. Neal, CCM

SECTION 14
COPIES OF WRITTEN COMMENTS RECEIVED AND RESPONSES MADE

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GOVERNOR

ESTHER UEDA
EXECUTIVE OFFICER

STATE OF HAWAII
DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT & TOURISM
LAND USE COMMISSION
Room 104, Old Federal Building
335 Merchant Street
Honolulu, Hawaii 96813
Telephone: 587-3822

July 10, 1995

The Honorable Benjamin J. Cayetano
State of Hawaii
c/o Office of Environmental Quality
Control
220 South King Street
Suite 400
Honolulu, Hawaii 96813

Dear Governor Cayetano:

Subject: Draft Environmental Impact Statement (EIS) for the Kohala Water Transmission System Project, North and South Kohala, Hawaii

We have reviewed the draft EIS received with the memorandum from OEQC, and have no additional comments to our letter dated July 11, 1994.

Thank you for the opportunity to comment on the draft EIS.

Sincerely,

for ESTHER UEDA
Executive Officer

EU:ky

cc: Department of Water Supply
Megumi Kon Inc.
DBEDT (95-079-B)

DEPARTMENT OF BUSINESS,
ECONOMIC DEVELOPMENT, AND TOURISM
ENERGY DIVISION, 335 MERCHANT ST., RM. 110, HONOLULU, HAWAII 96813 PHONE: (808) 587-3800 FAX: (808) 587-3820

BENJAMIN J. CAYETANO
Governor
SEIJI F. NAYA
Director
RICK EGGED
Deputy Director

049 OEQC

July 7, 1995

The Honorable Benjamin J. Cayetano
Governor
c/o Office of Environmental Quality Control
220 South King Street, Fourth Floor
Honolulu, Hawaii 96813

Dear Governor Cayetano:

SUBJECT: Kohala Water Transmission System
Tax Map Key: 5-2-05:1, 5-2-06:3,5-3-03:1,5-03-04:1,5-4-03:2,5-4-03:3,5-5-2:23,5-6-01:51,5-9-03:4,6-1-01:3,6-2-01:63,6-8-01:6

We wish to inform you that we have no comments regarding the subject Kohala Water Transmission System.

Thank you for the opportunity to submit any comments or recommendations.

Sincerely,

for Maurice H. Kaya
Energy Program Administrator

MHK:aw

c Quirino Antonio, Jr., Dept of Water Supply
Megumi Kon, Inc.

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, HONOLULU
FORT SHAFTER, HAWAII 96858-5440

REPLY TO ATTENTION OF

July 14, 1995

Planning Division

State of Hawaii
Office of Environmental Quality Control
220 South King Street, Suite 400
Honolulu, Hawaii 96813

Dear Sir/Madam:

Thank you for the opportunity to review and comment on the Draft Environmental Impact Statement for the Kohala Water Transmission System, North and South Kohala, Island of Hawaii. We do not have any additional comments to offer beyond those provided in our previous letter dated July 22, 1994.

Sincerely,

/s/ Pelnuski

Ray H. Jyo, P.E.
Director of Engineering

Copies Furnished:

Mr. Quirino Antonio, Jr.
Department of Water Supply
25 Aupuni Street
Hilo, Hawaii 96720

Mr. Megumi Kon
22 Kapaa Street
Hilo, Hawaii 96720

BENJAMIN J. CAYETANO
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
STATE HISTORIC PRESERVATION DIVISION
33 SOUTH KING STREET, 6TH FLOOR
HONOLULU, HAWAII 96813

MICHAEL D. WILSON, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTY
GILBERT COLOMA-AGARAN

AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND ENVIRONMENTAL AFFAIRS
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION DIVISION
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

July 13, 1995

Governor, State of Hawaii
c/o Office of Environmental Quality Control
220 South King Street #400
Honolulu, Hawaii 96813

LOG NO: 14935
DOC NO: 9507PM14

SUBJECT: **Draft Environmental Impact Statement for Kohala Water Transmission System**
North and South Kohala, Hawaii Island

The archaeological inventory survey for this project (Appendix D in the EIS) has been reviewed by our office and approved. We have concluded that the proposed water line and related facilities would have "no effect" on significant historic sites.

Sincerely,

for DON HIBBARD, Administrator
State Historic Preservation Division

PM:jk

c. Quirino Antonio, Jr., Hawaii County Department of Water Supply
Megumi Kon, Inc.

BENJAMIN J. CAYETANO
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

KAZU HAYASHIDA
DIRECTOR

DEPUTY DIRECTORS
JERRY M. MATSUDA
GLENN M. OKIMOTO

IN REPLY REFER TO:
STP 8.6937

August 11, 1995

TO: The Honorable Benjamin J. Cayetano
Governor, State of Hawaii
c/o Office of Environmental Quality Control

FROM: Kazu Hayashida
Director of Transportation

SUBJECT: KOHALA WATER TRANSMISSION SYSTEM
DRAFT ENVIRONMENTAL IMPACT STATEMENT (DEIS)
TMK: 5-2-05: 1; 5-2-06: 3; 5-3-03: 1; 5-3-04: 1; 5-4-03: 2;
5-4-03: 3; 5-5-02: 23; 5-6-01: 51; 5-9-03: 4; 6-1-01: 3;
6-2-01: 63; 6-8-01: 6

Thank you for your transmittal requesting our comments on the subject DEIS.

The proposed project is not anticipated to have an adverse impact on our State transportation facilities.

Please coordinate your implementation schedule with our Highways Division. Plans for any construction work within the State highway right-of-way must be submitted for our review and approval.

We appreciate the opportunity to provide comments.

bc: Mr. Quirino Antonio, Jr., Department of Water Supply
Mr. Megumi Kon, Megumi Kon Inc.

BENJAMIN J. CAYETANO
[redacted]
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF BUDGET AND FINANCE
HOUSING FINANCE AND DEVELOPMENT CORPORATION
677 QUEEN STREET, SUITE 300
HONOLULU, HAWAII 96813
FAX (808) 587-0600

ROY S. OSHIRO
[redacted]
ACTING EXECUTIVE DIRECTOR

IN REPLY REFER TO
95:PPE/4255

July 17, 1995

Governor, State of Hawaii
c/o Office of Environmental
Quality Control
220 South King Street, Suite 400
Honolulu, Hawaii 96813

Dear Governor:

Subject: Draft Environmental Impact Statement for Kohala Water Transmission System

We have reviewed the subject draft EIS and have no comments to offer at this time.

Thank you for the opportunity to comment.

Sincerely,

Roy S. Oshiro
Acting Executive Director

c: Quirino Antonio, Jr., Department of Water Supply
Megumi Kon

(P)1660.5

SEP 29 1995

TO: Governor, State of Hawaii
c/o Office of Environmental Quality Control

SUBJECT: Kohala Water Transmission System
North and South Kohala, Hawaii
Draft EIS

Thank you for the opportunity to review the subject document. The proposed project will have no impact on our facilities. Therefore, we have no comments to offer.

If there are any questions, please have your staff contact Mr. Ralph Yukumoto of the Public Works Division at 586-0488.

State Comptroller

RY:jy
c: Department of Water Supply, Hawaii County
Megumi Kon, Inc.
OEQC

Governor, State of Hawaii
C/O Office of Environmental Quality Control
220 South King Street
Fourth Floor
Honolulu, Hawaii. 96813

Dear Sirs,

This letter is in regard to the proposed Kohala Water Transmission System project in the North Kohala and coastal areas of South Kohala. As a resident of the Big Island and a native hawaiian I strongly approve of this project for the following reasons.

1- The water is high quality potable water that at the present time is not used towards any useful purpose.

2- Growth along the "Gold Coast" is undeniable if we are to provide a future for our children and theirs. Having the water pipeline in place will help to quicken this growth.

3- The people of the Kohala area do not hear their own complaint. They will benefit because they will no longer have to use the some what questionable ground water which is what they have use of now.

4- In time all the people of the Big Island will benefit from the pipeline and even though the economy is not that great here now being ready for a boom is a good plan. If the cost of the pipeline can be passed on to minimize the impact on the small guy "taxpayer", then, yes, this pipeline is exactly what we need.

Your Truly,

Deborah Noa

BENJAMIN J. CAYETANO
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF HEALTH
P.O. BOX 3378
HONOLULU, HAWAII 96801

LAWRENCE MIIKE
DIRECTOR OF HEALTH

In reply, please refer to:

RECEIVED
'95 AUG -3 A6:05
OFC. OF ENVIR.
QUALITY CONT.

July 26, 1995

94-149/epo

To: The Honorable Benjamin Cayetano
Governor, State of Hawaii
c/o Director, Office of Environmental Quality Control
220 South King Street, 4th Floor
Honolulu, Hawaii 96813

From: Lawrence Miike
Director of Health

Subject: Draft Environmental Impact State

Kohala Water Transmission System
North and South Kohala, Hawaii

Thank you for allowing us to review and comment on the subject document. We have no additional comments to offer, besides those in our letter to Mr. William Sewake Manager of the Hawaii Department of Water Supply, dated August 15, 1994 (Enclosed).

Enclosure

c: Hawaii County Department of Water Supply
Megumi Kon, Inc.
Hilo District Health Office

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF HEALTH
P. O. BOX 3378
HONOLULU, HAWAII 96801

PETER A. SYBINSKY, Ph.D.
[redacted]
DIRECTOR OF HEALTH

In reply, please refer to:

August 15, 1994

94-149/epo

Mr. H. William Sewake
Manager
Department of Water Supply
County of Hawaii
25 Aupuni Street
Hilo, Hawaii 96720

Dear Mr. Sewake:

Subject: Environmental Assessment and Notice of Preparation of Environmental Impact Statement
Kohala Water Transmission System
North and South Kohala
Island of Hawaii

Thank you for allowing us to review and comment on the subject project. We have the following comments to offer:

Water Pollution

A National Pollutant Discharge Elimination System (NPDES) permit is required for any discharge to waters of the State including the following:

1. Storm water discharges relating to construction activities for projects equal to or greater than five acres;
2. Storm water discharges from industrial activities;
3. Construction dewatering activities;
4. Cooling water discharges less than one million gallons;
5. Ground water remediation activities; and
6. Hydrotesting water.

Any person wishing to be covered by the NPDES general permit for any of the above activities should file a Notice of Intent with the Department's Clean Water Branch at least 90 days prior to commencement of any discharge to waters of the State.

Any questions regarding this matter should be directed to Mr. Denis Lau of the Clean Water Branch at 586-4309.

Nonpoint Source Pollution Concerns

Proper planning, design, and use of erosion control measures and management practices will substantially reduce the total volume of runoff and limit the potential impact to the coastal waters from nonpoint source pollution. The following measures are suggested steps that can be taken to minimize erosion during construction:

1. Conduct grubbing and grading activities during the low rainfall months.

2. Replant or cover bare areas as soon as grading or construction is completed. New plantings will require soil amendments, fertilizers, and temporary irrigation to become established. Use high planting and/or seeding rates to ensure rapid stand establishment.

3. Properly dispose of sediment and debris from construction activities.

4. Minimize amount of construction time spent in the stream beds.

If you should have any questions on this matter, please contact Ms. Shirley Nakamura of the Environmental Planning Office at 586-4345.

Sincerely,

PETER A. SYBINSKY, Ph.D.
Director of Health

c: Clean Water Branch
Nonpoint Source

Note: Response to comments included in draft EIS.

See Final EIS, pages 1-6 and 9-2 for notes on NPDES and erosion control.

BENJAMIN J. CAYETANO
[redacted]
GOVERNOR

GARY GILL
DIRECTOR

STATE OF HAWAII
OFFICE OF ENVIRONMENTAL QUALITY CONTROL
220 SOUTH KING STREET
FOURTH FLOOR
HONOLULU, HAWAII 96813
TELEPHONE [illegible]
FACSIMILE [illegible]

August 22, 1995

Mr. Milton Pavao, Manager
Hawaii County Department of Water Supply
25 Aupuni Street
Hilo, Hawaii 96720

Dear Mr. Pavao,

Subject: Draft EIS for the Kohala Water Transmission System Project

Thank you for the opportunity to review the subject document. We have the following comments.

1. This project proposes to withdraw 20 mgd of water from the Hawi aquifer. Most of the water withdrawn will be transfered to South Kohala for resort and residential uses. The sustainable yield for the Hawi aquifer is 27 mgd. This proposed withdrawal would leave little ground water reserve for North Kohala. In the future, if there is demand for water in North Kohala, what mechanisms are proposed to guarantee that the water needs of the North Kohala community will be met?

2. The proposed water withdrawal could cause some reduction of stream flow near the mouth of Pololu Stream. According to the Draft EIS, because of the absence of field data concerning the hydraulic connection of this stream with the basal aquifer, the magnitude of the reduction cannot be assessed at this time. Since the impact to Pololu Stream cannot be assessed at this time, we recommend that this issue be listed as an unresolved issue. Steps that will be taken to resolve this issue must be listed in the final EIS.

3. Diesel-fueled generator sets would be located at well sites C, D, and E to power the pumps. Please list all the precautions that will be taken to ensure that the stored fuel for the generators will not leak and contaminate any water resource.

4. The financial plan for the funding of this project is not included in the draft EIS. If the financial plan will be available at the time of the printing of the final EIS, the plan should be included in the EIS.

If you have any questions, please call Jeyan Thirugnanam at 586-4185. Mahalo.

Sincerely,

Gary Gill
Director

c: Mr. Megumi Kon

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
25 AUPUNI STREET • HILO, HAWAII 96720
TELEPHONE (808) 969-1421 • FAX (808) 969-6996

October 23, 1995

Mr. Gary Gill, Director
Office of Environmental Quality Control
220 South King Street, 4th Floor
Honolulu, HI 96813

DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for commenting on the DEIS for the subject project. The following responses are in order of the comments in your letter of August 22, 1995.

1. Proposed mechanism to guarantee future North Kohala water needs can be met.

The Hawi aquifer [80101] is the proposed source to meet the future water needs for the North Kohala area that is generally north of Mahukona (northern North Kohala). The estimated potable water needs for the area to year 2010 is 4.3 mgd. However, this total includes 3 mgd for possible future land uses of former Kohala sugar plantation lands. Without the inclusion of this reserve, the total need for northern North Kohala would be 1.3 mgd (see Appendix F, p. F-7).

The following computation gives an idea of the population that can be serviced with 3.0 mgd supply. Based on an assumed average per capita consumption of 150 gallons per day, the 1.3 mgd and 4.3 mgd estimates translate to populations of about 8,600 and 28,600 persons. Depending on the consumption rates of future activities, the projection could fall above, below or somewhere between these figures. The population projections shown - below are given for comparison.

	Yr 2005	Yr 2010	Yr 2020
County General Plan Series A . . .	5,363		
County General Plan Series B . . .	6,721		
County General Plan Series C . . .	7,998		
State DBED M-K Series		8,470	
State Land Transport Master Plan (preliminary)			11,800

(Note: The population projections given above are for all of North Kohala District. No adjustments have been made for future population in areas south of Mahukona.)

Because of the unpredictability of the long term future, there is no reliable way to guarantee that future water needs of northern North Kohala will be met. However, there are several mechanisms that are available to balance community growth and water resources management. The primary mechanisms for directing growth (and resulting water need) in the county are the State Land Use Commission land use designation (LUCD) and Hawaii County General Plan (GP). In addition, in an area with an increase in water use or authorized

planned use that may cause the maximum rate of withdrawal from the groundwater source to reach 90 percent of the area's estimated sustainable yield, the State Commission on Water Resources Management can designate it as a water management area and impose water allocation controls.

From a practical viewpoint, if northern North Kohala is to maintain its rural and agricultural characteristics, as desired by many of its residents, there should not be large future potable water needs. Most of the lands in northern North Kohala are presently designated for Agriculture Use in the GP map. The built up sections along the Hawi-Niulii Highway and connecting secondary roads are generally in low and medium density uses. Thus, other than for agricultural use, any proposed higher density use in areas beyond those already designated must receive appropriate LUCD and/or GP designations together with appropriate county zoning change. The availability of water would be an important consideration in such change.

The estimated sustainable yield for the Hawi aquifer system [80101] given in the State Water Resources Protection Plan is 27 mgd. Our discussions with USGS suggest that withdrawing an additional 4.3 mgd beyond the 20 mgd plus 0.6 mgd at the existing Hawi Well is feasible. The Water Department is arranging with the USGS to apply its modeling studies to verify the discussions based on a set of assumed well locations, depth, and pumping rates. In the interim, the Water Department will report the feasibility of withdrawing the additional water as an unresolved issue under Section 12.1 Environmental Concerns in the final EIS.

Note: The State's Water Resources Protection Plan points out that the estimates of sustainable yield are not meant to be exact numbers which could be used in final planning documents. Also, the sustainable yield figure is not necessarily equal to developable groundwater. For example, the USGS report (Appendix B) noted that a water resources study (Bowles and others, 1974) using a simplified water budget and Darcy's law estimated that 40 to 45 mgd flowed through the Hawi aquifer, and of that quantity, 30 to 35 mgd (75 percent of flow through the system) was available for development. The USGS study estimated the total recharge to the area at 70 mgd. It also stated that the location, depth, and pumping rate of the wells within an aquifer would affect the amount of groundwater that can be developed from the aquifer.

2. Possible reduction in streamflow near the mouth of Pololu Stream.

The Water Department is arranging with the USGS to obtain the necessary field data to determine if there is a hydraulic connection between Pololu Stream near its mouth and the basal aquifer and, if there is, to estimate the size of possible reduction in streamflow near the mouth of Pololu Stream. This would provide information to find out the potential impact to Pololu Stream and appropriate mitigation measures that can be taken to alleviate negative impacts. In the interim, the Water Department will report this item as an unresolved issue under Section 12.1 Environmental Concerns in the final EIS.

3. Precautions to avoid potential water resource contamination from leakage of stored fuel.

   The diesel-fueled generator sets at sites C, D, and E are planned for installation if power from the utility company is not available. They would be used until power becomes available. Each tank will be constructed of a UL Listed rectangular steel tank enclosed in secondary containment membrane and encased in six inches of reinforced concrete. The fuel storage system design will be based on above ground tanks manufactured by ConVault, or an approved equal. ConVault fuel storage tanks are installed at many locations on the Big Island, as well as, statewide and nationwide. The following precautionary measures will be taken to assure the stored fuel will not leak and contaminate any water resources:

   a. The tanks will be designed to withstand vehicle incursions and tipping during earthquakes and other natural disasters and include earthquake restraint hardware.

   b. The unit will comply with the 1991 Uniform Fire Code Appendix II-F for above ground storage dispensing of motor fuels.

   c. A leak detection access tube will be located between the inner tank and secondary barrier. In case of a leak, a positive space shall be available to allow leaked fluid to flow to the detection tube.

   d. The tank system will include a minimum 5-15 gallon, powder-coated external or internal UL Listed overfill/spill containment surrounding the fill pipes. The overfill/spill container will include a normally-closed valve to release spilled fuel into the main tank.

   e. Overfill protection will be provided by two or more of the following methods: 1) direct reading level gauge at tank visible from fill pipe access; 2) valve located within fill pipe to close automatically at a specified fill level; 3) audible high level alarm activated by a float switch at a specified fill level.

   f. Vaults will have concrete support legs of unitized monolithic construction to provide visual inspection capability.

4. Project financial plan.

   The financial plan for the funding of the project is not expected to be available at the estimated time for printing the final EIS. Current economic conditions have prevented private sector water users from making any committment now to any course of action. Thus, the financial plan may need to await stronger economic time for completion and approval by the County Council. As part of the review and approval process, the County Council would

be holding public meetings and hearings on the issue at appropriate times. Project construction will not start until the financial plan is approved and funding is in place.

In the interim, the Water Department will report the financial plan as one of the items that must be completed and approved before project construction can start. It will be reported under Section 12.2 Project Implementation in the final EIS.

Milton D. Pavao, P.E.
Manager

STATE OF HAWAI'I
OFFICE OF HAWAIIAN AFFAIRS
711 KAPI'OLANI BOULEVARD, SUITE 500
HONOLULU, HAWAI'I 96813-5249
PHONE (808) 594-1888
FAX (808) 594-1865

August 16, 1995

Governor, State of Hawaii
c/o Office of Environmental Quality Control
220 South King St. #400
Honolulu, HI 96813

Dear Sir/Madam:

Thank you for the opportunity to review the Draft Environmental Impact Statement (DEIS) for the Kohala Water Transmission System, North and South Kohala Districts, Island of Hawaii. The project intends to withdraw water from the Hawi aquifer on the North Kohala for a total of 20 mgd by the year 2,010 and deliver it to three reservoirs located in Kawaihae, Kaunanoa, and Lalamilo on the South Kohala District.

We find the information contained in the DEIS comprehensive and the DEIS authoritative in developing the technical framework for the Kohala water transmission system. But we have serious reservations about the project's scope. In page 1-1 of the DEIS, the overall purpose of the project reads as follow:

> "The purpose of the proposed Kohala Water Transmission System project is to provide a high quality and reliable potable water supply that would meet the estimated future needs of North Kohala and coastal areas of South Kohala."

We find the above statement inaccurate and somewhat misleading for the following reasons.

First, a review of beneficiaries shows that except for the DHHL Kawaihae project, all beneficiaries are located in the South Kohala District (Figure 2.2-1 of DEIS). Thus, we view the project as one designed primarily to benefit coastal resort developments in the South Kohala District.

Second, a review of future water needs of major beneficiaries shows that DHHL water needs are zero up to the year 2,000, 1.3 mgd or 17% of the water withdrawn from the Hawi aquifer by the year 2,004, 3.1 mgd or 29% by the year 2,009, and 7 mgd or 35% by the year 2,014 (Figure 2.2-1). The above data indicate that (i) water withdrawn from the Hawi aquifer will not benefit the North Kohala area in this century, and (ii) in the likelihood that DHHL will proceed with its housing development plans, it will be after the year 2,010 that water withdrawn from the Hawi aquifer will actually benefit a North Kohala development. We find the proposed water allocations unequal and disproportionate and the allocation process biased.

Third, except for those of the DHHL Kawaihae project, water needs of existing and potential beneficiaries in the North Kohala District are not addressed in the project. Taking into account that large segments of the population in the North Kohala District engage in agriculture and other related activities and heavily depend on water for their sustenance, we find this to be a serious oversight and one that in our view virtually renders the project unfeasible.

In conclusion, we view the proposed project as one resembling the features of the much controversial Waiahole Ditch on the Island of Oahu. That is one that collects and transports water from one area to another and in the process ignores and/or bypasses local water needs and rights. Given the Waiahole Ditch legacy of water monopoly and greed, disrupted ecosystems and natural habitats, and endemic disregard of Hawaiian tradition, culture, and values, we at the Office of Hawaiian Affairs are not prepared to endorse the present scope of the Kohala water transmission project. But we are ready to support projects in the Kohala area that foster development based on equal access and participation of local communities. Please contact me, or Linda K. Delaney, the Land and Natural Resources Division Officer (594-1938), or Luis A. Manrique (594-1935), should you have any questions on this matter.

Sincerely yours,

Dante K. Carpenter
Administrator

LM:lm
cc BOT

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
25 AUPUNI STREET • HILO, HAWAII 96720
TELEPHONE (808) 969-1421 • FAX (808) 969-6996

October 18, 1995

Administrator
Office of Hawaiian Affairs
711 Kapiolani Boulevard, Suite 500
Honolulu, HI 96813-5249

DRAFT ENVIRONMENTAL IMPACT STATEMENT (DEIS)
KOHALA WATER TRANSMISSION SYSTEM

Thank you for commenting on the DEIS for the subject project. The following responses are in order of the comments in your letter of August 16, 1995.

We should first correct your perception that the project intends to withdraw 20 mgd water from North Kohala by Year 2010. The Water Department plans to construct the project in two phases of 10 mgd each. Although the tentative schedule for the project (see Section 3.6 on page 3-15) shows construction in 1996 to 1998, the actual time would be dependant on approval of the financing plan and arrangements by the County Council. Construction for Phase II is not scheduled and would be initiated only when demand for the additional water develops. Thus, 20 mgd withdrawal would most likely not occur by Year 2010. We will clarify Section 3.6 and Figure 2.2-1 in the final EIS.

On your comments regarding the project's scope and purpose statement, the following information may help to clarify the statement:

(First) You are correct that the beneficiaries of the project (including DHHL Kawaihae project, which extends up slope past Kohala Mountain Road) are located in the coastal area of the South Kohala District. However, the project is also intended to improve water services to the existing North Kohala systems, although small in scale compared to the total project. The county water systems in North Kohala are currently served by a combination of tunnel and well water supplies. There are two problems with the existing systems: poor supply reliability during dry weather and potential non-compliance with EPA safe drinking water regulations. The interconnection of the existing and proposed systems (see page 3-9, last item Phase I, draft EIS) would provide a reliable all ground water supply that would not be affected by the vagaries of the weather. It would also provide a water supply that complies with EPA regulations.

(Second) Although the "water allocation" appears disproportionate by looking at the numerical figures, we do not agree with you that the allocation process is biased. The allocations were based on estimates of water needs. The numbers shown in Figure 2.2-1, draft EIS reflect water need estimates based on information from land owners or, where unavailable, from land use assumptions in parcels designated in the County General Plan for resort, urban, and urban expansion (see Figures 2.2-3 and 6.5-1 and Appendix F, draft EIS).

The Water Department follows the County General Plan as a guide in planning its system expansions. Generally, because water rate revenues are primarily used for water system operations and maintenance, the Water Department relies on funds from State legislative appropriations and Federal loans and grants for system expansion. In areas of the island where there are water needs and water users agreeable to paying for system expansion, the Water Department plans on making potable water available. In the proposed project, the major water users in South Kohala must agree to participate in the payment of their share of the system financing before construction can start.

(Third) You are correct in your observation that a clear explanation of the estimate of future needs for North Kohala is not covered in the draft EIS. It will be included in the final EIS. A worksheet accounting the needs that make up the 4.3 mgd estimate is included as page F-7 in Appendix F of the draft EIS. Because of concerns that there would be little left in the Hawi aquifer for possible future water needs in North Kohala, a discussion with Chalon Hawaii, owner of the former Kohala sugar plantation lands, led to including 3.0 mgd for possible long-term future needs for that section of North Kohala generally Hawi side of Mahukona. The figure is included for estimate purpose. As noted in the draft EIS, discussions with USGS suggest that withdrawing an additional 4.3 mgd beyond the 20 mgd plus 0.6 mgd at the existing Hawi well is feasible. The Water Department is arranging with the U.S. Geological Survey (USGS) to apply its modeling studies to verify the discussions based on a set of assumed well locations, depth, and pumping rates. In the interim, the feasibility of withdrawing the additional water will be reported as an unresolved issue under Section 12.1 Environmental Concerns in the final EIS.

The following computation gives an idea of the population that can be serviced with 3.0 mgd supply. Based on an assumed average per capita consumption of 150 gallons per day, the 4.3 mgd and 1.3 mgd (4.3 less 3.0) estimates translate to populations of about 28,600 and 8,600 persons. Depending on the consumption rates of future activities, the projections could fall above, below or somewhere between these figures. The population projections given - below are for comparison.

	Yr 2005	Yr 2010	Yr 2020
County General Plan Series A . . .	5,363		
County General Plan Series B . . .	6,721		
County General Plan Series C . . .	7,998		
State DBED M-K Series		8,470	
State Land Transport Master Plan (preliminary)			11,800

(Note: The population projections are for all of North Kohala District. No adjustments have been made for future population in areas south of Mahukona.)

Chalon Hawaii, owners of the Kohala Ditch, presently provides irrigation water to a few agricultural users and one hydroelectric power plant in North Kohala. We have assumed that future agricultural water uses would rely on the Kohala Ditch for their irrigation water supply. The source for the Kohala Ditch is surface and ground water from the streams between Waimanu and Pololu valleys of Kohala Mountain. The source for the proposed project is basal groundwater from the Hawi aquifer system. The ground water withdrawals by the supply wells of the proposed project would not affect the flow in Kohala Ditch. There are several streams within the general area of the supply wells recognized as having aquatic, cultural, and recreational resources by the Hawaii Stream Assessment report (see Section 5.2.6, page 5-12, draft EIS). These streams would not be affected by the pumping operations of the project.

We differ with your opinion that the situation in the proposed project resembles that of the Waiahole Ditch on the Island of Oahu. Although the proposed project may be transporting ground water from one district to another, it can be seen from the explanations given above that northern North Kohala's water needs were not ignored. It is not an arbitrary reallocation of water. Except for withdrawals by the Water Department's Hawi Well, the basal water in the Hawi aquifer is currently not used and recharge to the system is lost to the ocean. It also does

not foster developments in South Kohala while denying developments in North Kohala from a water availability standpoint. This would be particularly true if agriculturally oriented activities were to be pursured. In addition, withdrawal of the groundwater is not expected to disrupt ecosystems and natural habitats of streams near the well sites. (The evaluation of impact on Pololu Stream from a potential reduction in flow at the mouth of the stream will be completed as part of unresolved issues).

Providing additional water to South Kohala has the potential for creating a situation in which a worker can find employment in South Kohala while residing in North Kohala and enjoying its rural ambience and lifestyle. The project has allocated 35% of the water transported to South Kohala for the DHHL Kawaihae Master Plan, as part of the effort to provide water for Hawaiian homestead developments.

While in northern North Kohala, Chalon Hawaii's interest in maintaining agricultural uses on its lands and the ready availability of irrigation water in the Kohala Ditch opens a window of opportunity for those interested in agricultural pursuit.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

OFFICE OF STATE PLANNING

Office of the Governor

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STREET ADDRESS: 250 SOUTH HOTEL STREET, 4TH FLOOR
TELEPHONE: (808) 587-2846, 587-2800

BENJAMIN J. CAYETANO, Governor

FAX: Director's Office 587-2848
Planning Division 587-2824

Ref. No. C-1426

September 20, 1995

MEMORANDUM

TO: The Honorable Benjamin J. Cayetano
Governor, State of Hawaii

ATTN: Office of Environmental Quality Control

FROM: Gregory G.Y. Pai, Ph.D.
Director

SUBJECT: Draft Environmental Impact Statement for Kohala Water Transmission System

We have reviewed the draft environmental impact statement (DEIS) for the Kohala water transmission system and have the following comments.

Section 12, 2.1 of the DEIS states that, "There are no environmental issues addressed by this DEIS that are unresolved." There are, however, several issues which we believe remain unresolved.

The DEIS asserts that portable diesel generators may be used to power the well pumps in the event that HELCO cannot supply power to the project site. If diesel products are stored on-site, there is the danger of fuel spills. Mitigation measures such as leak detection equipment and emergency fuel spill containment structures, should be designed and proposed in the final environmental impact statement (FEIS) to address the contingency of a fuel spill for compliance with statutory Coastal Zone Management (CZM) objectives and policies.

According to the USGS modeling study on water withdrawal rates, pumping of an additional 20 mgd of ground water from the Hawi aquifer could result in reducing stream flow near the mouth of Pololu Stream. This is a concern because nearshore aquatic ecosystems may be adversely affected by fluctuations in water volume, salinity, and sediment load. The FEIS should thoroughly explore the potential for stream flow reduction and mitigation measures such as pumping restrictions to alleviate negative environmental impacts.

The 4:1 benefit/cost ratio for the project is unsubstantiated. The ratio should be explained in detail, including how the figures were derived.

Finally, the projected potable groundwater needs for the North Kohala/Waimea area estimated to be 40.1 mgd are a concern. However, because the parcels in this area are owned by the Queen Emma Foundation, Tri-Kohala Development and the State, and no definite development plans are available, the actual groundwater needs may vary from the estimates.

Therefore, the 40.1 mgd projected need may be somewhat overstated. Given that future development in the North Kohala/Waimea area will require additional potable water, an imbalance in water distribution could occur should the demand in the South Kohala source area increase simultaneously while 40.1 mgd is being supplied to the North. The FEIS should examine and discuss this potential imbalance issue as well as the 40.1 mgd projected need for the North Kohala/Waimea area.

We appreciate the opportunity to review and comment on this document. In the event that there are any questions, please call Harold Lao of our CZM program at 587-2883.

cc: Dept. of Water Supply, County of Hawaii
✓ Megumi Kon, Inc.

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
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October 18, 1995

Gregory G.Y. Pai, Ph.D., Director
Office of State Planning
P. O. Box 3540
Honolulu, HI 96811-3540

DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for commenting on the DEIS for the subject project. The following responses are in order of the comments in your letter of September 27, 1995.

- Fuel Storage For Power Generator Sets

The following information will be included in the final EIS.

The diesel-fueled generator sets at Sites C, D, and E are planned for installation if power from the utility company is not available. They would be used until power becomes available. Each tank will be constructed of a UL Listed rectangular steel tank enclosed in secondary containment membrane and encased in six inches of reinforced concrete. The fuel storage system design will be based on above ground tanks manufactured by ConVault, or an approved equal. ConVault fuel storage tanks are installed at many locations on the Big Island, as well as, statewide and nationwide. The following precautionary measures will be taken to assure the stored fuel will not leak and contaminate any water resources:

a. The tanks will be designed to withstand vehicle incursions and tipping during earthquakes and other natural disasters and include earthquake restraint hardware.

b. The unit will comply with the 1991 Uniform Fire Code Appendix II-F for above ground storage dispensing of motor fuels.

c. A leak detection access tube will be located between the inner tank and secondary barrier. In case of a leak, a positive space shall be available to allow leaked fluid to flow to the detection tube.

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d. The tank system will include a minimum 5-15 gallon, powder-coated external or internal UL Listed overfill/spill containment surrounding the fill pipes. The overfill/spill container will include a normally-closed valve to release spilled fuel into the main tank.

e. Overfill protection will be provided by two or more of the following methods: (1) direct reading level gauge at tank visible from fill pipe access; (2) valve located within fill pipe to close automatically at a specified fill level; and (3) audible high level alarm activated by a float switch at a specified fill level.

f. Vaults will have concrete support legs of unitized monolithic construction to provide visual inspection capability.

- Streamflow At Mouth Of Pololu Stream

The Water Department is arranging with the US Geological Survey (USGS) to obtain the necessary field data to determine if there is a hydraulic connection between Pololu Stream near its mouth and the basal aquifer and, if there is, to estimate the size of possible reduction in streamflow near the mouth of Pololu Stream. This would provide information to find out the potential impact to Pololu Stream and appropriate mitigation measures that can be taken to alleviate negative impacts. In the interim, the Water Department will report this item as an unresolved issue under Section 12.1 Environmental Concerns in the final EIS.

- Benefit/Cost Ratio

A series of fiscal benefit/cost ratios were computed and presented in Appendix A of the draft EIS (pp. 63-69). The computations were made based a number of assumptions regarding resort build-out rates, visitors and new resident arrival rates, estimated state and county revenue generation, expected per capita state and county government expenditures, and other relevant assumptions.

In a revised Socio-Economic Impact Analysis, additional benefit/cost ratios are computed to better reflect the "cumulative" or "secondary" impact. The results are summarized below and will be included in the SIA report for the final EIS.

Fiscal Benefit/Cost Ratio For The State Government:

	For Year 2010	For Year 2020
Historical Build-out Scenario		
Ratio for Project only	6.7	4.0
Ratio for Cumulative	4.7	2.4
As-Planned Build-out Scenario		
Ratio for Project only	3.4	1.7
Ratio for Cumulative	7.9	3.4

In the Historical Trends scenario the "cumulative" ratio is much smaller than the "project only" ratio, as expected. Also, the ratios decline in the Year 2020 as the number of new resort developments approaches maximum. For the "As-Planned" scenario, the cumulative ratio is larger than the "project only" ratio. These unusual results are traceable to the fact that under the "As-Planned" scenario the ratio between visitors and new state residents is higher, leading to lower state expenditures per capita. It is important to note from this exercise that the important determinant of the benefit/cost ratio lies in the division of net increase in population between "visitors" and residents. The larger the proportion of residents relative to visitors, the lower will be the benefit/cost ratio.

Fiscal Benefit/Cost Ratio For The County Government:

	For Year 2010	For Year 2020
Historical Build-out Scenario		
Ratio for Project only	3.2	0.9
Ratio for Cumulative	3.3	2.5
As-Planned Build-out Scenario		
Ratio for Project only	5.9	5.1
Ratio for Cumulative	7.2	7.0

Similar patterns can be observed for the county government benefit/cost ratios. Again (and as expected), the cumulative ratios for both periods are smaller than the "project only" scenario. However, for the "As-Planned" scenario the cumulative ratios are greater.

- Waimea Aquifer System Water Budget

We assume that the 40.1 mgd that the reviewer refers to in the comment is from Figure 2.2-1, draft EIS. It represents the estimated groundwater requirement for projects in the area generally overlying the Waimea Aquifer System. The accounting for the estimated amounts shown in Figure 2.2-1 may be found on pages F-6 & F-7 of Appendix F in the draft EIS.

The potential imbalance in the Waimea Aquifer System water budget is the major reason for importing additional water from North Kohala to supplement the County's coastal water system. We feel that this issue is discussed fairly well in Section 2.2 of the draft EIS (see page 2-8 for Waimea system), except for future needs and supply in the northern North Kohala area. A discussion for North Kohala will be added in the final EIS.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

BENJAMIN J. CAYETANO
GOVERNOR

MAJOR GENERAL EDWARD V. RICHARDSON
DIRECTOR OF CIVIL DEFENSE

ROY C. PRICE
VICE DIRECTOR OF CIVIL DEFENSE

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PHONE (808) 734-2
FAX (808) 737-

September 6, 1995

TO: Governor
State of Hawaii
c/o Office of Environmental Quality Control (OEQC)

FROM: Roy C. Price, Sr.
Vice Director of Civil Defense

SUBJECT: DRAFT ENVIRONMENTAL IMPACT STATEMENT (DEIS); KOHALA WATER TRANSMISSION SYSTEM PROJECT

State Civil Defense (SCD) appreciates this opportunity to comment on the Hawaii County Department of Water Supply Kohala Water Transmission System Project DEIS; TMKs: 5-2-05:1, 5-2-06:3, 5-3-03:1, 5-3-04:1, 5-4-03:2, 5-4-03:3, 5-5-02:23, 5-6-01:51, 5-9-03:4, 6-1-01:3, 6-2-01:63 and 6-8-01:6, North and South Kohala Districts, island of Hawaii, County of Hawaii.

While we do not have negative comments specifically directed at this DEIS, we do have a proposal that the State should seriously evaluate during the approval process for this application. This proposal entails that a four-inch conduit, with an adequate number of installed pull boxes, be laid along side this proposed water main. This conduit would be reserved for future State telecommunications use.

SECTION 1, SUMMARY, paragraph 1.3, DESCRIPTION OF PROPOSED PROJECT, describes a two-phase project. Regarding reservoirs, Phase I consists of two 3-million gallon (mg) collection reservoirs near Puakea Ranch and three terminal reservoirs located in Kawaihae, Kauanoa and Lalamilo, respectively; Phase II consists of one 6-million gallon (mg) collection reservoir at the Puakea site and one 1-million gallon (mg) terminal reservoir at Lalamilo. SECTION 5, DESCRIPTION OF ENVIRONMENTAL SETTING, paragraph 5.2, PHYSICAL ENVIRONMENT, subparagraphs 5.2.2, 5.2.4 and 5.2.9 discuss TOPOGRAPHY, CLIMATE and NATURAL HAZARDS, respectively. The impact of terrain amplified winds and torrential rains associated with tropical cylones, to include hurricanes, are not addressed in the preceding subparagraphs. With reservoir elevations ranging from approximately 300 to 1,100 feet, any structures/enclosures for the wells and support equipment should be designed and constructed to withstand the potentially destructive winds associated with tropical cyclones. Additionally, the flood potential from overtopping/breaches in the reservoirs, new and existing, as a result of rainfall associated with tropical cyclones, must be evaluated.

Our SCD planners and technicians are available to discuss this further if there is a requirement. Please have your staff call Mr. Mel Nishihara of my staff at 734-2161.

MN:jnt

bc: HCDA
Mr. G. Burnett
State Radio Shop
Mr. M. Nishihara

State of Hawaii, Dept of Land and Natural Resources
Division of Water and Land Development
1151 Punchbowl Street, Room 227
Honolulu, Hawaii 96813

State of Hawaii, Dept of Budget and Finance
Information & Communications Services Division
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Hawaii County Department of Water Supply
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✓ Megumi Kon, Inc.
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October 20, 1995

Mr. Roy C. Price Sr., Vice Director
State of Hawaii
Office of Director of Civil Defense
3949 Diamond Head Road
Honolulu, HI 96816-4495

DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for commenting on the DEIS for the subject project. The following is in response to your letter of September 6, 1995.

You have proposed to the Governor that the State evaluate installing a four-inch conduit and pull boxes for future telecommunication use in the project's pipeline trench. Please contact me or Mr. Quirino Antonio, our Deputy Manager, to discuss your proposal.

Regarding tropical cyclone conditions, we agree with you that above ground structures at the well and reservoir sites should be designed and constructed to withstand potentially destructive winds associated with tropical cyclones. We will advise the project consultants to design project components according to appropriate building criteria. We will also note the potential for occurrence of tropical cyclone in the project area in Section 5.2.4 of the final EIS.

The proposed reservoirs are completely enclosed cylindrical tanks with reinforced concrete wall and roof. As such, we do not expect any overtopping of the tanks from rainfall associated with tropical cyclone. The reservoir pad elevations would range from about 650 feet to 300 feet.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

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BENJAMIN J. CAYETANO
Governor of Hawaii

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

P. O. Box 621
Honolulu, Hawaii 96809

Chairperson
MICHAEL D. WILSON
Board of Land and Natural Resources

Deputy Director
GILBERT COLOMA-AGARAN

Aquaculture Development
Aquatic Resources
Boating and Ocean Recreation
Bureau of Conveyances
Conservation and Environmental Affairs
Conservation and Resources Enforcement
Forestry and Wildlife
Historic Preservation
Land Management
State Parks
Water and Land Development

REF: OCEA:TES

File No.: 96-001

AUG 31 1995

MEMORANDUM

TO: Gary Gill, Director
Office of Environmental Quality Control

FROM: Michael D. Wilson, Chairperson
Department of Land and Natural Resources

SUBJECT: Draft Environmental Impact Statement (DEIS): Kohala Water Transmission System Project, North and South Kohala, TMKs: various

We have reviewed the DEIS information for the subject project received on July 5, 1995, and offer the follow:

Office of Conservation and Environmental Affairs

Our Office of Conservation and Environmental Affairs (OCEA) comments that insofar as the proposed waterline will traverse the Conservation District in the Lapakahi State Park area (p. 6-9), a Conservation District Use Application (CDUA) would need to be filed with the Department and approved by the Board of Land and Natural Resources pursuant to Section 13-5-22(b)P-6(D-1), Hawaii Administrative Rules (HAR). OCEA also comments that as an area designated within the Protective "P" subzone, this proposed land use will require a separate public hearing pursuant to Section 13-5-40(a)(3), HAR.

We will forward the comments of the Commission on Water Resource Management and our Divisions of State Parks and Historic Preservation as they become available.

We have no other comment to offer at this time. Thank you for the opportunity to comment on this matter.

Please feel free to contact Steve Tagawa at our Office of Conservation and Environment Affairs at 587-0377, should you have any questions.

cc: Hilton Pavao, DWS
Gary Gill, OEQC
Megumi Kon

BENJAMIN J. CAYETANO
Governor of Hawaii

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. Box 621
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MICHAEL D. WILSON
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Aquaculture Development
Aquatic Resources
Boating and Ocean Recreation
Bureau of Conveyances
Conservation and Environmental Affairs
Conservation and Resources Enforcement
Forestry and Wildlife
Historic Preservation
Land Management
State Parks
Water and Land Development

REF:OCEA:TES

File No.: 96-001a

MEMORANDUM SEP 12 1995

TO: Gary Gill, Director
Office of Environmental Quality Control

FROM: Michael D. Wilson, Chairperson
Department of Land and Natural Resources

SUBJECT: Draft Environmental Impact Statement (DEIS): Kohala Water Transmission System Project, North and South Kohala, Hawaii, THKs: various

The following are our additional comments on the subject DEIS which supplement those forwarded by our previous memoranda dated August 31, 1995:

Commission on Water Resource Management

The Commission on Water Resource Management's (CWRM) staff notes the following:

* They recommend coordination with the County government to incorporate this project into the County's Water Use and Development Plans.

* Well Construction Permits and Pump Installation Permits from CWRM would be required before groundwater is developed as a source of supply for the project.

* Groundwater withdrawals from this project may affect stream flows. This may require an instream flow standard amendment.

* If the project diverts additional water from streams or if new or modified stream diversions are planned, the project may need to obtain a Stream Diversion Works Permit and petition to amend the interim instream slow standard for the affected stream(s).

* Based on the information provided, it appears that a Stream Channel Alteration Permit (SCAP) pursuant to Section 13-169-50, HAR, will be required before the project can be implemented.

CWRM also comments that on p. 5-7, the basal water table gradient is dependant not only on the infiltration rate of rainwater, but also on the regional and local hydraulic permeability of the geology. They also note on p. 5-11 that Pololu is at least one stream which may require a petition to amend interim instream flow standards and may be difficult to resolve. If any new access roads or piping cross stream channels, then a SCAP may be necessary

Division of Aquatic Resources

The Division of Aquatic Resources (DAR) has concerns that this proposed project may have deleterious effects on the stream ecology of the following streams: Niulii Gulch and its tributary Waikani Gulch; Aamakao Gulch and its tributaries Puwaiole and Walaohia gulches, Halawa Gulch and its tributary Halawa Gulch (East Branch), Halelua Gulch, Wainaia Gulch and Hanaula Gulch and its tributary Waikaulapala Gulch by impacting the stream flow near the mouths of the streams.

The 6 well sites are situated between these streams and pumping water from wells in these areas near the stream may decrease stream flow near the mouths or affect the estuary of these streams. Although, natives species may be limited to the upper stream section, the stream mouth may provide habitat for nearshore species such as oama, mullet, papio, aholehole, moi, etc., that use the estuary as a nursery.

DAR's Stream Database which is based on the Hawaii Stream Assessment (HSA) database, provided information only for Amakao Stream. Based on a survey conducted in 1980, 'O'opu hi'ukole, *Lentipes concolor* was observed. No biological surveys were performed on any of the other streams adjacent to the well sites.

DAR comments that further biological surveys are necessary to determine what other native freshwater fish and insect species are present. The further collection of hydrologic data and gaging of the streams is necessary to determine whether the well sites will have an effect on stream flow and the stream estuary. DAR suggests the monitoring of stream flows near the mouth or estuaries of streams, as well as at the elevation of the wells during test pumping, to collect the necessary field data to determine the magnitude of any reduction in stream flow.

We have no further comment to offer at this time. Thank you for the opportunity to comment on this matter.

Please feel free to contact Steve Tagawa at our Office of Conservation and Environmental Affairs at 587-0377, should you have any questions.

cc: Milton Pavao, DWS
Megumi Kon

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October 20, 1995

Mr. Michael D. Wilson, Chairperson
State of Hawaii
Department of Land and Natural Resources
P. O. Box 621
Honolulu, HI 96809

COMMENTS FROM OFFICE OF CONSERVATION AND ENVIRONMENTAL AFFAIRS,
COMMISSION ON WATER RESOURCE MANAGEMENT, AND DIVISION OF AQUATIC RESOURCES ON
DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for commenting on the DEIS for the subject project. The following responses are in order of the comments in your letter of August 31, 1955 and September 12, 1955.

Office of Conservation and Environmental Affairs (OCEA)

- The Conservation District Use Application and Protective "P" Subzone use permit will be added to Section 1.9 Listing of Permits and Approvals in the final EIS.

Commission on Water Resource Management (COWRM)

- The proposed project is incorporated in the Hawaii County WUDP Draft, Feb 1992, under regional water development plans (see pages 1-22, 6-9, 7-9).
- The well construction and pump installation permits are listed under Section 1.9 of draft EIS. The permits will be listed under their proper labels in the final EIS.
- Groundwater withdrawals by the project are not expected to affect stream flows, except possibly at the mouth of Pololu Stream (see next paragraph). The source for the project is basal groundwater from the Hawi aquifer system. COWRM Water Resources Protection Plan (page 123) states that in the Hawi system "the coast is rocky and is not rimmed with a sedimentary caprock." USGS study report (Appendix B, page 16) states that "sedimentary deposits similar to those found along the shoreline of other islands in Hawaii are not present along the Kohala shoreline because of the relatively young age of the basalts in the area." In the absence of sedimentary caprock or deposits, the basal water in the Hawi aquifer would be unconfined. DLNR Report R84 Hawaii Stream Assessment (page 6) states "unconfined basal water flows directly into the sea and does not contribute to streams."

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The USGS study (Appendix B, page 52) reported that the numerical model calculated a water-level decline of slightly more than 1 ft near the mouth of Pololu Stream where the stream discharges into the ocean. It is possible that the Pololu Stream is hydraulically connected to the basal aquifer in this area. As a result, a decline in water level near the mouth of the stream could cause a reduction in streamflow. Because the model terminates along the Pololu watershed boundary, the model would be expected to over-estimate the water-level decline in the area of Pololu Streams, perhaps by as much as 0.5 ft. Due to lack of field data concerning the hydraulic connection of this stream with the basal aquifer, the size of the reduction was not addressed in the study.

The Department of Water Supply is arranging with USGS to obtain the necessary field data to determine if Pololu Stream is hydraulically connected to the basal aquifer and, if it is, to estimate the possible reduction in stream flow. Should there be any reduction, an evaluation of the impact on the area at the mouth of Pololu Stream will be completed. Mitigation measures, if necessary, will also be decided as part of the evaluation. In the interim, this item will be listed as an unresolved issue in the final EIS.

- The proposed project does not include any diversion of additional surface water or new or modified stream diversions.
- The proposed project does not include any stream channel alteration work since no stream diversions or crossings by pipeline are anticipated.
- The first paragraph in Section 5.2.5 on page 5-7 was intended to generally define gross water supply and hydrological cycle. We will add your reference to hydrologic permeability to the first paragraph on page 5-9.
- The Pololu Stream is outside of the proposed project area and no project construction will take place in the stream channel area. The possible reduction in stream flow from pumping of project wells is discussed above.

Division of Aquatic Resources (DAR)

- We are concerned, as the reviewers are, that the pumping of the basal water from the Hawi aquifer system does not negatively impact the marine ecosystem along the shoreline makai of the project wells. As discussed above, in our response to COWRM about the effect of pumping on stream flow, our understanding is that basal water from the Hawi aquifer does not contribute to the streams within the aquifer. The base flow of the streams in the study area is from spring discharge in the wet eastern and upland reaches. Consequently, pumping of basal water from the Hawi aquifer would not affect stream flows to the mouth or estuary of the streams near the wells. The exception, as discussed above, is Pololu Stream.

There was also concern about the effects of basal water pumping on nearshore water salinity and resulting impacts on nearshore ecosystem. The studies on this subject (see Appendix C, page 1) concluded that there appears to be no potential for negative impacts to marine ecosystems in either North or South Kohala from the diversion of the groundwater.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

University of Hawai'i at Mānoa

Environmental Center
A Unit of Water Resources Research Center
Crawford 317 • 2550 Campus Road • Honolulu, Hawai'i 96822
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August 22, 1995
RE: 0662

Governor Benjamin Cayetano
c/o Office of Environmental Quality Control
220 South King Street, Room 220
Honolulu, Hawai'i 96813

Dear Governor Cayetano:

Draft Environmental Impact Statement
Kohala Water Transmission System
Kohala, Hawai'i

The referenced project would recover 20 million gallons per day of potable ground water from the Hawi-Makapala sector of North Kohala and transmit it to the South Kohala coastal area. The Department of Water Supply plans to construct the project in two phases of 10 mgd capacity each. Phase One would include six supply wells at three sites, a pumped water transmission pipeline, two-3 mgd collection reservoirs in North Kohala and a 36-inch diameter gravity flow transmission pipeline. The pipeline would run from the collection reservoirs to a 1-MG pressure-breaker reservoir in Makiloa, then to three 1-MG terminal reservoirs in Kawaihae, Kaunaoa and Lalamilo in South Kohala. Power for the well pumps would be provided through on-site diesel-driven generators until utility company electricity becomes available. Phase Two would consist of six wells at four sites, one 6-MG collection reservoir in North Kohala and one 1-MG terminal reservoir in Lalamilo.

Our review of this Draft EIS was completed with the assistance of Dave Penn, Geography; Paul Ekern, Agronomy and Soil Science, Emeritus; George Curtis, UH Hilo and Tom Hawley, Environmental Center.

We are pleased to see that the Draft EIS has been carefully prepared and is attentive to the spirit of the EIS process. Numerous comments on and responses to the Environmental Assessment and the Environmental Impact Statement Preparation Notice (June/July 1994) are included which resolve several prior concerns. It further appears that direct environmental effects are minor and incidental to providing normal utility service.

Some areas of this Draft EIS, however, are incomplete. First, the probable occupancy and feasible alternate water supply for the Hawaiian Homelands are not adequately discussed. This particular issue warrants additional attention in the Final EIS. In addition, the actual occupancy of any future Hawaiian Homelands projects in the area will be determined by the availability of additional jobs in the region, which likely will be dependent on the proposed project. Second, the EIS notes that development in the region is dependent on the development of infrastructure. We concur in this assessment and the attendant implication that this project is part of such development. On the other hand, no mention is made of the fact that for several years the State has limited, actively or by default, further development of electrical generation capacity on the island. Ultimate replacement of the proposed diesel generators to power the water pumps is moot if electricity is not available for the region. Either utility can serve to control growth, and there is obviously no point to developing one without the other. As a result, it is important not to simply assume that adequate electrical service will be in place for the region in the planning of this project. Similarly, an analysis of the consequences of inadequate electrical power to the proposed project should be included in the Final EIS.

Our reviewers also note that the climate analysis (Section 5.2.4, p. 5-7) could be made more specific to include more information on winds and sea breeze circulation. In particular, we would direct the attention of the Department of Water Supply to several studies performed by University of Hawai'i at Manoa meteorologist Thomas Schroeder regarding various climatological features of the region: These findings are discussed in article entitled *Characteristics of Local Winds in Northwest Hawai'i* which appeared in the Journal of Applied Meteorology, Vol. 20, 1981. More of Schroeder's studies can also be found in two volumes resulting from experiments performed in February of 1979 and 1980. They are entitled *Project Ahupua'a* and referenced under UHMET 79-01 and UHMET 79-05, available for loan from the UH Meteorology Department.

Also, in Section 7-1 it is stated that the Department of Water Supply will monitor the aquifer and if depleted, "mitigation measures" will be taken. These measures are clearly of critical importance to the adequate functioning of the system and should therefore be stated explicitly.

Alternatives

In general, we are pleased with the discussion of alternatives presented in this Draft EIS. This project appears to be have been developed with the realization that it is among the more feasible methods available to supply water to the Kohala Region of Hawai'i. We find it encouraging that one alternative, the Water Resource Development and Across Island Transmission project, received detailed consideration through the preparation of a 1992 Draft EIS. The Department of Water Supply should be commended for such detailed analysis. However, other alternatives to the proposed project which received no attention in the Draft EIS should be considered for the Final EIS.

First, there is neglible discussion in the Draft EIS of existing and prior water systems, both of which are major water supply factors in the Kohala area. Since North Kohala plantations required ample water supplies for their cane, adequate supplies were developed privately throughout the late nineteenth and early twentieth centuries. Although these systems are no longer in good repair, the water of the ditch systems exists and can be used for irrigation if needed and for domestic use with normal treatment. The alternative of transporting this water to the service area as the proposed pipeline would do should be analysed. In addition, it is known that high volumes of groundwater are discharged at various locations along the West Hawaii coastline. Feasibility of access to this resource should be discussed.

A much more serious flaw in the Draft EIS as it relates to alternatives is the absence of any mention or discussion of the OTEC alternative for power production and/or potable water supply for the island of Hawai'i. We find this to be a particularly glaring omission, given the extensive research and testing already performed at the Keahole site. The *OTEC for Oahu* study commissioned in 1980 by the Department of Planning and Economic Development expounds at length on the potential benefits of OTEC use, and some discussion of this option should be included in the Final EIS.

Secondary and Cumulative Impacts

Our final area of concern regards the secondary and cumulative impacts attendant on the proposed project. In general, we concur with assertions in the Draft EIS which suggest that development will occur in the project area regardless of whether or not the project is completed. Similarly, it seems true that water shortages in the area will be solved one way or another, and that perhaps a coordinated and high-quality project such this one would be significantly better than haphazard provision of water to the area. Furthermore, we appreciate the sustained discussion in the Draft EIS of the relationship between the proposed project and future development in the area, and we recognize that it is beyond the scope of either the Department of Water Supply or the EIS process to completely resolve all these issues in their entirety. Still, these issues are of increasing importance, especially on the Big Island, and thus warrant careful consideration.

We are troubled by the absence of any discussion of water rights in the area. Clearly, this is an important issue, especially as it concerns Native Hawaiians and the Department of Hawaiian Homelands. This project engenders the possibility that a small number of users could end up controlling a vast proportion of the available water in the area. This possibility in turn raises the question of water rights and the extent to which disproportionate allocation of resources is both legal and fair to all potential users in the area. Given the importance of this issue, the absence of a discussion on this subject in the Draft EIS is unacceptable and needs to be remedied in the Final EIS.

Similarly, the larger issue of the extent to which this project will promote future development remains important. Based on information provided in the Draft EIS, it is clear that no consensus exists on the issue of resort development in Kohala, and we suggest that the trade-off between the No-Action alternative and the proposed action forms the crux of this debate. We are concerned that the degree to which the project constitutes a commitment to future development is not fully acknowledged in the Draft EIS. The possible reality of this commitment seems especially large, given that additional resort growth in the area would be easiest way to recover the initial high costs of building the project. Yet we wonder whether the implied resort market which this project could eventually help serve really exists. It appears as though an honest appraisal of the economic viability of existing as well as proposed resort development is lacking from this Draft EIS.

By raising this question, it is not our intent to suggest that economic development is either unnecessary or inevitable. Still, it seems possible that the removal of water from windward-side locales could pose an analogous future dilemma to that now playing out on Oahu as windward subsistence farmers seek to regain water rights competitively against leeward urbanization. Given this possibility, it is critically important to assess both the economic viability of the Kohala resort market as well as future scenarios for the regions from which the water for the proposed project is being withdrawn.

Thank you for the opportunity to review this document.

Sincerely,

John T. Harrison
Environmental Coordinator

cc: Department of Water Supply, Hawaii County ✓
Megumi Kon
Roger Fujioka
Dave Penn
Paul Ekern
George Curtis
Tom Hawley

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October 23, 1995

Mr. John T. Harrison, Environmental Coordinator
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DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for commenting on the draft EIS for the subject project. The following responses are in order of the comments in your facsimile letter of August 22, 1995.

1. Probable occupancy and feasible alternate water supply for State of Hawaii Department of Hawaiian Home Lands (DHHL) Kawaihae project.

   We see no reliable way to predict the actual occupancy rate for the Kawaihae project. A number indeterminate factors are involved: DHHL funding, alternative housing and farming opportunities, availability of irrigation water, general state of the economy, employment opportunities in West Hawaii and others. At this point in time, it is possible only to identify (but not quantify) the relationship among these variables as pointed out by the reviewers. Because of the unreliability of occupancy predictions, we normally make available the full amount of water supply requested when the development's distribution system is accepted by the Water Department.

   Alternate water sources for the DHHL Kawaihae project were not discussed in detail since the selection of water sources for the project lies with DHHL and the Water Department has no control. However, we have reviewed the final EIS for the Kawaihae Ten-Year Master Plan. The final EIS lists the securing of necessary potable water source for project implementation as an unresolved issue. The possible sources planned for the development were drilling on-site wells, desalinizing brackish water, and importing water from wells located in North Kohala. It summarized by saying "because of the limited amount water anticipated from the wells and desalinization plant, the future expansion and development of the project will depend greatly on all sources of water."

   The on-site wells were anticipated to provide about 3 mgd. The EIS reported that an exploratory well drilled in early 1990 yielded brackish water. Another exploratory well located at 1,600-foot elevation close to the adjacent Kohala Ranch subdivision was drilled by DLNR in 1991. Test results indicated the well could produce potable water at a constant rate of 130 gpm or about 0.19 mgd. The pumped water had salinity of 170 ppm and temperature of 84.2W°F.

   On desalinizing of brackish water, the EIS reported that the initial construction cost and annual operating costs of a desalinization plant will be high. It also raised concern about the effect on the water table, disposal

... Water brings progress...

   of waste products, and the effect on ocean salinity and marine life. The EIS also reported that although some private enterprises expressed interest in constructing and operating a desalinization plant, none have submitted a detailed proposal. (Kawaihae Cogeneration Partners has since obtained a lease to DHHL property in Kawaihae for a cogeneration plant to produce power and desalinized water. However, the lease award is currently in litigation. Information on the amount and terms under which desalinized water would supplied is not publicly available at this time.)

   DHHL has shown continued interest in the proposed Kohala Water Transmission System because of the difficulty in finding other water sources with the capacity and quality to meet its development needs. No commitment decision from DHHL is expected until the project's financial plan is completed and cost of participation is available. Current economic conditions in Hawaii have prevented private sector water users from making any commitment now to any course of action. Thus, the financial plan may need to await stronger economic time for completion and approval by the County Council.

2. Electrical generation capacity.

   We concur with your reviewer's observation that the island of Hawaii is currently experiencing a shortage of electrical generation capacity. It is also conceivable that if this shortage is extended into the future, planned development may be limited. Historically, however, capacity has increased to meet demand. Despite the uncertainties surrounding specific energy related projects, several potential sources for increased generation capacity are proposed: expansion of the HELCO Keahole facility, the Kawaihae Cogeneration Partners facility in Kawaihae, and the Enserch facility in Haina to name the most prominent. A discussion of this issue will be added to the final EIS.

3. Climatological information.

   We appreciate your reviewer informing us of the climatological studies for Northwest Hawaii that are available in the UH Meteorology Department. We will include in the final EIS data from the Northwest Hawaii study that may be pertinent to the project.

4. Aquifer monitoring.

   Your reviewer's comment that "in Section 7-1 it is stated that the Department of Water Supply will monitor the aquifer and if depleted, mitigation measures will be taken" is not correct. There is no mention of depletion. Unlike a mining operation wherein the resource could be eventually depleted, basal water withdrawal from the aquifer is more like a harvesting operation because of the constant recharge of the aquifer. However, development of the basal water must be done with care to avoid any degradation of the aquifer. Early detection is critically important to allow time for action to prevent degradation from happening. Thus, rather than drawing up mitigation measures for a list of potential problems that may or may not occur, we believe it is more productive to pursue an active and consistent monitoring program.

The spacing, depth, and pumping rates of the wells have been carefully selected for optimum performance. Computer modeling tests by US Geological Survey (USGS) have shown their acceptability. Although no significant adverse effects are likely to occur, only actual pumping can verify predicted performance.

The USGS study of the Hawi aquifer (Appendix B, draft EIS) concluded that withdrawal of 20 mgd of basal water is feasible. Phase I of the project is limited to pumping 10 mgd or 50 percent of the feasible withdrawal amount. This provides a large margin of safety. As explained on page 9-4, draft EIS, the Water Department foresees pumpage starting at 5 to 6 mgd and building up to 10 mgd in 10 to 15 years, depending on how projected demands develop. This gradual build-up of pumpage will allow the Department time to evaluate the impact of the Phase I wells in detail over several years.

4. Alternatives.

Kohala Ditch Water. Your comment on existing and prior water systems seems to refer to the Kohala Ditch which has been and continues to be the primary system for irrigation water in North Kohala. According to the attached diagram the Kohala Ditch system had an average flow of 27 mgd during the plantation era (only about 13 mgd of the 18 mgd flow from East Honokane Nui is estimated to enter the ditch system). However, since the abandonment of the Awini Division streams the average flow is about 10-15 mgd. Although the Awini Division is a valuable water source its extremely remote location and resulting high cost of maintenance have led to its abandonment. The Water Department did not consider the Kohala Ditch as an alternative for several reasons.

First, the future of agricultural activities and associated need for irrigation water in North Kohala have not been established. Chalon Hawaii, owner of the former Kohala sugar plantation lands, intends for much of the land to remain in agricultural use. The State has been considering an agricultural park in North Kohala. About 4 mgd of irrigation water would be needed for the park. The availability of lower cost irrigation water from the Kohala Ditch would be an important factor in encouraging and maintaining agricultural activities in North Kohala. Currently, the Kohala Ditch supplies water to a few agricultural users and a hydroelectric power plant.

Second, the Kohala Ditch today has an average flow of about 10-15 mgd. If the ditch water is to be used as source for both irrigation water for North Kohala and potable water for South Kohala, it would be necessary to increase the flow volume. The return of the Awini Division into service must be considered. A water resources management and development study for the Kohala Ditch-Phase III (Akinaka, Bowles, Mink, 1975) reported that any construction in the Awini Section of the ditch would be relatively costly compared to urban and rural construction. The prices would reflect the high risk factors found in the ditch site due to safety, weather, and logistics. They reiterated that 17 lives were lost in the construction and maintenance of the ditch. The report estimated construction cost, at that time, for similar ditch tunnels ranging from $300 to $500 per lineal foot. This was not meant to say that construction of improvements were not feasible. Construction, today, for comparable work would be considerably higher given today's material and labor costs, safety and insurance requirements, and environmental regulations. For the same reasons, system maintenance would also be very high. There may be questions on water ownership and water rights. The Kohala Ditch system has received little, if any, maintenance since the closing of the plantation in early 70's. Consequently, much of the system may require major reconstruction or new construction.

Third, to provide for supply reliability during periods of dry weather a large storage capacity must be provided. The Akinaka, Bowles, Mink study mentioned above, did an analysis of the storage required to provide for a gross irrigation water demand of 26.4 mgd. The water demand model (Alexander) used for the analysis indicated that the optimum storage capacity lies between 1000 and 3000 million gallons. These are huge storage requirements. For example, the Wahiawa Reservoir on Oahu has a capacity of about 2900 mg. The three reservoirs that store raw water for the Waimea-Puukapu system on Hawaii have total capacity of 150 mg. Alternatives to supplement surface storage would need to be evaluated.

Fourth, a large water treatment plant would be required to treat the raw ditch water for potable uses. The EPA federal safe drinking water regulations are very stringent and water treatment would be expensive and add to system operations cost.

Water Discharging Into Ocean. The groundwater discharges into the coastal waters of Kona on Hawaii were described in an interesting article titled "Fresh Water From The Sea?" (Wilkins and Curtis, 1990.) The discharges were discovered from a series of infrared photographs of the ocean surface in the Kona coast. Although they may be potential sources of potable water, the authors concluded that more investigation is needed in three areas: further mapping is required to discover important flows; several lava tubes discharging water should be instrumented and monitored for water quality and rate and variation of flow; and techniques to intercept the water must be developed, tested, and evaluated. In addition, questions of water ownership and rights must be settled. No further investigative work has been done on this possibility.

OTEC. We agree with your reviewer's comment that extensive research and testing have been carried out at the Keahole site on OTEC. However, we have no information that shows the OTEC process is ready for practical application toward production of potable water supply at competitive cost with groundwater withdrawal.

5. Water rights in the area.

We agree with your reviewers that water rights in the area are an important issue. On the other hand, clear guidelines have yet to emerge on related items such as priority of uses, Hawaiian water rights, out-of-watershed transfers, conservation, and so forth. We believe the draft EIS has been attentive to water rights-related items, although they may not have been labeled as such. The following are some examples. On your concern about disproportionate allocation of resources: the allocations were based on water needs, using as a guide the county General Plan and where available, landowners' development plans. Although the numbers themselves (20 mgd to South Kohala and 4 mgd for northern part of North Kohala appear disproportionate) they reflect estimated foreseeable needs. In addition, irrigation water from the Kohala Ditch would be available to those who desire to pursue diversified agricultural activities in North Kohala. More information on the water need estimate for northern North Kohala may be helpful. We will add a discussion on the subject in the final EIS.

Regarding allocation of water for Hawaiian homestead developments, the proposed project has included in its estimate of South Kohala water user needs 3.1 mgd in Phase I for the Kawaihae Ten-Year Plan. Although planning for the remainder of the Master Plan area is very general, 4.0 mgd is included in Phase II for the long-term needs of Kawaihae. The allocation to DHHL amounts to 35 percent of the water being transported to South Kohala, the largest share of all potential water users.

On gathering rights, there was great concern about the effect of basal groundwater pumping on the limu and opihi populations along the shore makai of the project well sites in North Kohala. There was concern, also, about the effect on nearshore coral communities in South Kohala coast. Studies were specifically conducted to evaluate these concerns. The studies revealed that there appears to be no potential for negative impacts to marine ecosystems in either North or South Kohala from the diversion of groundwater.

6. Degree to which project represents commitment to future development.

The reviewer cites (indirectly) a significance criterion from the DOH Administrative Rules for Chapter 343, HRS, [§11-200-12(b)(8)]. We agree that the project's impacts are significant according to this criterion, among others. For this reason, the major share of the discussion on impacts is taken up in Section 9.2 of the draft EIS, which deals with secondary impacts, i.e., those impacts that would result from actions not directly related but partially dependent upon the project. We believe that the draft EIS pays more than adequate attention to such impacts.

Regarding the issue of resort development in Kohala, the County General Plan is the critical planning tool that lays out the land use allocation pattern for the island. The Department of Water Supply is generally guided by the concept of "water follows land use" in its system expansion. Therefore, the appropriate forum for discussion on regional land use is at the County Planning Commission and County Council levels during their deliberations on amendments to planning documents such as the General Plan and Community Plan.

It has been a major assumption of the EIS that without a committed market for water --i.e., users obligated in some way to pay facility charges that cover the costs of the system--the proposed project would not be constructed. If this assumption is true, then the actual existence of the resort market must be verified prior to or during the County Council deliberations to authorize and set up funding for the project. We agree that absent such a safeguard, it would be imprudent to construct the project.

Consequently, we are committed to preparing a financial plan for proposed project. The plan would need to be accepted by the major water users and approved by the County Council. It would provide the basis for the County to authorize and set up funding for the project.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

University of Hawaii at Manoa

Water Resources Research Center
Holmes Hall 283 • 2540 Dole Street
Honolulu, Hawaii 96822

9 August 1995

Governor, State of Hawaii
c/o OEQC
220 South King Street, #400
Honolulu, Hawaii 96813

Dear Governor:

Thank you for allowing WRRC to review your document entitled "Kohala Water Transmission System." WRRC staff have reviewed this document and our relevant comments are included below:

1. Please offer a simple map in the summary section clearly showing the Phase I and Phase II project sites. If possible, please indicate what Fig. in the text should be used to find them (e.g., Fig. 2.2-3 page 2-5).

2. Your reported total cost is $80,030,000 in page 3-9. Your reported earning is $66.5 million + 8.1 million excise tax during construction (page 1-2).

After construction earnings are not clearly reported. How can you arrive at Benefit Cost Ratio ≥ 4?

Sincerely,

Roger S. Fujioka, Ph.D.
Director, WRRC

RSF:jm
cc: Dept. of Water Supply
Megumi Kon Inc. ✓
H. Gee
Y. Fok

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October 17, 1995

Roger S. Fujioka, Ph.D., Director
Water Resources Research Center
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DRAFT ENVIRONMENTAL IMPACT STATEMENT (DEIS)
KOHALA WATER TRANSMISSION SYSTEM

Thank you for commenting on the DEIS for the subject project. The following responses are in order of the comments in your letter of August 9, 1995.

1. In view of the large expanse of the project area, several maps were included in the draft EIS. The general arrangement of the system's components is shown in Figure 3.3-1, page 3-4. A more detailed map of the well and collection system components may be found on page 3-6. Detailed maps of the well and reservoir sites may be found on pages 3-19 to 3-29.

2. The estimated total construction cost for Phases I and II is $80,030,000. The total income (direct and indirect/induced) generated from project construction activities for both phases is estimated to be $66.6 million. In addition, excise tax revenue of $8.1 million is expected. The details are shown in Table 3.4, page 48 of Appendix A.

The benefit cost ratios are computed based on a number of assumptions. Some assumptions are resort build-out rates, occupancy rates, visitor populations, net increase of resident populations, expected tax revenues from different sources, and expected state and county expenditures to provide an increase in public goods. The benefit/cost ratio of 4:1 is an average of the ratios during the projected twenty-year period of resort build-out. The details on the ratios are discussed on pages 59 to 69 of Appendix A.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

... Water brings progress...

JOHN RAY
Councilman

COUNTY COUNCIL
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August 22, 1995

The Honorable Ben Cayetano, Governor
State of Hawaii
c/o Office of Environmental Quality Control
220 South King Street #400
Honolulu, Hawaii 96813

RE: DRAFT EIS FOR KOHALA WATER TRANSMISSION SYSTEM PROJECT NORTH AND SOUTH KOHALA DISTRICTS ISLAND OF HAWAII

Dear Sir:

Thank you for the opportunity to comment on the draft EIS for the Kohala Water Transmission project. A number of areas appear to be under-evaluated in the present draft EIS. The following is a summation of my observations:

1) Financing of the Project:
Since the stated funding source is County general obligation bonds it seems appropriate that more detailed information be supplied as to the proposed users. Also, this amount of bond funding should be put into the perspective of the overall County long term debt and debt service. It should consider the other current and potential uses for capital improvement dollars throughout the island with a comparative cost/benefit analysis. Will this 60-80 million dollar expenditure deliver the maximum economic and social return?

2) Demand for the Project:
The demand for the water that would be supplied by this project needs to be addressed in more detail. The present resort comlexes seem to have adequate water and future large scale resort development is not proposed at this time. In light of the recent setbacks in tourism, more conservative estimates for future resort growth in Hawaii, and the tremendous competition world wide, how realistic are your growth scenarios? I also think it would be extremely imprudent to depend on DHHL plans for Kawaihae.

3) Alternative Water Sources:
I believe alternative water sources have a much greater potential than represented. The high level Waimea water is substantial and if developed incrementally may prove more cost effective, over time, to deliver to South Kohala. Additionally, coastal water from the Kohala Ranch to Mahukona may have the potential to service the North Kohala coastline, which according to your representation in public information meetings, may be a user area for this transmission line.

4) Energy Needs of the Project:
The energy source in North Kohala needs to be more thoroughly covered. There are no HELCO power plants in North Kohala and no 69kv line. In fact, the single route delivery over the Kohala mountain road leaves much to be desired. If the scenario is to use diesel powered generators indefinitely, what are the specifics regarding long-term fuel storage, fuel delivery, air quality, noise, etc?

Again, thank you very much for the opportunity to provide feedback. I hope my comments are helpful.

Sincerely,

John Ray, Councilman
County of Hawaii

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November 1, 1995

The Honorable John Ray, Councilman
County of Hawaii
25 Aupuni Street
Hilo, HI 96720

DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for commenting on the DEIS for the Kohala Water Transmission project. We realize this is a major project which will have a significant impact on the District you represent. Following is our response to your numbered paragraphs.

1. Financing of the Project:

Detailed information as to the estimated time and specific use of the project's water is included in Appendix F of the DEIS. We should add that the projected water needs of the individual landowners were provided by the owners after they were informed that they would carry their pro-rata share of the project cost. While no specific method of payment was proposed at the time, the net effect of these discussions was a scaling down of previous estimated needs to those shown in the DEIS.

We do not believe it is within the purview of the Department of Water Supply to assess the proposed project against other diverse capital improvement projects such as wastewater treatment, recreational facilities, etc. Those comparisons and decisions are more appropriately carried out by the County's elected officials.

2. Demand for the Project:

While it is true that the present resort complexes seem to have adequate water, and future large scale resort development is not proposed at this time, it is also true that the market influences which drive tourism have a cyclical history. This lack of apparent immediacy is referred to in Section 2.2 of the DEIS:

2.2 NEED FOR THE PROJECT

The Hawaii County Water Use and Development Plan, a component of the State Water Plan, points out that proposed development plans in the South Kohala coastal area would require more water than is available in the area's ground water aquifers. This imbalance between need and supply is not expected to occur immediately.

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However, because of the large volume of anticipated water needs and long lead time necessary to construct a major water system, the proposed project is being considered now to assure that water will be available when needed. The Hawaii County Department of Water Supply (DWS) will construct and operate the proposed water system.

South Kohala is the only district in the island where the estimated future water needs are higher than the estimated capacity of the water supply available from sources within the district.

While DHHL estimates they will utilize 7 MGD (1/3 of the 20 MGD project capacity), the first phase of the project, at 10 MGD, would support itself without DHHL.

3. Alternative Water Sources:

The DEIS considered high level ground water in upland Waimea (see page 4-4, 4-5, DEIS) and concluded that, even assuming a sufficient resource (which has not yet been established), the capital cost would be substantially the same as the proposed project. There would be, however, a major operational cost difference favoring the Kohala project based.

Development of either the Kohala project or a similar project in upland Waimea would require construction of the full-sized pipeline as well as pressure reducing reservoirs within the first phase. The potential for incremental development for the balance of the project would have the same advantages and constraints for either location.

With regard to the North Kohala coastline, there are no current prospective users between Kohala Ranch and Mahukona, and the County General Plan does not provide for any large scale developments in that area. DWS responses to questions about availability of water from the project in that area have been generic in nature, i.e., if the County should approve development in any area serviceable by DWS, water will be made available.

4. Energy needs of the project:

Though HELCO has plans to upgrade their service to Hawi, it does not appear that this will happen prior to the planned construction of the subject project.

A noise level study was carried out by Y. Ebisu & Associates and is included in Appendix E of the DEIS. A summary of the study is contained on page 9-4 of the DEIS.

Noise. The proposed well pumps are of submersible type and pump noise would not be audible. The portable diesel-fueled power generator stationed at each well site to power the deep well pumps would be enclosed in a quiet suite with estimated noise levels of 72 dBA at 50 feet distance. The predicted noise level of the generators at the nearest existing residence (between 1,200 to 1,400 feet from well site) range from 32 to 46 dBA. Under worst case conditions, generator noise levels may exceed the State DOH nighttime limit of 45 dBA for residences on Oahu, and will probably be audible above the lower nighttime background ambient noise levels of 37 to 45 dBA. See Appendix E for noise study report.

The engineering design for the generators will include noise mitigation measures suggested in the Ibesu report.

An air quality study was carried out by B.D. Neal & Associates and is included in Appendix E of the DEIS. A summary of the study is contained on page 9-4 of the DEIS.

Air Quality. The proposed diesel generator units at the well sites are considered relatively small sources of air pollution. Atmospheric dispersion modeling results indicate that nitrogen oxides emissions from an individual generator unit could potentially exceed ambient air quality standards if a discharge plenum or rooftop stack is used. On the other hand, the dispersion modeling results show that maximum impacts would be well within ambient air quality standards if the generator stack height conforms with good engineering practice. Odorous compounds will likely be present in the generator exhaust gases at low concentrations, but these should not be detectable at or beyond the well site boundaries. See Appendix E for air quality study report.

The engineering design for the generator stack height will conform to good engineering practice as outlined in the Neal study.

Fuel Storage. The diesel-fueled generator sets at sites C, D, and E are temporary installations. The fuel storage tank systems would be located above ground. Each tank will be constructed of a UL listed rectangular steel tank enclosed in secondary containment membrane and encased in six inches of reinforced concrete. The fuel storage system design will be based on above ground tanks manufactured by ConVault, or an approved equal. ConVault fuel storage tanks are installed at many locations on the Big Island, as well as statewide and nationwide. The following precautionary measures will be taken to assure the stored fuel will not leak and contaminate any water resources:

1. The tanks are designed to withstand vehicle incursions and tipping during earthquakes and other natural disasters and have earthquake restraint hardware.

2. The unit will comply with the 1991 Uniform Fire Code Appendix II-F for above ground storage dispensing of motor fuels.

3. A leak detection access tube will be located between the inner tank and secondary barrier. In case of a leak, a positive space shall be available to allow leaked fluid to flow to the detection tube.

4. The tank system will include a minimum 5-15 gallon, powder-coated external or internal U.L. Listed overfill/spill containment surrounding the fill pipes. The overfill/spill container will include a normally-closed valve to release spilled fuel into the main tank.

5. Overfill protection will be provided by two or more of the following methods: a) direct reading level gauge at tank visible from fill pipe access; b) valve located within fill pipe to close automatically at a specified fill level; c) audible high level alarm activated by a float switch at a specified fill level.

6. Vaults will have concrete support legs of unitized monolithic construction to provide visual inspection capability.

7. The connecting line between the storage tank and diesel generator sets will also be above ground on support legs to provide visual inspection capability. It will be of steel tubing encased in reinforced concrete jacket.

We hope the above explanation is helpful.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

Stephen K. Yamashiro
Mayor

County of Hawaii
PLANNING DEPARTMENT
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Virginia Goldstein
Director

Norman Olesen
Deputy Director

August 25, 1995

Mr. Quirino Antonio, Jr.
Assistant Manager
Department of Water Supply
25 Aupuni Street
Hilo, HI 96720

Dear Mr. Antonio:

Draft Environmental Impact Statement (DEIS) for the Proposed Kohala Water Transmission System
Tax Map Keys: 5-2-05:1; 5-2-06:3; 5-3-03:1; 5-3-04:1; 5-4-03:2 & 3; 5-5-02:23; 5-6-01:51; 5-9-03:4; 6-1-01:3; 6-2-01:63; 6-8-01:6

We have completed our review of the above-described Draft Environmental Impact Statement and have just a brief comment to offer.

Under Section 6-Relationship to Land Use Plans, Policies and Controls, the DEIS fails to define the relationship of the proposed transmission system project to County Zoning. The majority of lands affected by proposed project are designated Agricultural-20 acres (A-20a) by the County. The DEIS needs to recognize the various zoned districts, the proposed transmission system will traverse as well as provisions within Chapter 25, Hawaii County Code (Zoning Code) relevant to the proposed use. For your information, the following sections of Chapter 25, Hawaii County Code are relevant to the proposed project:

"Section 25-51. Power lines; utilities substations; public buildings.

"(a) Communication, transmission, and power lines of public and private utilities and governmental agencies are permitted uses within any district.

"(b) Substations used by public utilities for the purpose of furnishing telephone, gas, electricity, or water shall be permitted uses where the [Planning] director finds that the same are not hazardous, dangerous, or a nuisance to surrounding areas and has granted plan approval therefor."

Thank you for allowing our office the opportunity to comment on the DEIS. We apologize for our delay in responding to your submittal. Please feel free to contact Daryn Arai of this office should you have any questions.

Sincerely,

VIRGINIA GOLDSTEIN
Planning Director

DSA:mjs
LDWSC001.DSA

xc: Mayor Stephen K. Yamashiro
OEQC
Megumi Kon, Inc.
West Hawaii Office

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
25 AUPUNI STREET • HILO, HAWAII 96720
TELEPHONE (808) 969-1421 • FAX (808) 969-6996

October 20, 1995

Ms. Virginia Goldstein, Director
Hawaii County Planning Department
25 Aupuni Street
Hilo, HI 96720-4252

**DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM**

Thank you for commenting on the draft EIS for the subject project. The following is in response to your letter of August 25, 1995.

We will amend the final EIS to contain a description of the relationship of the proposed project to Hawaii County Zoning Code's definition of permitted uses.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

... Water brings progress...

Stephen K. Yamashiro
Mayor

County of Hawaii
POLICE DEPARTMENT
349 Kapiolani Street Hilo, Hawaii 96720-3998
(808) 961-2244 Fax (808) 961-2389

Wayne G. Carvalho
Police Chief

James S. Correa
Deputy Police Chief

August 17, 1995

Mr. Gary Gill, Director
State of Hawaii
Office of Environmental Quality Control
220 South King Street, 4th Floor
Honolulu, Hawaii 96813

Dear Mr. Gill:

SUBJECT: DRAFT ENVIRONMENTAL IMPACT STATEMENT
PROJECT TITLE: KOHALA WATER TRANSMISSION SYSTEM PROJECT
LOCATION: NORTH AND SOUTH KOHALA, HAWAII
TAX MAP KEY: 5-2-05:1, 5-2-06:3, 5-3-03:1, 5-3-04:1, 5-4-03:2, 5-4-03:3, 5-5-02:23, 5-6-01:51, 5-9-03:4, 6-1-01:3, 6-2-01:63, 6-8-01:6

The above Draft Environmental Impact Statement has been reviewed and this project, if completed, will have a major affect on the North and South Kohala Districts and the ability to provide adequate police services. This project will substantially increase commercial businesses and residential subdivisions in both districts.

The requirements of infrastructure (i.e. police and fire services) would need to be addressed.

Sincerely,

Wayne G. Carvalho
WAYNE G. CARVALHO
POLICE CHIEF

DW:if

cc: Department of Water Supply
Megumi Kon, Inc., Consultant ✓
North Kohala Police
South Kohala Police

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
25 AUPUNI STREET • HILO, HAWAII 96720
TELEPHONE (808) 969-1421 • FAX (808) 969-6996

October 20, 1995

Mr. Wayne G. Carvalho, Police Chief
Hawaii County Police Department
349 Kapiolani Street
Hilo, HI 96720-3998

DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for commenting on the draft EIS for the subject project. The following is in response to your letter of August 17, 1995.

We agree that the proposed project will have major effects on the need for police and fire services. This point was discussed in Section 9.2.2 of the draft EIS and in Section 3.3.3 of the Socio-Economic Impact Assessment (Appendix A of draft EIS).

The extent, location, and timing of necessary upgrades in police and fire services can only be decided as actual development-which is dependent upon a number of factors-begins to occur.

The draft EIS did contain a recommendation regarding the potential location of new services. The State of Hawaii Department of Hawaiian Home Lands (DHHL) Kawaihae Master Plan includes a "Town Center" with provisions for a police and fire station. Kawaihae may be well situated to provide the hub for public safety services.

Milton O. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

... Water brings progress...

THE QUEEN EMMA FOUNDATION

615 Piikoi Street, Suite 701 • Honolulu, Hawaii 96814 • Phone (808) 594-4700 • FAX (808) 594-4705

August 15, 1995

Governor, State of Hawaii
c/o Office of Environmental
  Quality Control
220 South King Street #400
Honolulu, Hawaii 96813

Gentlemen:

Re: Kohala Water Transmission System

As a Participant in receipt of the Draft Environmental Impact Statement (DEIS) for the above referenced project, The Queen Emma Foundation reviewed the DEIS and there are no comments relative to the proposed transmission system at this time.

We would, however, like to comment on Figure 2.2-3 entitled LOCATION OF POTENTIAL WATER USER SUB-AREAS of the DEIS. The map included in Figure 2.2-3 identifies landowners and/or users along the route of the proposed transmission system, including The Queen Emma Foundation. However, the map incorrectly identifies the Foundation's ownership. Attached is a copy of tax map key 6-2-01 which generally outlines the area owned by The Queen Emma Foundation.

We thank you for the opportunity to comment on the DEIS and ask that we be kept appraised of any further developments regarding the DEIS or the project itself.

Should you have any questions, please feel free to contact the undersigned at 594-4724.

Sincerely,

Les Goya
Project Manager

Attachment: Tax Map 6-2-01

cc: Quirino Antonio Jr.
Hawaii County, Dept. of Water Supply

Megumi Kon
Megumi Kon, Inc.

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII

25 AUPUNI STREET • HILO, HAWAII 96720
TELEPHONE (808) 969-1421 • FAX (808) 969-6996

October 18, 1995

Mr. Les Goya, Project Manager
The Queen Emma Foundation
615 Piikoi Street, Suite 701
Honolulu, HI 96814

DRAFT ENVIRONMENTAL IMPACT STATEMENT (DEIS)
KOHALA WATER TRANSMISSION SYSTEM

Thank you for commenting on the DEIS for the subject project. The following is in response to your letter of August 15, 1995.

The potential water user sub-areas shown on Figure 2.2-3 identified only that portion of the Foundation's parcel designated for "urban expansion, resort, and industrial" in the Hawaii County General Plan. This is the area for which 1-mg potable water and 1-mg brackish water was estimated as needs in Appendix F, page F-5.

We will have the map modified to show the boundaries of the Foundation's ownership. However, the water need's estimate will be limited to the area mentioned above.

Milton D. Pavao, P.E.
Manager

HAWI AGRICULTURE & ENERGY CORPORATION
PO Box 1656
Kamuela, Hi 96745

July 25, 1995

Governor Ben Cayetano
State of Hawaii
c/o Office of Environmental Quality Control
220 South King Street
Fourth Floor
Honolulu, Hawaii 96813

SUBJ: DRAFT ENVIRONMENTAL IMPACT STATEMENT - COUNTY DEPARTMENT OF WATER SUPPLY KOHALA WATER TRANSMISSION SYSTEM PROJECT

Gentlemen:

The Hawi Agricultural and Energy Corporation, Inc. has, to date, not been included in any correspondence, discussion, notices or other official contact regarding the proposed pipeline crossing of its leasehold land (TMK 5-5-07:10). We became aware of this proposed crossing by our initiative on the evening of July 19, 1995 at a public meeting held at the Kohala High School by the sponsoring agency, the Department of Water Supply.

The potential for disruption of our present and planned business and agricultural activities may be severe and no mention or contact has been made with our company. Our attendance at this meeting was accidental, and we have had no formal or informal inquiries regarding the impact to our business.

We request that any future action(s) regarding the E.I.S. and the project give full consideration to the impact such actions will have on small businesses, such as ours, and our tenants. We have been placed in a very difficult position financially as a result of this action, yet we have never been consulted by any party regarding such a crossing.

By this letter we request that our company be considered an "aggrieved party" under the requirements and qualifications set forth in Chapter 343 HRS (Rule X sub F)

Sincerely,

Herbert M. Richards
President

SPB:skim
cc: Department of Water
Megumi Kon, Inc.

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
25 AUPUNI STREET • HILO, HAWAII 96720
TELEPHONE (808) 969-1421 • FAX (808) 969 6996

November 1, 1995

Mr. Herbert M. Richards, President
Hawi Agriculture & Energy Corporation
P.O. Box 1656
Kamuela, HI 96745

DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for commenting on the DEIS for the subject project.

Let me extend my apology for the oversight of failing to contact you directly regarding the Kohala Water transmission System. Our contact has been with the landowner, Chalon International.

I understand that the project coordinator, Dennis Haserot, has spoken with you and that a meeting between Hawaii Ag and Energy, Chalon, and Mr. Haserot will be scheduled soon to discuss appropriate mitigation measures to address your concerns.

Thank you again for your comments.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

... Water brings progress...

ABORIGINAL NATIVE HAWAIIAN ASSOCIATION
568 KAHAOPEA STREET
HILO, HAWAII 96720
PHONE: (808) 959-4676

AUGUST 22, 1995

GOVERNOR BEN CAYETANO
STATE OF HAWAII
C/O O.E.Q.C.
220 KING ST., #400
HONOLULU, HI 96813

RE: KOHALA WATER TRANSMISSION SYSTEM TESTIMONY-DUE AUGUST 22, 1995.

Dear Governor Cayetano:

The Aboriginal Native Hawaiian Association is a statewide organization of 50% blood quantum beneficiaries and their families, of the Hawaiian Homes Commission Act, 1920, as amended. The purpose of this organization is for...the betterment of the conditions of the native Hawaiians...pursuant to the Admissions Act, Section 5(f)...self-determination and self-sufficiency...

This organization is credited with acquiring the 25% blood quantum successorship, genealogy lab, etc.

Access to water resources is not limited to Kawaihae, this is a state-wide concern that indicates the serious need for improvement of infrastructure; for Kawaihae, there is very little infrastructure.

The Kawaihae Hawaiian Home Lands is bordered on one side by the Kawaihae Harbor, Puukohola Heiau, and Spencer Park which presently is connected to the County managed Lalamilo waterwells.

HHL is bordered on the north side by Kohala Estates, Kohala By The Sea, and Kohala Ranch subdivisions. These subdivisions have enjoyed the mined waterwell resources for many years from a private Water Company at a cost triple what the County Department of Water Supply charged the general public.

KHHHCA and ANHA approached the Water Department with a concept that included the self-determined, self-sufficient program of connecting to the waterline which presently supplies the Harbor areas. ANHA was quoted an approximate cost of $2.3 million to:

1. Enlarge the pipeline from the present 8" to 12" from the Queen Kaahumanu Highway intersection along Kawaihae-Waimea Highway and Akoni Pule Highway to the HHL boundary (approximately Ka Opae Point,
2. Provide a pumping station,
3. Provide a reservoir on Hawaiian Home Lands
4. Miscellaneous expenses, EIS, etc.

This concept was also shared with the Department of Hawaiian Home Lands.

RECEIVED AUG 2 2 1995

About this time, the discussion of a general lease for a proposed energy plant and desal facilities were being negotiated with the Commission. Without mitigating any issues from the discussion or providing an Environmental Impact Statement, a general lease was approved. This "General Lessee" is now appealing the decision to make the EIS. This company is misleading the public that they will be ready to provide energy by 1996. The Kawaihae Hawaiian Homes Homeowners Community Association lessees (212 awards-except one, plus commercial/industrial lessees-except one) do not want this plant.

A majority of these lessees do not reside on their accelerated awards. The Commission and DHHL to this date, have not mitigated any concerns for health, safety, responsibility, benefits and rights, etc. The lessees do not want HELCO to negotiate with a company with this type of credibility. This general lessee has no responsibility to the public or the beneficiaries, as we have been able to determine so far.

The cost to produce private desal water is indeterminate at this time. The timetable for the water production, the consumers, the transmission plan, environmental impacts, HEALTH AND SAFETY FACTORS are all unknown or not understandable and flexible on Hawaiian Home Lands.

A suggestion of researching the revenues due for ceded land trusts on the Harbor areas at least, could possibly pay for this concept (maybe many times over). A suggestion of actually measuring the water tables in the State of Hawaii would offset the $2M. Our membership has actively attended meetings, participated in community planning, etc. ANHA president (Lillian K. Dela Cruz) is a party in the court case, as is KHHHCA president (Josephine Tanimoto).

As is prevalent throughout the EIS, this project will cost tremendously; the community disagrees who should access the water (even though their complaints for better services and better improvements are a factor in our request for the Hawi transmission line); this project will take a long time.

A very important factor that Kohala and the beneficiaries do share is the protection of the shoreline, especially the fish spawning areas that provide food for our families. This resource has served all communities during the sugar companies going out of business many years ago, the hotels low house counts in the past and present; and we will aggressively try to protect this impact along the way.

Please help us acquire the water access we need in Kawaihae and begin the Kohala Transmission Waterline. Mahalo.

Sincerely,

Lillian K. Dela Cruz
President

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
25 AUPUNI STREET • HILO, HAWAII 96720
TELEPHONE (808) 969-1421 • FAX (808) 969-6996

November 1, 1995

Ms. Lillian K. Dela Cruz, President
Aboriginal Native Hawaiian Association
568 Kahaopea Street
Hilo, HI 96720

DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for commenting on the DEIS for the subject project.

Your letter expressed a concern for "the protection of the shoreline, especially the fish spawning areas that provide food for our families."

As a direct result of similar concerns raised during the early part of the EIS process, the Department of Water Supply contracted the services of Tom Nance Water Resource Engineering, and Marine Research Consultants. The results of the studies conducted by the two firms are contained in Appendix "C" of the DEIS. The Executive Summary contained on page 1 of *Assessment of Impacts to Water Quality and Marine Community Structure From the Proposed Kohala Water Transmission System, Kohala Coast, Island of Hawaii*, states "The studies revealed that there appears to be no potential for negative impacts to marine ecosystems in either North or South Kohala from the diversion of groundwater."

We hope the above explanation is helpful.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

...Water brings progress...

NA ALA HELE
P.O. BOX 6334
KAMUELA, HAWAII 96743

Governor, State of Hawaii
c/o Environmental Quality Commission
220 South King Street #400
Honolulu, HI 96813

August 21, 1995

RE: Draft Environmental Impact Statement
Kohala Water Transmission System

Dear Governor Cayetano:

The nonprofit trails and environmental group E Mau Na Ala Hele has been in existence since 1979 and has approximately 250 members. On its behalf we submit the following comments on the Draft EIS for the 20 million gallon water transmission system proposed by the County of Hawaii Department of Water Supply. In general, the project appears to inevitably commit the North Kohala lee coast to resort and luxury style development, endangering extensive archaeological resources there as well as local-style public access to the shoreline along a network of traditional foot and jeep trails. There are also other concerns.

Regional Context Needs To Be Included

At several places, for example page 4-6, the DEIS conveys that the resort region of the South Kohala district is the major economic engine for the region now and in the future, and that rapid intense development of South Kohala is to be supported. However, the DEIS does not mention nearby zoned development. The adjacent district, North Kona, is zoned for eight more large hotels at the Keauhou, Kukio, Kohanaiki and Kaupulehu Resorts. North Kona is zoned for at least 4,000 more resort residential units at these locations, and another 1,000 shoreline units at Haniniowale have major approvals. In addition the Waikoloa Beach Resort in South Kohala, which is not dependent on this water transmission line, is zoned for another 1,200 hotel rooms and an additional 2,000 or so resort residential units. We ask that the DEIS portray this legally committed future in careful detail in order to set the current project in a cumulative, meaningful context.

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Water Needs Appear To Be Overestimated

A transmission system of this size may be unnecessary during the next ten years, according to the following logic.

The DEIS (page 2-2) indicates nine developments that "need" potable water. Of these, three show no need until 2010. Among them, TriKohala is a speculative development that is not in the state urban district. Also, projected resort development of the Queen Emma makai lands, which surround Spencer County Beach Park, will probably meet stiff public opposition.

Through 2004 the water "need" for remaining projects is cited as 7.1 mgd. However the DEIS states that an unused 2.5 mgd is still available from the existing Lamamilo Pumping System (page 3-1), so the projected shortfall is in fact 4.6 mgd. The DEIS also reveals (page 2-8) that the Waimea aquifer which could provide 3.8 mgd more potable water will probably instead be committed for irrigation water. In this regard the DEIS should explicitly list the thirteen additional golf courses that have been approved for South Kohala, which with existing courses will give the district twenty golf courses. Has the Department of Water Supply made a policy choice to commit Waimea aquifer resources to golf course irrigation while withdrawing potable water for resort development from the Hawi aquifer? If so, this policy choice should be clearly stated. Without it, the water "need" for remaining projects including DHHL drops to .8 mgd through 2004.

E Mau Na Ala Hele supports provision of water to the DHHL project in a timely and appropriate manner. But, based on this analysis, the "No Action" alternative (page 4-6) looks far preferable to the transmission line. This alternative forecasts slower but continuing coastal development with a likely higher cost to resort landowners who may turn to desalinization, golf course irrigation with treated wastewater, and other measures.

Potential Development of Lee North Kohala Underplayed

The major South Kohala developers portrayed as needing the transmission system have evidenced scant interest in it and have not committed to pay for it. With this and the lack of actual need cited, strong pressures to develop the lee North Kohala Coast are foreseeable, both to use the transmission-line water and to recoup financing for the line. The DEIS references (pages 3-3 and 5-23) to potential development there are brief and general, and should be expanded. The list of potential lee North Kohala projects (page A-108) is incomplete. Additional projects were reported in the Northwest Hawaii Community Development Plan of 1992 and can be included. Among them are Kukuipahu Mauka and Makai, 100 lots and golfcourse; Mahukona Resort, 5,200 units and golfcourse; Kahua Shores, 300 single and multifamily units; and (more recent) a 200-unit Gentry resort.

Because of the extensive development that has occurred and is planned for South Kohala and North Kona, the lee North Kohala coast (the Mahukona Coast) has become an important recreational resource for longtime residents. The DEIS should discuss how development of the coast will curtail local-style recreational options including shoreline access by way of foottrails and jeep trails. It needs also to discuss how development will impact the extraordinary, large collection of Hawaiian archaeological sites found on the ahupuaa of Lamaloloa, Kaiholena, Kaupalaoa and Kehena 2 (see Belt Collins, Mahukona Resort EIS, 1981, pages V-35 to 41). We would like to see the private owner of these lands, amounting to 1,000 acres, indicated as a major landowner among others on page 5-20.

If completed, the transmission line may force the determination to develop the Mahukona Coast when both wise planning and resident preferences would keep it largely in open space.

Benefit/Cost Analysis Is Flawed

The DEIS describes two possible future buildout scenarios for secondary growth enabled by the transmission line. They are termed Historical Projection and As-Planned Projection. The DEIS makes clear (page A 76, table 3.27) that all operational labor needed to staff the secondary growth is either inmigrant labor not available in the current labor force of the region, for the Historical Projection; or the net effect of Hawaiian labor introduced into the region from the DHHL project for the As-Planned Projection. The benefit/cost analysis for these two scenarios deserves careful review.

A) In the Historical Projection (page A 76) the number of inmigrant workers needed for slightly over ten years is given as 3,045, resulting in an increase to the resident population of 4,750 including dependents. The DEIS also states (page A 64) that the cost to the state for each new resident is $4,441. But when the DEIS calculates costs to the state for new residents, it seems to overlook these inmigrant workers and their children. Thus the DEIS states, "For the computation of annual state expenditure, the following specific assumption are made: 1) DHHL units are all occupied by state residents, 2) the resort residential units have a 50 percent occupancy rate, and 3) the remaining resort-residential units are divided into one half occupied by visitor and the other half by permanent resident in-migrated from out of state." (pages A 60-62)

For the Historical Projection, if hypothetically only half the in-migrant workers and dependents come from out of state, the cost to the state in year 2010 will be approximately $10 million (4,750 x 4,441 ÷ 2). There will also be an incremental cost during each of the preceding ten years as the in-migrant population enters the resident population. All these costs need to be included in the DEIS analysis.

In addition, for the Historical Projection, if it is assumed half the inmigrant-workers come from in state, they have presumably been employed elsewhere in the state. Therefore, for them, the income and excise taxes which the DEIS has apparently counted as revenue derived from the project's secondary growth, must be deducted. Alternatively state expenditures on these residents could be included. Otherwise, the benefit/cost analysis is basically double-dipping. These changes should show the benefit/cost ratio is far less favorable than claimed.

B) Turning to the As-Planned Projection (see table 3.27, page 76), since by the year 2010 an increase of (potentially all-Hawaiian) workers is projected as 1,738 and all are assumed by the DEIS to come from in state, all their income and excise taxes which the DEIS may have entered as revenue to the state, should be deducted because they have presumably previously earned a livelihood elsewhere in the state. This adjustment will substantially alter the benefit/cost ratio for the As-Planned Projection.

C) As background for these considerations, note that Belt Collins' EIS for the South Kohala Resort (1987; page V-40) forecast that 70 percent or more of workers for West Hawaii resort-related development during the 1990s would be derived from inmigrant labor. Also, the state commissioned "A Benefit/Cost Analysis of Hawaii's Visitor Industry" from Mathematica, Princeton in 1970. It emphasized (page 3): "Increasingly, it appears that the labor needs of the growing influx of visitors will have to be met by immigrants. These immigrants themselves will require substantial public outlays for the education of their children, etc. Our calculations show that the benefit-cost ratio for a visitor falls sharply as the proportion of immigrants in the labor force needed to serve additional visitors grows."

Schools, Police Protection Are Shortchanged

A) The DEIS needs to convey with more care existing conditions at area schools and parks. Unfortunately, Hawaii's youth may experience among the most negative effects of the growth enabled by the pipeline. The DEIS does reveal that regional school enrollment has increased 44 percent during the last five year period (page A-38). It also states (page A 89) that as a result of secondary growth enabled by the transmission line, at least one more high school and several intermediate schools will be necessary. However, it does not provide, for the benefit/cost analysis, CIP estimates for the needed new facilities, and there is no indication that the state can afford to pay for new facilities.

B) The numbers we arrive at to determine costs to the county for the Historical Projection are very different from those shown by the DEIS in table 3.22, page A 67. The cost to the county for each new resident is given as $929 annually. Suppose, hypothetically, all the 4,750 immigrant workers and their dependents expected by 2010 were new to the county. The cost at year 2010 would be $4.413 million annually. But the DEIS reports only $2.926 million, which assumes 3,150 new residents. Yet this is exactly the increased resort residential population forecast for the Historical Projection by year 2010 (page A 63, table 3.16). Once again, it appears the incoming workforce has not been counted, and county financial shortfalls, especially in the area of police protection, can be foreseen. Costs for police protection/ public safety involve over a third of county operating expenses.

Sincerely,

Judith Graham
Treasurer

Keith Wallis
Director

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
25 AUPUNI STREET • HILO, HAWAII 96720
TELEPHONE (808) 969-1421 • FAX (808) 969-6996

November 1, 1995

Ms. Judith Graham, Treasurer
Mr. Keith Wallis, Director
Na Ala Hele
P. O. Box 6384
Kamuela, HI 96743

DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for commenting on the DEIS for the subject project. The following responses are in order of the comments in your letter of August 21, 1995.

Your general comment that the project appears to inevitably commit the North Kohala lee coast to resort and luxury style development is not entirely accurate. Although water availability is a vital factor, many other factors such as market demand, financing climate, and government approvals must be favorable before development can occur. Thus, water availability alone would not necessarily commit the lee coast to the kinds of development that you cite.

It should noted that the proposed pipeline in Akoni Pule Highway along the lee coast is designed basically as a water transmission system (transporting water from the collection reservoirs to the terminal reservoirs). This is not to say that water cannot be drawn from points along the line. However, there would be strict conditions under which water might be drawn. These could include conditions such as the water being requested is to service a properly zoned use, an allocation of water is available, the withdrawal would not affect the integrity of the system, and the water must feed into a storage reservoir before being distributed.

- Regional Context

  The County General Plan is the critical planning tool that lays out the land use allocation pattern for the island. The Department of Water Supply is generally guided by the concept of "water follows land use" in its system expansion. Therefore, the appropriate forum for discussion on regional land use is at the County Planning Commission and County Council levels where amendments to planning documents such as the General Plan and Community Plan are considered and approved.

  The proposed project would not supply water for Kona and it would not in any other way directly affect the district in any significant manner.

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The most important connection between the project and the Kona environment involves the exchange of labor. As discussed in Section 3.3.1.2, surveys of hotel workers indicate that between 3 and 16 percent of workers may reside in Kona. Kohala residents also find jobs in Kona. The exact balance of this exchange in the future will be determined by the relative availability, desirability, and Treasurer accessibility of jobs to each area's residents. Given the socio-economic similarities of the districts and the fact that hotel construction is likely in both districts, it can be expected that the current pattern of more or less equitable exchange will continue into the future.

The final EIS will include an updated and more complete list of known projects for the Kohala/North Kona area, including golf courses.

Just as with any project whose secondary effects may induce population growth, there is the inevitability that some residents of and visitors to Kohala will visit adjacent areas, such as Kona. Indeed, they may and probably will also visit Hamakua and Hilo, possibly Puna and Kau, and potentially, other Hawaiian islands as well. The effects of such visits, especially when viewed in the context of the already significant resident population and work force in Kona, do not merit special attention.

- Water Needs and Sources

  One of the difficulties in estimating water needs is not so much in arriving at the gross need of a development or area but in projecting the time period during which the increments of the gross would be needed. The cyclical nature of the economy adds to the difficulty. The methodology used in estimating the water needs is discussed in Appendix F of the draft EIS.

  On your comments about the capacity of the sources that can be used to meet the 7.4 mgd (not 7.1) water need through 2004 (see Fig. 2.2-1), we differ with you on the expectations of the sources that you pointed out.

  Lalamilo source. This potable water pumping center, made up of four wells, is a good pumping center. However, it has its limits and care should be taken in increasing the number of wells to avoid increasing salinity. Incidentally, in counting the effective output of a well group, the largest pump is normally assumed to be on standby for malfunction or maintenance, thus in Lalamilo the effective output would be 3.9 mgd.

The scenario as seen by the Water Department for the Lalamilo wells is to place the wells on standby after completion of Phase I. The reason for the change to standby is primarily to reduce pumping cost, which is a continually rising operating cost. The average ground elevation of the proposed Phase I wells in Hawi aquifer is about 400 feet compared to an average ground elevation of 1100 feet for the four existing wells at Lalamilo. The difference in ground elevations between the Hawi and Lalamilo wells has a direct affect on pumping costs. Pump maintenance cost would also be less because of shallower well depth. Since the pumped water from the Hawi wells must be raised to the collection tank elevation of 675 feet, the difference in pumping lifts would be about 38 percent less than at Lalamilo. The reduction in annual power cost alone could amount to $50,000.00 for every million gallons per day of water pumped.

Irrigation water. The 3.8 mgd that is referred to in the first paragraph on page 2-8 of draft EIS is the need for non-potable "brackish water" for irrigation uses (see Appendix F, page F-6, non-potable water column, total for Waimea 80301). That amount is not interchangeable with potable (fresh) water. However, it is included in the total groundwater needs for Waimea in Figure 2.2-2

The management of groundwater in the State is the responsibility of the State Commission on Water Resource Management. All permits for drilling a well and installing pump in a well are issued by this Commission. The intent of the discussion on page 2-8 was to disclose the aquifer's water budget situation as the Water Department saw it. No policy choice was made on the issue you mentioned. The reason for the plan to place the Lalamilo wells on standby is explained above.

Need and Timing. As was said earlier, estimating the timing of need is most difficult. It could differ considerably from what is projected. Depending on the recovery of the economy, some of the projections may be delayed. Similarly, the project might not be constructed until the economy is stronger. The construction of the project in two phases allows flexibility in adjusting supply to need.

Drilling additional wells in the Waimea, Anaehoomalu, and Mahukona aquifers to meet the projected total coastal are water needs for the next ten years may be possible, but it would be a short term solution. It would not address the longer term needs beyond the next 10-year period as projected needs come into being and resources become heavily taxed, e.g., see potential imbalance between need and estimated sustainable yield for Waimea aquifer in Figure 2.2-2. The strategy, as seen by the Water Department, to address the longer term need is discussed in the first paragraph of page 2-8.

The provision of water supply for Hawaiian Home Lands projects is important and we agree with you that the effort should be supported. Although we appreciate your comments on the "no action" alternative, we believe the proposed project responds much better to the longer term water needs of the Kohala coastal area, as discussed in Section 4 on alternatives in the draft EIS.

- Potential Development of Lee North Kohala

Other than the projects proposed by Chalon in Mahukona and the projects makai of Kohala Ranch, there are no current prospective water users between Mahukona and Kohala Ranch. The County General Plan designates resort and urban expansion uses in Mahukona. It designates low and medium density uses in the area makai of Kohala Ranch (Kohala Makai and Kahua Shores obtain water from Kohala Ranch).

It is not necessarily true that "strong pressure to develop the lee North Kohala coast is foreseeable, both to use the transmission line water and to recoup financing for the line." Compared to other pre-development costs of a major development, the cost of assuring a water source is not (in this instance) overly large. For example, at $6.00 per gallon capital cost (the estimated cost per gallon for Phase I of the project), and a water need of 1200 gallons per day per unit, the investment per unit would be $7200. While to it prudent for landowners to await signs of a stronger economy before committing to this investment, it would not be prudent to push development beyond the limits of a market just to avoid a relatively small holding cost.

As discussed in the section above on Regional Context, the final EIS will include an updated and more complete list of projects for the Kohala/North Kona area.

- Benefit/Cost Analysis

In general, the fiscal benefit/cost analysis computations are based on a series of economic assumptions and as such, any change in assumptions would obviously change the ratio. In this study, there are two major assumptions relative to secondary developments: 1) the number of hotels and resort housing units that may be built over the next twenty to thirty years time horizon, and; 2) increases in the number of visitors and new residents (in-migration) to the State of Hawaii and to the Island of Hawaii.

With respect to the first assumption, there are two build-out scenarios, namely; the Historical and As-Planned. For each of these two scenarios, benefit/cost computations are made for every five year interval (largely because build-out rates differ over time). Then, these benefit/cost ratios are averaged to arrive at a single ratio. In the Socio-Economic Impact Assessment (SIA) appended to the draft EIS (Exhibit A), the benefit/cost ratios for both scenarios were computed to reflect the impact of resort development with an additional assumption that all jobs created would be met by using locally available labor supply. Thus, the net increase in population was assumed to be from 1) increase in visitors and, 2) increase in residents residing within the residential units.

The SIA consultants have made the following revision. Additional sets of benefit/cost ratio were computed to reflect "cumulative effects" of the resort developments (These changes will be included in Exhibit A of the final EIS). For example, it is assumed that some of the jobs would be taken by in-migrants, who, along with their families, become new residents and thereby increasing the resident population count. It is also assumed that one-half of those occupying the resort units are visitors renting the units and the other one-half are new in-migrants. This assumption would tend to increase visitor population while decreasing resident population. The results of the new computations at two selected points in time are shown below.

Fiscal Benefit / Cost Ratio For The State Government:

	For Year 2010	For Year 2020
Historical Build-out Scenario		
Ratio for Project only	6.7	4.8
Ratio for Cumulative	4.7	2.4
As-Planned Build-out Scenario		
Ratio for Project only	3.4	1.7
Ratio for Cumulative	7.9	3.4

In the Historical Trends scenario the "cumulative" ratio is much smaller than the "project only" ratio, as expected. Also, the ratios decline in the year 2020 as the number of new resort developments approaches maximum. For the "As-Planned" scenario, the cumulative ratio is larger than the "project only" ratio. These unusual results are traceable to the fact that under the "As-Planned" scenario the ratio between visitors and new state residents is higher, leading to lower state expenditures per capita. It is important to note from this exercise that the important determinant of the benefit/cost ratio lies in the division of net increase in population between "visitors" and residents. The larger the proportion of residents relative to visitors, the lower will be the benefit/cost ratios.

Fiscal Benefit/Cost Ratio For The County Government:

	For Year 2010	For Year 2020
Historical Build-out Scenario		
Ratio for Project only	3.2	0.9
Ratio for Cumulative	3.3	2.5
As-Planned Build-out Scenario		
Ratio for Project only	5.9	5.1
Ratio for Cumulative	7.2	7.0

Similar patterns can be observed for the county government benefit/cost ratios. Again (and as expected), the cumulative ratios for both periods are smaller than the "project only" scenario. However, for the "As-Planned" scenario the cumulative ratios are greater.

- Schools and Police Protection

Included in the benefit/cost analysis is the total economic tradeoff. It would be infeasible, unsound and entirely unnecessary to detail specific budget items and legislative appropriations for the next 25 years.

The larger question is what degree of detail is necessary for the description and mitigation of secondary impacts. It would be unwise to devise (and especially to implement) complex, costly and detailed mitigation measures for problems that may not come into being or may assume forms significantly different from those that are now envisioned. The economic and revenue benefits that would result from growth associated with the project are expected to be substantial. The direction of spending for these funds (e.g., towards housing, recreation, transportation, public safety facilities, schools, etc.) should not be constrained by specific measures devised prematurely, before the nature and scope of the actual growth fully unfolds. Instead, it is only sensible that those government agencies responsible for planning facilities and improvements in the region monitor the actual needs of the area closely and consistently.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

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OF COUNSEL

August 15, 1995

CERTIFIED MAIL--Return Receipt Requested

Milton D. Pavao
Manager
County of Hawaii
Department of Water Supply
22 Aupuni Street
Hilo, HI 96720

Re: Draft Environmental Impact Statement for the Proposed Kohala Water Transmission System

Dear Mr. Pavao:

I have been engaged on behalf of the Friends of Puako Reef, an organization dedicated to preserving the quality of the marine environment in Puako and elsewhere in West Hawaii, and the Water Resources Committee of the Puako Community Association, to comment on environmental review to date of the proposed Kohala Water Transmission System. This letter represents the initial response to the DEIS of the Friends of Puako Reef and, at the committee level, the Puako Community Association. While the DEIS is in many ways thorough and balanced, the following remarks will emphasize areas where further assessment appears warranted.

1. Impacts on the Marine Environment.

a) Direct Impacts.

We appreciate the fact that Puakó was included as a study sampling site. We have not had time to submit the Nance study (Appendix C to the DEIS) for technical critique, but have the following initial comments.

The Nance study concedes that along the Puako Reef and elsewhere in the near-shore South Kohala marine environment the project would decrease salinity and increase nutrient discharge. Nevertheless, on the principle that coral ecosystems can withstand even extreme alterations of water chemistry and quality, the study conclusively states there will be no direct marine impacts.

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From the point of view of the Friends of Puako Reef and the Puako Community Association, the coral reefs in Puako and elsewhere in South Kohala are national treasures. A rebuttable presumption should be that coral reef systems are vulnerable to environmental degradation. The Nance study may not go far enough in finally rebutting that presumption and concern.

The Office of State Planning recommended that the DEIS provide for monitoring and mitigation of the project's South Kohala marine impacts: "Since salinity changes can adversely affect sensitive marine ecosystems downstream from the proposed wells, ocean water quality monitoring should be undertaken and mitigation measures employed to assure consistency with the Coastal Zone Management Policy to, 'Promote water quantity and quality planning and management practices which reflect the tolerance of fresh water and marine ecosystems...'"

The DEIS, against the recommendation of the Office of State Planning, provides for no monitoring and no mitigation measures with respect to water quality. It justifies its failure to do so on the ground that there is "no potential for negative impacts to marine ecosystems," according to the Nance study.

While the Nance study has not been technically reviewed, there are reasons on its face for concern about this sweeping conclusion. It appears that water engineers but neither marine biologists nor coral ecologists were significantly involved in the Nancy study. Several of the scientific references relied on for the no-possible-impact conclusion are worrisome (particularly the fourth, fifth, sixth, ninth and tenth, of the nineteen references on pages 23 and 24 of the study). These studies by Dollar and Grigg have often been used in the past to support arguments that coral ecosystems are very hardy and will withstand all variety of environmental change. Other schools of thought are more attuned to the sensitivity of corals to their environment and the subtleties of their responses. It may be that closer evaluation is needed of the effects of greatly-increased ground water discharge not just on the gross biomass but on the biodiversity of the reef.

Given its reliance on Dollar and Grigg, Nance's conclusions of no possible impacts would be more credible if supported by the second opinion of an involved marine biologist or coral ecologist less aligned with the no-impact school. Jorge Cortez, Ph.D. of the University of Costa Rica, Robert Richmond, Ph.D. of the University of Guam, and Peter Ginn, Ph.D. of the University of Miami would be imminently qualified for consultation or critique of the study.

b) Secondary Impacts on the Marine Environment.

The DEIS does not appear to specifically assess secondary impacts on the near-shore marine environment at all. The DEIS is candid in conceding that the thrust of the project will be to promote and service the full resort and housing build-out of South Kohala over the next twenty years. An aspect of such a transformation of South Kohala is likely to be the urbanization of the reef. The project's promotion of developments that will greatly intensify recreational use, and escalate boating pressure, fishing pressure, anchor damage, damage from running aground, conflicting uses, pollution, safety, crowding, and endangered species impacts, needs to be seriously weighed in the cost-benefit balance of the project's secondary impacts.

2. Secondary and Cumulative Socio-Economic Impacts.

a) Cumulative Impacts.

Director Harold Masumoto of the Office of State Planning stated, "The final Environmental Impact Statement should consider the cumulative impacts associated with the change in land use from primarily rural to urban resort and housing development." (Emphasis supplied.)

The Environmental Center of the Water Resources Research Center at the University of Hawaii at Manoa likewise advised as follows:

> A central question to be addressed in the Environmental Impact Statement (EIS) is the cumulative effect of planned resort development potential created by supplying water to North and South Kohala. How will future development, which needs the proposed water system, affect the aesthetic, socio-economic and natural environment? Will the development enhance land prices, causing dislocation of local residents, or will land become more affordable and available? Will historic rights and privileges of Native Hawaiians be adversely affected by a tourist-based community? How will the long-term liability of biotic communities be affected by the potential development? All of these issues need to be addressed for the different alternatives, including the "no action alternative."
>
> Our reviewers also suggest that the EIS should address the feasibility of the implied resort development. What is the actual pent up demand for

> development in the North and South Kohala region? How much of the demand is extraterritorial (i.e., for second homes, resorts and golf courses that cater almost exclusively to non-resident populations), and how much would directly benefit residents of the County of Hawaii? What benefit, in housing, services and economic amenities will any resort option bring? What potential cost will increased population bring with it in terms of police, hospital, fire, social work, educational facilities, public facilities (libraries, parks, etc.)? (Emphasis supplied.)

As you know, assessment of cumulative impacts are required by law under the Hawaii Environmental Quality Commission Law and federal legislation. However, the lengthy socio-economic impact assessment of W. K. Hahn and Associates, on pp. 107-09, explicitly refrains from assessing cumulative impacts.

The Hahn study commented that project-related and non-project-related combined population growth in Kohala could exceed 50,000 over the next twenty years if the project and other currently-planned developments occur. The full cumulative impact on population of both the project and non-project-related increases therefore could apparently reach 75,000 people in Kohala within 20 years (given that, at 7-13, the DEIS assumes project-related population increases of 25-50,000). Clearly, the unassessed potential cumulative impacts of such wholesale urbanization of Kohala could be enormous.

The Hahn report attributed its failure to specifically assess cumulative impacts to the uncertainties of the future. That is all the more reason, however, to proceed with caution and maximum forethought. The genius of environmental impact law is that, properly enforced, it forbids proceeding with significant governmental actions when cumulative and other major impacts are too uncertain to be assessed.

At this point the failure of the DEIS to conduct the analysis called for by the Office of State Planning and the Environmental Center of the Water Resources Research Center, and required under state and federal law, must be regarded as a defect. The Hahn report concludes, "It is too early to know the context of the impacts of the proposed project in terms of cumulative future growth. It will be the duty of State and County government to monitor this context..." The law requires otherwise: analysis in the DEIS to inform the decisionmaking of the governmental entities.

b) Secondary Impacts.

The DEIS is to be commended for setting forth a range of potential adverse impacts, but falls short in what it makes of them: "All adverse secondary impacts are potentially mitigable, and therefore the project could proceed without substantial harm to the physical or social environment." 10.2.2. The discussion of mitigation measures of 11.2 and elsewhere in the DEIS consists largely of the naming of problems rather than strategies to solve them.

The DEIS seems driven by a deference to in some cases out-dated planning policies that impedes the hard analysis required of a complying environmental impact statement. The no-action alternative is dismissed in the Hahn report with the following language: "Government policy clearly supports the development of water system infrastructure as necessary to support existing and planned needs...[F]ailure to support a new source of water would clearly be inconsistent with planning policy."

The purpose of environmental assessment law is to assure that government decision-makers know *before* deciding what they will really be getting us all in for. To state that action decisions have already been determined through past planning policy documents could be described as begging the question. To add that potential adverse outcomes need not be addressed in the project decision-making process because they can always be mitigated later by other government action could be described as passing the buck.

3. <u>Failure to Assess Fiscal Impacts</u>.

We question the propriety of assessing project financing separately and after-the-fact of environmental assessment. Fiscal impacts ordinarily should be part of a single comprehensive assessment, especially in light of straightened economic circumstances in the county and state. Given the present heightened importance of fiscal concerns in this county, deferring financing analyses until after a final EIS is accepted would appear to put the cart before the horse.

Many essential questions cannot be evaluated outside the context of fiscal impacts: Is there enough water without the project to meet the needs of already-approved development if those needs were limited to supplying drinking water only? If so, is the project's very large bonded indebtedness, which could hamstring the county in many ways for a long period of time, justified? Aren't there other more pressing infrastructure and other needs the county would have more flexibility to meet without taking on this debt? For example, Puako has been waiting for decades for a waste water utility line.

4. <u>The Absence of a Scaled-Down Alternative</u>.

There was no scaled-down plan presented among the four alternatives for consideration. Especially in light of the admitted manifold uncertainties of the future, an alternative that sets forth a modified and much-reduced project in terms of size and cost, designed to meet only presently-known, real needs rather than to accommodate all assumed potential build-out, would seem reasonable and necessary.

<u>CONCLUSION</u>

For many in Puako, as elsewhere in Kohala, conservation of the rural and wilderness character of the mountains, coast and sea remains a high priority. The DEIS pays lip service to these values but takes as a given that the time has come to radically alter Kohala from a primarily rural and wilderness region to complete urban resort and housing build-out. The role of the project in facilitating that build-out is acknowledged to be critical. The rationale running through the DEIS is that the transformation of Kohala is already assumed in various state and county planning policy instruments. The cost and magnitude of the project is such that a more searching evaluation of what it means for Kohala's future is appropriate. Not only do potential effects on the marine environment deserve more scrutiny and safeguards, a scaled-back alternative and the no-action alternative would seem to merit more serious attention at this stage.

Very truly yours,

Baine P. Kerr

BPK/jmm

cc: Cynthia A. Carlisle
Chair, Water Resources Committee of the Puako Community Association
Director, Friends of Puako Reef

Al Conrad, Ph.D.
President, Puako Community Association

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August 23, 1995

CERTIFIED MAIL--Return Receipt Requested

Milton D. Pavao
Manager
County of Hawaii
Department of Water Supply
22 Aupuni Street
Hilo, HI 96720

Re: Supplemental Comment Regarding Draft Environmental Impact Statement for the Proposed Kohala Water Transmission System

Dear Mr. Pavao:

This letter will acknowledge and correct a mistaken assumption of the August 15, 1995, comment letter on behalf of the Friends of Puako Reef and the Water Resources Committee of the Puako Community Association.

We assumed, and so stated, that no marine biologist was significantly involved in reaching the conclusions of the marine environmental study of the Nance engineering firm appended to the DEIS as Appendix C. This was based on the fact that no marine biologist was identified by name in the studies as having been involved in their preparation.

On further review of the DEIS, Steven Dollar, Ph.D. is named on page 13-3 of the DEIS as a "participant" and it is apparent that Marine Research Consultants prepared the second portion of Appendix C for the Nance engineering firm. Marine Research Consultants is apparently Dr. Dollar's firm, although his name does not appear in connection with Appendix C.

The fact that Dr. Dollar evidently did participate in reaching the Nance studies' conclusions of no possible impact on the marine environment does not change the substance of our comments. As stated in the August 15, 1995 comment letter, we are not comfortable with Dr. Dollar's assessment philosophy. His participation is all the more reason for a second opinion or

critique of the DEIS's conclusion that adverse affects to the marine environment from the project would be impossible.

Very truly yours,

Baine P. Kerr

BPK/jmm

cc: Cynthia A. Carlisle
Chair, Water Resources Committee of the Puako Community Association
Director, Friends of Puako Reef

Al Conrad, Ph.D.
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November 1, 1995

Baine P. Kerr, Esq.
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Boulder, Colorado 80302

DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for commenting on the DEIS for the Kohala Water Transmission project. We are in receipt of your letter dated August 15, 1995 and your supplemental letter of August 23, 1995. Our response to your comments is as follows:

1. Impacts on the Marine Environment.

a) Direct Impacts.

Your dissatisfaction with the conclusions reached in the study completed by Tom Nance Water Resource Engineering and Marine Research Consultants appears to be based on philosophical rather than technical issues. In as much as the study is of a technical nature, we are unable to respond to philosophical concerns.

With regard to OSP's recommendation that ocean water monitoring be undertaken and mitigation measures employed to assure consistency with the Coastal Zone Management (CZM) policy, we note that the Nance/Dollar study was undertaken in response to OSP's and others' concerns. The three major resorts in the South Kohala region began ocean water monitoring in the late 1980's and two of the three, Mauna Kea Properties and Waikoloa Resort, continue to do so today. The data from these studies forms the basis of a well documented base-line for the area and was directed and compiled by Dr. Dollar. While the Dollar study concludes that "In sum, it is clear that the projected changes in groundwater flux from the Kohala Water Transmission System will not have any effect on nearshore marine communities," we note that ocean water monitoring is a common requirement attached to specific coastal projects such as resorts, golf courses, and sewage treatment plants. We believe that monitoring requirements are more appropriately applied to specific users and sites than to the water provider.

b) Secondary Impacts on the Marine Environment

You are correct that the DEIS does not specifically address secondary impacts on the near-shore marine environment. Any development of boating facilities in the region (or anywhere in the State) would require an EIS specifically for that project and would look at primary and secondary impacts to the near-shore areas.

... Water brings progress...

2. Secondary and Cumulative Socio-Economic Impacts

a) Cumulative Impacts

Cumulative impacts are discussed in Section 3.4 of Appendix A. An EIS must consider cumulative impacts, although the definition of what these are is far from precise. It should be noted that "cumulative" is an undefined term in Chapter 343, HRS and §11-200, Department of Health Administrative rules. Our practice has been to include discussion of similar (but not directly related) projects that could magnify the effect of the subject project's impacts. Calculation of cumulative impacts may be relatively straightforward, yielding accurate and reliable results, or it may be exceedingly speculative, leading to questionable results.

In the case of actions that indirectly influence growth, but do not specify its nature, timing, and precise location (such as the proposed project), the assessment of cumulative secondary impacts is highly problematic. This is particularly true in a setting in which the potential for growth is not seriously constrained (and, therefore, predictable) because of saturation by existing uses, market inflexibility, or governmental regulation.

Although growth plans and projections do exist for Kohala, it is extremely naive to rely on these projections as even approximate measures of the nature, distribution or magnitude of the actual growth that will ensue. In the case of Kohala, there are literally hundreds of landowners and entrepreneurs ready to consider and reconsider ventures based on the ever-changing real estate, visitor industry, and regulatory climates. There is clearly no way to accurately forecast what type of growth will take place and when and where it will actually occur. It would be fruitless and bad science to perform detailed calculations of impacts related to vague and uncertain plans simply for the (false) appearance of accuracy.

The wiser course is to consider the spectrum of primary and secondary impacts of the project in the context of ranges of possibility for the Kohala region. The SIA and EIS discussed activities and events related to not only this and other water systems, but also to other projects of all type with implications of population growth.

Throughout the text, note was taken of the fact that the Kohala Water Transmission Line is only one stimulus for development in Kohala, and that various projects are likely to transform population, jobs, housing, and the social composition of the area in ways that augment or cancel out trends that would result from the proposed project.

Section 3.4, "Cumulative Impacts of the Project," discussed the range of proposed developments for the Kohala area and attempted to frame the net impact of the project in this rough context. However, because nearly every one of these proposed projects is speculative and subject to complete change, it is impossible to determine precisely the joint social, housing, economic and cultural impacts of project and non-project related growth.

b) Secondary Impacts

We do not agree with your statement that the discussion of mitigation measures in the DEIS "consists largely of the naming of problems rather than strategies to solve them" and note that it is contradicted by the actual list of mitigation measures proposed in Section 1.5 and elsewhere in the document.

The statement that the EIS is "passing the buck" by deferring formulation of some mitigation measures for later action by government agencies overlooks the fact that many listed impacts may or may not occur and may occur at a date far in the future.

It would be unwise to devise (and especially to implement) complex, costly and detailed mitigation measures for problems that may not come into being or may assume forms significantly different from those that now envisioned. The economic and revenue benefits that would result from growth associated with the project are expected to be substantial. The direction of spending for these funds (e.g., towards housing, recreation, transportation, public safety facilities, schools, etc.) should not be constrained by specific measures devised prematurely, before the nature and scope of the actual growth fully unfolds. Instead, it is only sensible that those government agencies responsible for planning facilities and improvements in the region monitor the actual needs of the area closely and consistently.

3. Failure to Assess Fiscal Impacts

We do not agree with you that the EIS is the proper vehicle for discussion of the specifics of a financial plan. The County Council is charged with the responsibility of setting priorities for funding diverse capital improvement projects and weighing the potential risks and rewards of competing capital improvement projects. Prior to the County Council acting on any financing plan for the project, they are required to hold hearings on the matter. Full disclosure and public discussion about the possible financial impacts of the project, the specific commitments to be given by the users, other competing capital improvement projects, prudent County indebtedness, and other relevant matters will properly be discussed at that time.

With regard to your question "is there enough water without the project to meet the needs of already-approved development if those needs were limited to supplying drinking water only?", we refer you to Table F-1 Appendix F, Estimate of Future Water Needs, and paragraph 1, Section 1.3 of the DEIS:

> 1.3 DESCRIPTION OF PROPOSED PROJECT
>
> The purpose of the proposed Kohala Water Transmission System project is to provide a high quality and reliable potable water supply that would meet the estimated future needs of North Kohala and the coastal area of South Kohala. The proposed project would be carried out in two phases.

The purpose of the proposed project is to provide drinking water.

4. The Absence of a scaled-down Alternative.

A scaled-down alternative will not meet the purpose of the project which is to provide a high quality and reliable potable water supply that would meet the *estimated future needs* of North Kohala and the coastal area of South Kohala. South Kohala is the only district in the Island where the estimated future water needs are higher than the estimated capacity of the water supply available from sources within the district. The long term economics of bringing the water in from any source outside the district will require a large diameter pipeline similar to the planned project and precludes a scaled-down alternative. Also, while improvements in technology may allow development of currently marginal resources into valuable sources, other needs may arise. For example, on the supply side, high-level ground water sources are being explored in the forest reserve area in Waimea. Test drilling has shown possibilities. However, the performance of the such wells is not known and monitoring to validate their performance would be necessary before their reliability can be assured. On the need side, the DHHL has recently acquired additional lands from the State in Lalamilo and Keoniki. DHHL is now evaluating its options on use of the lands, and additional water from the Waimea aquifer will more than likely be needed.

It appears from your conclusion that you make no distinction between North Kohala and South Kohala with regard to the potential project impact. The primary impact of the project on North Kohala will be the introduction, into the water system, of high quality ground water to replace current tunnel sources. The South Kohala area, which the project is intended to serve, can hardly be called a primarily rural or wilderness region when it contains over 3000 hotel rooms, 1500 condominium units, and 6 golf courses.

We hope the above explanation is helpful.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

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August 18, 1995

Mr. Milton Pavao
Director, Department of Water Supply
County of Hawaii
25 Aupuni Street
Hilo, Hawaii 96720

Re: KOHALA PIPELINE - draft EIS
Public Comment period 8-22-95

Dear Mr. Pavao:

On behalf of the Board of Directors of the Hawaii Island Economic Development Board, we respectfully submit the following comments:

•The long-term benefits to the Kohala and Waimea region are significant and important for sustainable economic development.

•The economic impact to the region may be somewhat simplified in describing set numbers of jobs in construction, resort contributions and "traditional" economic indicators. We would suggest a larger view to sustainable agricultural and scientific endeavors which broaden our economic base and provide future employment potential outside of service industry jobs.

•We believe that it will become important to consider unconventional financing mechanisms which do not impact the County's ability to finance other large infrastructure projects, such as reimburseable General Obligation bonds backed by the County and supported by present and future beneficiaries.

We are in support of the project concept and general methodology and thank you for the opportunity to submit these comments.

Yours sincerely,

Paula Z. Helfrich
Executive Director

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October 18, 1995

Ms. Paula Z. Helfrich, Executive Director
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DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for commenting on the DEIS for the subject project. The following is in response to your letter of August 18, 1995.

We concur with your view that the potential long-term benefits to the northwest Hawaii region of the island are significant and important for sustainable economic development.

Although it is important that other than service industry jobs such as sustainable agriculture and scientific endeavors are needed to broaden the regional economic base, we are not certain of the extent to which the expansion of such industries would result from the availability of water from the proposed project.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

... Water brings progress...

KAWAIHAE HAWAIIAN HOMES HOMEOWNERS
COMMUNITY ASSOCIATION
P. O. BOX 44337
KAWAIHAE, HI 96743
PHONE: (808) 326-7182 (O)

AUGUST 21, 1995

GOVERNOR BEN CAYETANO
STATE OF HAWAII
C/O D.E.Q.C.
220 KING ST., #400
HONOLULU, HI 96813

RE: KOHALA WATER TRANSMISSION SYSTEM TESTIMONY DUE AUGUST 22, 1995.

Dear Governor Cayetano:

We, the residents of the Kawaihae Hawaiian Homes Homeowners Community Association are told by the Department of Hawaiian Home Lands that we need potable water. We strongly request that we be able to "access" this County water transmission system. It is important to us that the Department of Water Supply is the responsible and accountable agency to service us and the general public in Kawaihae.

The priority concern is the decisions of the Hawaiian Homes Commission and the Department of Hawaiian Home Lands. The beneficiaries cannot trust the Commission or the Department to be responsible for us. The Commission who is supposed to be responsible for our health and safety, rights, rehabilitation and benefits, etc.; are not sure which side of the fence to sit on (Section 207(a) HHCA lessees or General Lessees). We are in the Supreme Court to acquire an environmental impact statement, "to protect ourselves". This example is indicative of the processes the beneficiaries have had to live with for many years.

The department of Hawaiian Home Lands is not a real estate company nor a banking institution. It is a rehabilitation program that is charged with the responsibility of settling the Section 207(a), HHCA beneficiaries on the land. Recognizing that DHHL cannot address their own charges at this time, it is best that the County provide this responsibility because there is a need and the need is immediate.

Originally, KHHHCA requested that the water come from the Lalamilo wells which presently services the Kawaihae harbor. The cost would have been $2.3 million in 1993 for expanding the size of the pipes along Kawaihae-Waimea Highway, providing piping along the Commerical areas and subdivisions, and a reservoir on Hawaiian Home Lands. The request for this section would service the Harbor,

Spencer Park and the two (2) forcasted DLNR small boat harbors; principally the Kawaihae portion of this transmission line.

Another concern is with the cost of the project as estimated by the County. The County insists that the Hawi phases must be developed first. The community does not seem to view this same priority because the community views no growth is best for their community. Kawaihae is impatient to improve our area and still provide sufficient resources to the Harbors (and perhaps gambling one day with a withdrawal clause). A connection at the Kawaihae boundaries could be envisioned in the future.

The next concern is the timetable. The County envisions long phases that need to be completed in Hawi before reaching Kawaihae. This would take unnecessary years. After living the HHL system for (3) generations, it is conceivable that the HHL plans will change an undetermined amount of times before completion. An example is the Makai Hawaiian Homes subdivision which sat idle for 2 years, with encumbered funds and numerous delays.

The Department of Hawaiian Home Lands is supposed to receive revenue for Water rights. So far, the Water Department confirms there has been no measurement of the water table to designate how much to collect from this benefit. The $2.3 million required in 1993 could have been available many times over already. Collection of water rights could also pay for the interim use from private wells whose water is also considered mineral rights.

The Department of Hawaiian Home Lands also has a Claim against them for mining the soil and rocks from the makai subdivision. The funds could have supported the $2.3 million expense to improve the infrastructure on the Kawaihae-Waimea Highway.

The Office of Hawaiian Affairs is supposed to receive 20% of the ceded land revenues from the State. From 1990 to 1995, how much was supposed to be provided for the Hawaiians from the coral flats and the small boat harbor? Would there have been enough for another $2.3 million for the Lalamilo pipeline?

A few years ago, the Chalon Corporation who bought the sugar lands in Kohala, offered the Kohala Ditch to DHHL for $1. DHHL refused. DHHL expertise approved drilling two wells on the HHL and acquired brackish water. KHHHCA requested using this water for fire fighting and was denied. The well was promptly capped.

We ask ourselves, why would rehabilitation lessees (some of whom have been homeless for years) prefer man-made desal water which may cost more than we can afford? Why would these lessees prefer services from a private entity that is not responsible or accountable to anyone (on Hawaiian Home Lands)? Why the Commission prefers to be

Fax : 8083267182 Aug 21 '95 14:19 P04

Kohala Water Transmission
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deaf from the pleas of their charges? No, we do not want an energy plant nor this desal water facility in Kawaihae.

What we would like is to acquire professional, dedicated, expertise in the Department of Hawaiian Home Lands. People who know how to work with small budgets to service homeless, rehabilitation people. People who can relate with the hardships of the oppressed.

Water is available. Access to the water is the problem. Planning to make money by using the oppressed makes Sovereignty unwise, expensive, and immature. Self-determination and self-sufficiency is not recognized or allowed to be practiced by the Commissioners' decisions. This also contributes to the high cost of living which no one seems to be monitoring, except the oppressed.

If you have any questions or discussions about the Lalamilo wells alternative; please let us know.

Sincerely,

Jojo Tanimoto
President

cc: Mr. Megumi Kon, Consultant
Mr. Quirino Antonio, Department of Water Supply
Mr. Kali Watson, Hawaiian Homes Commission

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
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November 1, 1995

Ms. Jojo Tanimoto, President
Kawaihae Hawaiian Homes Association
Community Association
P.O. Box 44337
Kawaihae, HI 96743

DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for commenting on the DEIS for the subject project.

Regarding your concerns about "access" to the proposed water system, please note in Figure 2.2-3 of the DEIS, that the Department of Hawaiian Homes Lands is expected to utilize 7.05 million gallons daily from the system and that the Kawaihae-Puako area is identified as utilizing approximately 1 million gallons daily. These amounts are consistent with densities projected in the County General Plan and the DHHL Master Plan for its lands at Kawaihae. Access to the system will be predicated on the payment of the user's pro-rata share of the system's cost.

You have stated a concern about the timing and phasing of the project. Current economic circumstances make it difficult to project a start/completion date. There will need to be sufficient interest among the users of the project to support a financing plan which can, in turn, be supported by the County Council and its taxpayers. The first phase must include the pipeline, reservoirs, and a portion of the well field which is located in Hawi.

We hope the above explanations are helpful.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

... Water brings progress...

LIFE OF THE LAND

Mr. Milton Pavao, Director
Dept. of Water Supply
25 Aupuni Street
Hilo, HI 96720

Aug 8, 1995

Dear Mr. Pavao:

We are concerned that the financing of the proposed Kohala Water Transmission System has not been discussed in the recently released Draft Environmental Impact Statement. This appears to be a policy decision that does not conform with the Regulations which are available from the OEQC. I (Bill Graham) personally have been closely monitoring the progress of the planning for this project. Inasmuch as the issue at hand is one of proper implementation of HRS Chapter 343, it has direct relevance to Life of the Land's activities on behalf of the environment in Hawaii. I am a member of LOL's board of directors and a Big Island resident.

In most instances where an EIS is prepared for a privately funded project it is understandable that financing details might not be necessary or appropriate in an EIS. First, the source of the funds is individual or corporate and does not pertain to the readers of the document, the citizens and agencies of the State of Hawaii. Second, the funding specifics do not alter the impacts which might be expected to occur due to the proposed project.

This proposed pipeline project is markedly different in both these aspects. First, we are told that the project will be financed with General Obligation bonds on the County of Hawaii. Thus the readers of the document are the very same people who will be ultimately responsable for the financing. Second, the impacts, both economic and other, will be very much influenced by the manner and timing of the financing arrangements. I will discuss this second point in more detail.

My understanding is that the intention is to have the bonds guaranteed by the County of Hawaii, but to have commitments in place which will ensure that the repayments do not have to be borne by the taxpayers of the County. That is reasonable and I do not fault the intention. It is a close parallel to the Lalamilo Water System project of more than a decade ago. However, a closer look is needed.

Suppose that the county secures commitments from Big Island landowners to fully meet the repayment provisions of the bond, prior to issuance.

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In this case, the landowners make repayments before they can make use of the water. Obviously funding money must be raised well before the water from the project is put to use. In this scenario the landowners will necessarily need to bring their projects on-line as rapidly as possible to avoid the negative cash flow from their water payment obligations. That represents a direct impact on the pace of development due to the financing of the project.

Suppose that the county has firm commitments for eventual use of the water such that the long term financing impact can work out to be neutral to Hawaii Island taxpayers. But the taxpayers will be footing the bill in the short term. Here the contributions by the taxpayers must be directly figured into the economic analysis and its time course. We do not see such an analysis in the Draft EIS. There is no discussion of any public expenditures for the funding of this project in the EIS. Because of the cash drain on the county in the interim, many other worthy county expenditures may be foreclosed by the initiation of this project. Furthermore, the County Council and the administration will be under great pressure to move development projects along so that the taxpayers can be relieved from the burden of meeting the payments on the bonds. That could certainly weaken the county's hand in its search for quality development, as well as its ability to impose appropriate conditions of approval on developments.

Finally, suppose that the county has firm commitments for use of only some of the water, but can foresee acquiring further commitments once the project has commenced. Here we have all the impacts of the prior supposition, but greatly enhanced. Moreover, there is a new and substantial financial risk to county taxpayers.

Also, since county government has limited bonding capabilities, limited by its resource base, clearly any bond float restricts the capacity of the county to fund other capital expense projects. This is another clear economic impact.

The consultants who have worked on this EIS have been diligent in coming to the North Kohala community and giving progress reports as well as receiving community concerns. They have regularly informed us that discussions with landowners regarding water commitments have been ongoing. Thus the North Kohala community was unpleasantly surprised to learn that the results of these discussions would not be detailed in the EIS. We would like to know the specifics of what the Department of Water Supply is offering and what the responses have been, to date.

Another finance related impact is the obligation that goes with the issuance of a water commitment. On one hand we read that there will be monitoring of the water both as regards its removal from North Kohala and its addition to South Kohala. This monitoring will advise us of any problems that may occur as water usage picks up. But if the commitments are already in place, we are not at liberty to take action which could violate those commitments. Thus we might be forced into unwanted detrimental outcomes that are beginning to occur but cannot be avoided because of our commitments. This is another direct result of the financing arrangement.

Finally, the Department of Water Supply has repeatedly informed the community that our bi-monthly water bills are not paying for the planning or construction of this project. My understanding is that the state legislature appropriated money several years ago for the EIS and other planning studies for this project. Thus the very people who are working on the financing aspects are being funded by the citizens of the state of Hawaii. We find it inappropriate for DWS consultants to use these public funds to solicit water agreements and secure financial commitments, yet withhold the content and result of their efforts from the public.

It is simply not acceptable for the financing background to be held closely until eventual presentation to the Hawaii County Council at some future date. Currently, the consultants may anticipate that the package to be presented to the Council will look a certain way. Yet it may not turn out as such in the event. Thus a detailed description of the specific efforts undertaken, as well as a discussion of the various possible outcomes and their impacts, must be included in the EIS now.

If the deficiency in the Draft EIS is to be remedied with full disclosure in a Final EIS, then we strongly advise that the material to be included be reviewed by interested people in advance. At this late date we will not have the depth of review which would be natural if the Draft EIS had provided full disclosure.

Life of the Land will soon submit detailed comments on many areas of the Draft EIS where we believe the document falls far short of what is both customary and required. That submission is a different issue and is not a part of this letter because the issue we address here appears to be a policy issue, not a mere shortcoming in the execution of a generally accepted procedure.

Sincerely,

Bill Graham

Bill Graham
Director, LOL Big Island
P.O. Box 155
Hawi, HI 96719

cc: Gary Gill, OEQC
Gregory Pai, OSP
Rep. Dwight Takamine
Sen. Malama Solomon
Councilman John Ray
Megumi Kon

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
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October 30, 1995

Mr. Bill Graham
Director, LOL Big Island
P.O. Box 155
Hawi, HI 96719

DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for your comments on the DEIS for the Kohala Water Transmission project dated August 8, 1995.

The concerns you have expressed are primarily related to project financing. You are correct that it is our intention to propose to the County of Hawaii that the project be financed with General Obligation Bonds. The County will be the recipient of additional real property taxes due to development made possible by the project. You are also correct that it is our intention to have commitments in place from the major system users in order to insure the County that debt service on the bonds will not be borne by the taxpayers of the County.

Regarding your first supposition that the County secures commitments from Big Island landowners to fully meet repayment of the bond, prior to issuance, we do not agree that "the landowners will necessarily need to bring their projects on line as rapidly as possible to avoid the negative cash flow from their water commitment obligations." Compared to other pre-development costs of a major development, the cost of assuring a water source is not (in this instance) overly large. At $6.00 per gallon capital cost (the estimated cost per gallon for phase I of the project) and 1200 gallons per day per unit, the investment per unit would be $7200. While it is prudent for landowners to await signs of a stronger economy before committing to this investment, it would not be prudent to push development beyond the limits of a market just to avoid a relatively small holding cost.

Your second supposition is that "the County has firm commitments for eventual use of the water such that the long term financing impact can work out to be neutral to Hawaii Island taxpayers. But the taxpayers will be footing the bill in the short term." Your concerns are that "because of the cash drain on the County in the interim, many other worthy County expenditures may be foreclosed," and "the County administration will be under great pressure to move development projects along." Regarding your first concern, it is rightfully the County Council's job to compare and evaluate diverse funding requests from the different County departments such as wastewater treatment, water development, swimming pools, County office buildings, etc. It is not the purview of the Department of Water Supply to make those evaluations and, thus, they are not considered in the DEIS. Regarding your second concern, we do not agree with you that the administration will be under such pressure. The pressure to develop is market driven; the Council cannot stimulate development by lowering standards.

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Your third supposition is that "the County has firm commitments for use of only some of the water, but can foresee acquiring further commitments once the project is commenced." Our responses to your second supposition and concerns are reiterated here.

Regarding the County's bonding capabilities and the impact this project would have on other capital expense projects, we would agree with you that any bond float *affects* the capacity of the County to fund other capital improvement projects, and point out again that it is rightfully the County Council's job to compare and evaluate diverse funding requests from the different County departments and, thus, they are not considered in the DEIS.

With respect to the discussions the Department of Water Supply has had with landowners regarding water commitments, they are ongoing and directed at arriving at a strategy which will be acceptable to the County Council. The broad strategy is for the users to pay for the capital cost of the project. The specifics, especially timing, will depend on future economic events.

You expressed concern that the issuance of water commitments might be in conflict with the intent behind the monitoring of the aquifer. We point out that the first phase of the project and the financing commitments will be for 10 MGD, or one-half of the amount ultimately expected to be pumped. If the results of monitoring during the estimated 10- to 20-year pumping history of the first phase indicate any potential problems with the aquifer, there will be no obligation to provide additional water from the resource.

Your last several paragraphs again deal with the ongoing discussions with landowners, and you suggest that we are withholding the content and results of our efforts. The result of our discussions to date is as we have reported at the meetings in Kohala. There is agreement as to the broad strategy that the users will pay for the capital cost of the project. The current economic situation in Hawaii however, prevents them from committing to any specific course of action now.

We hope the above explanation is helpful.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

LIFE OF THE LAND

Aug 18, 1995

Governor, State of Hawaii
c/o Office of Environmental Quality Control
220 South King Street, suite 400
Honolulu, HI 96813

We offer the following comments with regard to the Draft EIS for the proposed Kohala Water Transmission System.

We find the most important, and also most difficult task when reviewing an EIS is to draw the important large scale issues out of the wealth of detail that is present. Our comments here will attempt to focus on the major concepts and deficiencies in the Draft EIS, and are presented in five sections:

1) Purpose and Need
2) Alternatives to the Action
3) Cumulative and Secondary Effects
4) Financing of the Project
5) Other Specific Deficiencies

I. Purpose and need - Section 2 of the Draft EIS

The statement of purpose reads (page 2-1), "The purpose of the Kohala Water Transmission System project is to provide a high quality and reliable potable water supply that would meet the estimated future needs of North Kohala and coastal area of South Kohala."

The evident strategy is to use the Hawi (North Kohala) aquifer to meet the potable water needs of South Kohala, and use the Waimea (South Kohala) aquifer to meet the non-potable needs of South Kohala. The EIS states (page 2-5) "The irrigation water needs are expected to be met by the underlying Waimea and Anaehoomalu aquifers." Currently, potable water is provided by the Lalamilo System, and the EIS indicates (page 2-8) "The existing Lalamilo wells would be kept as a standby source." We are not told why existing wells which are operating successfully and only at slightly above half capacity (page 3-1) should be taken out of service in favor of this major new project.

Although the purpose is to provide water for coastal South Kohala,

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the largest consumer by far is expected to be the Department of Hawaiian Home Lands (DHHL), with a future need of over 7mgd (Fig 2.2-1 on page 2-2). When we review the EIS by DHHL for the Kawaihae Ten Year Master Plan, they indicate a need of 3.1 mgd, which does conform with the numbers given in Figure 2.2-1 for years up until 2009. However the DHHL EIS covers development of their lands up to the 1200' elevation. Since the storage reservoir for water from the proposed pipeline is to be located at the 300 foot elevation, a large part of the DHHL usage will have to be pumped mauka again. The future phases of the DHHL plans which will supposedly create the total indicated need of 7mgd are mostly to be mauka of the 1200' elevation, hence pumpage costs would be even more costly to deliver that water. Our point is that this proposed project is not well addressed to the bulk of the DHHL project, which does not lie in the "coastal" area of South Kohala. Also note that the DHHL EIS indicates that they expect to get 3mgd of water from deep wells on their own lands. If that is true, there is no need for additional sources for them until after 2009.

Also note that the proposed Cogeneration Plant by Waimana Enterprises is to be sited at Kawaihae, and will desalinate water as a byproduct of electical energy production. Why is this source of water for the Kawaihae area not addressed in depth in the Pipeline EIS? Of course we do not know that this plant will be constructed. Certainly there is a chance that it will, and it is near term, and the available supply of water would be augmented by 2.6 mgd if it became operational according to plan.

II. Alternatives to the Action - Section 4 of the EIS

In the OEQC Regulations for preparing a Draft EIS, it is stated that "The draft EIS shall contain any known alternatives for the action." The regulations also call for a "rigorous exploration" of all the reasonable alternative actions.

The draft EIS for this Pipeline Project has a total of five pages of text devoted to four alternatives. Two pages are devoted to the possibility of bringing a like volume (20mgd) of water from East Hawaii, obviously a cost prohibitive alternative.

A second alternative is the concept of desalinating brackish water, and this alternative is briefly overviewed in the context of requiring it to provide the full 20mgd volume that is proposed for the pipeline project. No mention is made of the proposed Waimana Cogeneration Electrical plant at Kawaihae that would desalinate water as a part of its operation. (We are not indicating support or non-support of the Waimana project, only that it belongs in the draft EIS now under review.)

The third alternative is use of high level ground water from the Waimea area. Again the alternative is only evaluated in terms of providing a full 20mgd of water, and in terms of carrying it all the way down to the reservoir site at 300' elevation. The cost analysis here is obviously flawed because such a substantial portion of the usage will be for DHHL lands which stretch high into mauka areas. The cost of additional uphill pumping of water from the proposed pipeline to the users in DHHL lands must be figured into the analysis. And the Waimea alternative will have a shorter run from Waimea to these mauka DHHL lands than is shown in the EIS.

The fourth alternative is for the Department of Water Supply to make no additional contribution to the needs of the target area, coastal South Kohala (which is construed to include the DHHL lands in this Draft EIS). Here it is assumed that water development will be undertaken by private landowners, as has already taken place with Waikoloa and with Kohala Ranch, and others undoubtedly.

The glaring flaw in all these alternatives is two-fold: no time frame of reference is embodied, and no smaller scale alternatives are examined. We will next examine those two aspects and show why a consideration of only 20mgd alternatives is not warranted.

By the year 2009 an expected potable water need for coastal South Kohala (again, including DHHL non-coastal lands) is 10.7 mgd as shown in Figure 2.2-1. The combined pumping capacity of the existing four Lalamilo wells is 5.3 mgd and present pumpage is about 2.8 mgd. We are told that the water quality of these wells is good, but it is proposed that they be withdrawn from use and put on a standby basis. If they remain in use, then there is only an additional 5.4 mgd needed to meet the 10.7 mgd projection. The DHHL Ten Year Kawaihae Master Plan indicates that "Deep wells at the project site are anticipated to provide about 3mgd...". The remaining capacity to be filled then drops to 2.4 mgd.

Looking at the use side, Chalon has ample water to provide for their own needs, thus dropping the capacity to be filled to 2.0 mgd. In their Environmental Impact Report for the Mahukona Lodge, Chalon indicated no need for additional DWS source development.

Nansay Puako appears in Figure 2.2-1 as a user of 1.97 mgd by the year 2009. When we review the "County of Hawaii Planning Department Fact Sheet" for that project (by Puako Hawaii Properties), we read that "Potable water demands are estimated at 1.3 mgd. Potable demands will be met by the two deep well sources on the applicant's Ouli parcel about six miles from the project site at an elevation of 1300 feet." According to the Draft Environmental Assessment of the Ouli Affordable Housing Project, the potable water need of the Ouli project itself is only 0.27 mgd, and one well has already been drilled and tested which has a projected yield of 1.5 mgd. It certainly appears that there is no shortage for these projects.

Back to the supply side, the proposed Waimana Cogeneration Plant at Kawaihae indicates in their Draft Environmental Assessment that they will be producing 2.6 mgd of desalinated water. As stated before, we don't know whether this cogeneration facility will become a reality or not.

Altogether there is no shortage of potable water up through the year 2009, according to the usage requirements given in the Draft EIS. And that is assuming that the Department of Water Supply does no additional source development. According to the Draft EIS, the construction phase of this project is from 1996 until 1998. Water would be available in 1999 which is 10 years before any water is needed, much less the 10 mgd proposed in phase one of the project.

In looking at the alternatives, we have clearly drifted back to the initial topic, purpose and need for the project. What should have been "rigorously explored" in the alternatives section are some smaller scale sources that might be utilized if the projections in Figure 2-2.1 prove to be exceeded by actual demand. Given the current economy, and the strained financial situation of developers like Nansay, it is quite likely that the projections may not be attained until years thereafter.

III. Cumulative and Secondary Effects

We believe that the greatest shortcoming of this Draft EIS is the cursory to non-existent exploration of the secondary impacts which will accrue from the implementation of this project. In many less than precise ways, the authors admit that the secondary impacts will be substantial. Yet the impacts are not researched, quantified or discussed in detail.

The Regulations for the preparation of a Draft EIS indicate that "These secondary effects may be equally important as, or more important than, primary effects, and shall be thoroughly discussed to fully describe the probable impact of the proposed action on the environment." (11-200-17(i)).

First, the issue arises as to how to quantify the secondary impacts of the project. In rough terminology, the secondary impacts are those that arise from the increased development and population which will follow the delivery of all this potable water. Other secondary impacts may be more directly pinpointed.

Obviously it is difficult for the authors of this EIS to come up with a quantification of that part of the future growth in West Hawaii that can be attributed to this project. We don't intend to ask for the impossible. Their methodology is to describe two scenarios of possible growth in West Hawaii, the AS-PLANNED scenario and the HISTORICAL TRENDS scenario. Unfortunately, these two scenarios do not correspond to a without-project and a with-project comparison. So they really don't address the purpose of the EIS itself, which is to evaluate the impacts of the project. They are reasonable forecasting approaches to predicting the future of South Kohala, and do have value in themselves. Given that the actual future may lie somewhere in the middle of these two scenarios, what part of the growth can be attributed to this project?

In the environmental assessment, which preceded the EIS, we were told, with regard to secondary growth impacts, "Because water exercizes such an important influence in this entire process, examination of the total secondary impacts will be undertaken in the EIS."

The No-Action alternative (page 4-6) indicates, with regard to a prognosis of growth without this project, "Development might be much slower and geographically uneven, but it would probably continue."

In appendix A there is a brief but frank discussion of this issue on page 3. In an attempt to estimate the amount of growth that would occur if this project does not happen. "For the purpose of discussion in this report, it is assumed that growth of approximately 50 percent of with-project levels will occur."

These observations, and others in the EIS, show that it is recognized that the proposed project will have substantial secondary impacts. Unfortunately, Chapter 9.2 of the EIS which is intended to identify the secondary impacts of the project, does not do so. It follows right along with the AS-PLANNED and HISTORICAL TRENDS scenario, to show us some of the repercussions that will come with future growth in the area. Some unspecified portion of the growth is presumably attributable to this project. Let us leave it unspecified, and see if Chapter 9.2 and associated Appendices do meet the requirements of thorough discussion of the probable impacts.

Here are a few areas where we expect to see a detailed discussion of impacts, but where they are missing.

1) The ocean and marine environment: Appendix C directly addresses the impact of additional groundwater discharge (or removal) on the marine environment. Without commenting on the specifics of that issue, how about the plethora of other secondary effects? Fishing pressure on the resource, boating pressure on the harbors and marinas and corals, increased pollution from other than groundwater discharge. What lies ahead for our ciguatera toxin problem?

2) Flora and fauna: ??

3) Roads and highways: On page 9-13, "This equates roughly to a doubling or tripling of traffic on Kohala Roads, based on 1990 de facto population of near 18,000." We ask, which roads will fall to levels of degraded service, what will be the cost of improving the roads to maintain acceptable levels? No answers.

4) Schools: On page 9-14, "...at least one more high school and several intermediate schools, elementary schools and public libraries would be required." What is the cost of these schools, where and when will they be built? No answers.

5) Fire and Police: On page 9-14, "...these public facilities would

have to be expanded by the County of Hawaii." When, at what cost?

6) Air Quality: Appendix E is devoted exclusively to examining the emissions from the diesel generation units that will power the pumping. How about the impact on air quality from all the secondary growth, a substantial but unspecified portion of which can be attributed to this project? Nothing at all.

7) Housing: On page 9-13, "This would create a demand for roughly double the current inventory of housing." We don't find that to be a thorough discussion of the impacts of the project on housing. How will this housing shortage be met?

In our opinion the draft EIS makes no concerted effort to report the secondary impacts as required. The effort is there in some areas, such as social and economic, but is absent in most.

Yet Section 12 of the Draft EIS states that there are no unresolved "environmental" issues. And the only "other" unresolved issues are financing, land acquisition, and permits. It seems clear to us that all the above areas of secondary impact remain unresolved.

IV. Financing

Although this project will be financed by bonds issued by the County of Hawaii, the EIS is totally lacking in a discussion of the financing and the future impacts that will result from the method by which the project is financed. The economic analysis does not indicate a cost to the Hawaii County taxpayer. We wrote a prior letter, dated August 5, to the Department of Water Supply, which details our objections to this most important omission. We ask that the letter be considered a part of this comment on the Draft EIS, and will not duplicate it here.

V. Other Issues

North Kohala potable water needs: In presentations to the North Kohala community, and in written material distributed by the consultants (Section 13, Community Update #2) the estimated future North Kohala water needs are given as 1.5 mgd. Now in the Draft EIS we see that the future potable water need for North Kohala is 4.3 mgd (page 2-8). Why the big jump, with no explanation to the community or in the EIS document? What additional developments are responsible for this near tripling of local water needs? The USGS research that was done for this project was based on a drawdown total of 20.6mgd, not 24.3 mgd. We are casually led to believe that an additional 4 mgd is possible, based on a discussion between DWS-Milton Pavao and USGS-William Meyer. Increasing the drawdown by nearly 20% without the technical study to justify it is unacceptable.

Economic Analysis, Cost - Benefit ratios: The consultants have used the usual per-capita public expenditure method to work out a familiar 4 to 1 benefit over cost ratio to county and state governments. We have seen this same methodology applied to the growing resort sector in West Hawaii for the past 10 years, in multiple EIS documents. By now our public coffers should be overflowing and our infrastructure should be in great shape if this methodology were congruent with reality. In fact our infrastructure has fallen behind as our population has grown. We have already pointed out that the Draft EIS has failed to cost out or give a timetable for the SPECIFIC needs that will be generated in the public sector, such as schools and roads and parks and fire and police. We ask that the consultants pull together the SPECIFIC necessary expenditures by state and county government and give us an analysis that has a chance to be meaningful.

Employment: We are told that the construction employment has the potential for "1480 full-time jobs during two year phase I and 480 full-time jobs during one year phase II" (page 1-2). When we read the appendix our understanding is that half that many jobs will be created in phase I, for a 2 year period. So the 1480 is really a man-year number, and there will really be an average of 740 jobs in place during the two years of phase I. Even those numbers appear unrealistically high by common sense standards.

Irreversible and Irretrievable commitment of resources: Section 8 tells us that "The basal water withdrawal from the Hawi Aquifer System will not result in an irreversible and irretrievable commitment of basal water resource since it is a renewable resource that is continually replenished by rainfall." Are we to believe that this commitment of the resource, by our county government in the form of water commitments to pay for the system, is not irreversible and irretrievable because the resource is DYNAMIC, rather than STATIC? Obviously the remaining water available from the aquifer, for other uses, will be severely reduced. Is our resource not being commited?

Non-Potable Water Needs: Where is a discussion of the Kohala Ditch as a source of non-potable water for South Kohala, instead of drawing down the Waimea aquifer for landscape and golf course watering? We have no knowledge that it is appropriate or cost effective, but where is the analysis?

Bill Graham

Bill Graham, Big Island director
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Hawi, HI 96719

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November 1, 1995

Mr. Bill Graham, Director
LOL Big Island
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DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for your commenting on the draft EIS for the subject project. The following responses are in order of the comments in your letter of August 18, 1995.

1. Purpose and need - Section 2 of draft EIS

You correctly noted that the draft EIS did not explain the rationale for placing the Lalamilo wells on standby after completion of the proposed project. The following explanation will be included in the final EIS. The reason for the change to standby is primarily to reduce pumping cost, which is a continually rising operating cost. The average ground elevation of the proposed Phase I wells in Hawi aquifer is about 400 feet compared to an average ground elevation of 1100 feet for the four existing wells at Lalamilo. The difference in ground elevations between the Hawi and Lalamilo wells has a direct affect on pumping costs. Pump maintenance cost would also be less because of shallower well depth. Although the pumped water from the Hawi wells must be raised to the collection tank elevation of 675 feet, the difference in pumping lifts would be still about 38 percent less than at Lalamilo. The reduction in annual power cost alone could amount to $50,000.00 for every million gallons per day of water pumped.

The final EIS for the Department of Hawaiian Home Lands (DHHL) Kawaihae Ten-Year Master Plan listed the securing of necessary potable water sources for the project as an unresolved issue. It also reported that of the two test wells drilled on-site, one well, at about the 1400-foot ground elevation, produced brackish water. The other well, at about 1600-foot ground elevation, produced potable water at constant pumping rate of 130 gpm or about 0.2 mgd. Other possible sources being pursued included desalinization of brackish water and importing water via pipeline from wells in North Kohala. You are correct in your assessment that much of the water need for the Kawaihae Ten-Year Plan would be at higher elevations than the 319-foot level of the Kawaihae terminal reservoir. Although about 64 percent of the water needed for the Ten-Year Plan requires pumping to higher elevation tanks, a generalized assumption that the proposed project water is not well addressed to the Kawaihae project is not necessarily accurate. The table below

illustrates why. The tank elevation and average daily need figures are from the Ten-Year Plan. The table shows that a lift of 532 feet would be sufficient for almost two-thirds of the volume that requires boosting. The average of the lifts to boost the full volume (1.994 mgd) to the higher elevation tanks is 650 feet. This amount of lift, in addition to the 675 feet lift at the Hawi wells, would be lower than that required to pump potable water from deep wells in the DHHL Kawaihae parcel.

Tank No.	Tank Elev.	Avg. Daily Need	Req'd Lift		% of Volume
Water not requiring pumping					
1	310 ft	1.140 mgd	0 ft		
Water requiring pumping to higher elevation tanks					
2	576 ft	0.616 mgd	266 ft	163.856 mgd-ft	30.9%
3	842 ft	0.603 mgd	532 ft	320.796 mgd-ft	61.1%
4	1108 ft	0.415 mgd	998 ft	414.170 mgd-ft	81.9%
5	1374 ft	0.312 mgd	1064 ft	331.968 mgd-ft	97.6%
6	1640 ft	0.048 mgd	1330 ft	63.840 mgd-ft	100.0%
		Total= 1.994 mgd	Avg= 650 ft	1294.630 mgd-ft	63.6%

Total Water for development
Total= 3.134 mgd

In the DHHL Kawaihae case, the difficulty in securing water sources is the lack of resources at higher elevations with sufficient capacity that can be developed at competitive cost to meet project needs. The conceptual water distribution system for the Ten-Year Plan is based on water being boosted to the higher elevation tanks.

The water needs estimate for the future phases of the DHHL Kawaihae Master Plan were based on a generalized conceptual plan. Although part of the future phases lies below the 1640-foot elevation, the larger part lies above 1640-foot elevation. Your point that water from the proposed project may not be well addressed to this part of the future phases may be correct. Then again, the future phases might be modified to have low and medium density uses in the lower elevations parallel to the Ten-Year Plan lands and pastoral type uses in the mauka lands. If this happens, the larger part the water needs would be within reasonable reach of water from the proposed project. The much smaller requirement of the mauka lands could then be serviced from the 1640-foot level tank or from some higher elevation sources. The Water Department, in the spirit of reserving water for Hawaiian homestead developments, included the full potable water requirement of the DHHL Kawaihae Master Plan in the proposed project water needs count (see Appendix F, page F-2).

The Kawaihae Cogeneration Partners has obtained a lease on DHHL property in Kawaihae for its cogeneration plant. However, the lease award is currently in litigation. Any desalinized water produced by the proposed plant and delivered to users would certainly reduce the water needs in the South Kohala coast. Detailed information on the amount and terms under which desalinized water would be made available to the DHHL Kawaihae project or other developments are not available publicly at this time. If desalinized water is to be used in the DHHL Kawaihae Ten-Year Plan, the supply must be still pumped up from the desalinization plant to the Ten-Year Plan's distribution tanks.

II. Alternatives to the Action - Section 4 of draft EIS

One of the difficulties in estimating water needs is not so much in arriving at the gross need of a development or area but in projecting the time period during which the increments of the gross would be needed. The cyclical nature of the economy adds to the difficulty. The methodology used in making the estimates is discussed in Appendix F of the draft EIS.

On your comments about the sources that can be used to meet the 10.7 mgd water need during the 2005 to 2009 period, we differ with you on your expectations of the sources that you described. We also looked beyond 2010 at the longer-term needs that should be met by proposed sources.

Lalamilo source. This potable water pumping center, made up of four wells, is a good source. However, care must be taken not to overpump the center. The reason for placing the wells on standby after completion of Phase I of the proposed project is explained above. Incidentally, in counting the effective output of a well group, the largest pump is normally assumed to be on standby for malfunction or maintenance, thus in Lalamilo the effective output would be 3.9 mgd.

DHHL Kawaihae project. Although the final EIS may have stated that deep wells are anticipated to provide about 3 mgd, it also reported that of the two on-site exploratory wells drilled, one produced brackish water and the other produced potable water at pumping rate of about 0.2 mgd. This pumping rate is far less than the anticipated yield of 700 gpm or about 1.0 mgd.

Chalon does have ample water for its needs. However, the water source, whether ground or surface, needs to be developed for use. Chalon also needs to become a water purveyor, subject to stringent safe drinking water regulations, if it plans to build and maintain a private system. The proposed project is an alternative to its earlier plan. The amount for Chalon in the 10.7 mgd total is 0.4 mgd.

As in Chalon's situation, the proposed project gives Nansay Puako an alternative to developing its own water system. If Nansay decides to meet its water needs from the proposed project, the reduced requirement on Nansay's Ouli wells would also reduce demand on the Waimea aquifer.

You concluded that there is no shortage of potable water up through the year 2009 based on your analysis. However, our review of the situation as discussed above, does not support your conclusion. Because of changing conditions or uncertainties relative to the sources you pointed out, it is prudent for the affected water users to look at alternative sources to meet their needs.

An important factor from the supply side is the capacity of the pertinent aquifer to provide the needed water supply. For instance, take the Waimea aquifer system [code 80301]. The estimated cumulative need to year 2010 is 10.7 mgd for the DWS system as shown on page F-1, Appendix F, draft EIS. If 50 percent of Waikoloa's total potable water need is required by year 2010, it would add about 8 mgd (see page F-7, Appendix F). This would bring the total potable water need to 18.7 mgd. Since the irrigation water for Mauna Kea Properties, Hapuna Beach Park, and section of Waikoloa is also pumped from the Waimea aquifer, it would add another 2.3 mgd (see page F-7, Appendix F). The sum of the potable and irrigation water requirements would then total 21.0 mgd.

The Waimea aquifer system [80301], from which the supplies described in the above paragraph are pumped, has an estimated sustainable yield of 24 mgd. The 21.0 mgd requirement comes close to the limit. There is concern about planning withdrawals so close to the sustainable yield in this particular aquifer. First, the author of the sustainable yield estimates states that the figures should be used with caution (see pages 121, Appendix F). Second, the author further states that the sustainable yield estimate is poor (see page following page 121, Appendix F). Third, a large portion of the aquifer's drainage is not in a high rainfall area and recharge potential is limited (see page A33, Appendix F).

Although there is a possibility that sufficient potable water can be developed from the Waimea aquifer system to provide for the needs of the area to year 2010, the probability is poor that the system's resource can be stretched further to meet needs projected beyond year 2010 (see page 2-8 for discussions on adjacent aquifer systems). Thus, the primary issue of satisfying the long-term needs of the area would remain unresolved.

The construction time schedule that you refer to in the draft EIS is a tentative schedule. It may have been overly ambitious considering present economic conditions. A major assumption in implementing the proposed project is that sufficient commitments from water users must be in place to meet project financing requirements before funding can be approved by the County Council. From a practical standpoint, because project construction can start only when funds become available, the gap between project completion and need for additional water can be expected to be much closer than what you pointed out. A clarification on the tentative schedule will be added in the final EIS.

As stated earlier, estimating the timing of need is most difficult. It could differ considerably from what is projected. We agree with you that because of the current economy and strained financial situation of some developers, projections may not be attained until years later. Similarly, construction might not commence until the economy is stronger. This a major reason for constructing the proposed project in two phases of 10 mgd each. Since the financing commitments for the project is expected to fully cover the cost of the 10-mgd Phase I, construction of Phase II can be deferred until sufficient demand warrants the additional water.

Regarding smaller scale sources, with experience and improvement in technology some possible sources may develop into valuable sources. At the same time, other needs may arise. For example, on the supply side, high-level ground water sources are being explored in the forest reserve area in Waimea. Test drillings show good possibilities. However, the performance of the such wells is not known. Pumping and monitoring to validate their performance are necessary before their reliability can be assured. On the need side, the DHHL has recently acquired additional lands from the State in Lalamilo and Keoniki. DHHL is now evaluating its options on use of the lands and additional water will more than likely be needed. Although, smaller scale sources are good potential water suppliers, the primary issue is whether sufficient volume from such sources can be found in South Kohala to support the district's long-term future needs. Although we agree with you that actual demand may occur until much later than projected, nevertheless, as long as "water follows land use" the estimated need will remain.

III. Cumulative and Secondary Impacts

Although, as the reviewer states, "it is difficult....to come up with a quantification of that part of the future growth in West Hawaii that can be attributed to this project," the Socio-economic Assessment Impact (SIA) did attempt just that. The relative contribution of the project to projected population increase was analyzed in Section 3.3.1 of the SIA (see Appendix A), and subsequent sections discussed related social impacts.

We are puzzled by the reviewer's assertion that the secondary impact implications of the "No-Project" Alternative were not discussed. In addition to the Historical Trends and As Planned Scenarios (sub-Alternatives of the Proposed Projects), the No-Project case was explicitly discussed in sections on impacts in each impact category of the SIA (see Section 3.3). As discussed in the EIS (and affirmed by the reviewer in his letter), the actual growth of population in Kohala is nearly impossible to predict. For the purposes of the EIS, it was assumed that growth would continue to occur in the water-service area even without the project, and the level of growth was arbitrarily assigned as 50 percent of the project-related growth just to provide a benchmark. We readily admit that such a figure is just an approximation, but the unsuccessful track record of carefully crafted population projections for Hawaii demonstrates the need for caution in attributing accuracy to estimates based on very uncertain future conditions.

When the reviewer states that the "actual future may lie somewhere in the middle" of the As-Planned and Historical scenarios, then uses this fact to question whether the project-related growth can accurately be ascertained, he confirms precisely the point made in the EIS: these two scenarios are endpoints along a continuum of possible effects. The exact outcome along this continuum is at this point unknowable.

The following is in response to your list of questions on page 5 of your letter:

Ocean and Marine Environment: The reviewer includes in his list of indirect ocean and marine impacts additional pressure on fishing resources, incidence of ciguatera, and non-groundwater related pollution. Properly speaking, such impacts are not direct or secondary results of providing more water to the Kohala coastline. Instead, these are secondary effects of secondary effects. There is indeed a "plethora" of similar impacts that would continue to result from the diverse activities that potential new residents engage in.

This response is not meant to downplay the fact that such concerns are valid considerations for the general debate on development in West Hawaii. The forum for discussion, however, is not the EIS for the subject project. Instead, these issues might be taken up in formulation of the County General Plan, Community Development Plans, and policy documents and legislative debates with specific marine issues.

Flora and Fauna: No detailed discussion on flora and fauna impacts was included in Chapter 9 because there are virtually no impacts expected.

Air Quality: Developments that occur as secondary results of the project will produce low levels of air pollution. If development unfolds as anticipated in either the As-Planned or Historical Trend scenarios, the emissions would be those characteristic of resort hotels and housing subdivisions, along with associated increases in automobile traffic. Because the wind regime in Kohala is dominated by high velocity trades and onshore breezes, anthropogenic air pollution would continue to be minimal in the area. If the situation justifies, the State Department of Health is empowered to impose conditions on developments in order to minimize air pollution.

Roads and Highways, Schools, Fire and Police, Housing: General impacts in each of these areas are discussed in the EIS. What the reviewer seems to focus on in his specific questions are the solutions to the "problems" that some of these impacts might pose. It would be unwise to devise (and especially to implement) complex, costly and detailed mitigation measures for problems that may not come into being or may assume forms significantly different from those that are now envisioned. The economic and revenue benefits that would result from growth associated with the project are expected to be substantial. The direction of spending for these funds (e.g., towards housing, recreation, transportation, public safety facilities, schools, etc.) should not be constrained by specific measures devised prematurely, before the nature and scope of the actual growth fully unfolds. Instead, it is only sensible that those government agencies responsible for planning facilities and improvements in the region monitor the actual needs of the area closely and consistently in regard to cumulative impacts.

An EIS must consider cumulative impacts, although the definitions of what these are is far from precise. It should be noted "cumulative" is an undefined term in Chapter 343, HRS and §11-200, Department of Health Administrative rules. Our practice has been to include discussion of similar (but not directly related) projects that could magnify the effect of the subject project's impacts.

Calculation of cumulative impacts may be relatively straightforward, yielding accurate and reliable results, or it may be exceedingly speculative, leading to questionable results.

In the case of actions that indirectly influence growth, but do not specify its nature, timing, and precise location, the assessment of cumulative secondary impacts is highly problematic. This is particularly true in a setting in which the potential for growth is not seriously constrained (and, therefore, predictable) because of saturation by existing uses, market inflexibility, or governmental regulation.

Although plans and projections do exist for growth in Kohala, it is extremely naive to rely on these projections as even approximate measures of the nature, distribution or magnitude of actual growth that will ensue. In the case of Kohala, there are literally hundreds of landowners and entrepreneurs ready to adjust ventures based on the ever changing real estate, visitor industry and regulatory climate.

There is clearly no way to accurately forecast what type of growth will take place and when and where it will actually occur. It would be fruitless and bad science to perform detailed calculations or impacts related to vague and uncertain plans simply for the (false) appearance of accuracy.

The wiser course is to consider the spectrum of primary and secondary impacts of the project in the context of ranges of possibility for the Kohala region. The SIA and EIS discussed activities and events related to not only this and other water systems, but also to other projects of all type with implications of population growth.

Throughout the text, note was taken of the fact that the Kohala Water Transmission System is only one stimulus for development in Kohala, and that various projects are likely to transform population, jobs, housing, and the social composition of the area in ways that augment or cancel out trends that would result from the proposed project.

Section 3.4, "Cumulative Impacts of the Project," discussed the range of proposed developments for the Kohala area and attempted to frame the net impact of the project in this rough context. However, because nearly every one of these proposed projects is speculative and subject to complete change, it is impossible to determine precisely the joint social, housing, economic and cultural impacts of project and non-project related growth.

IV. Financing

Our response to your letter of August 5, 1995 commenting on financing of the proposed project is contained in a separate letter to you dated October 30, 1995.

V. Other Issues

North Kohala need estimate: You are correct in your observation that a clear explanation of the estimate of future needs for North Kohala is not covered in the draft EIS. It will be included in the final EIS. A worksheet accounting the needs that make up the 4.3 mgd estimate is included as page

F-7 in Appendix F of the draft EIS. Because of concerns that there would be little left in the Hawi aquifer for possible future water needs in North Kohala, a discussion with Chalon Hawaii, owner of the former Kohala sugar plantation lands, led to including 3.0 mgd for possible long-term future needs for that section of North Kohala generally Hawi side of Mahukona. The figure is included for estimate purpose. As noted in the draft EIS, discussions with USGS suggest that withdrawing an additional 4.3 mgd beyond the 20 mgd is feasible. The Water Department is arranging with the USGS to apply its modeling studies to verify the discussions based on a set of assumed well locations, depth, and pumping rates. In the interim, the feasibility of withdrawing the additional water will be reported as an unresolved issue under Section 12.1 Environmental Concerns in the final EIS.

The following computation gives an idea of the population that can be serviced with 3.0 mgd supply. Based on an assumed average per capita consumption of 150 gallons per day, the 4.3 mgd and 1.3 mgd (4.3 less 3.0) estimates translate to populations of about 28,600 and 8,600 persons. Depending on the consumption rates of future activities, the projections could be lower, higher, or fall somewhere between these figures. The population projections given below are for comparison.

	Yr 2005	Yr 2010	Yr 2020
County General Plan Series A	5,363		
County General Plan Series B	6,721		
County General Plan Series C	7,998		
State DBED M-K Series		8,470	
State Land Transport Master Plan (preliminary)			11,800

(Note: The population projections given above are for all of North Kohala District. No adjustments have been made for future population in areas south of Mahukona.)

Economic Analysis, Cost/Benefit Analysis: Our consultant points out that the stated benefit/cost ratios are average ratios expected during the resort build-out periods under two different development scenarios—the Historical Trend and As-Planned. It should be also noted that the tight fiscal condition facing both state and county governments are not attributable to the lower benefit/cost ratio for resort developments that have taken place in the past. The consultant's best estimate for the average benefit/cost ratio based on the assumptions made remains at 4 to 1.

Employment: Your observation is correct on the average number of jobs that will be in place during project construction (Table 3.3, p. A-47, Appendix A). The given figures include both direct, and indirect and induced jobs related to the project construction. Although it is difficult to visualize indirect and induced impacts, they should be recognized to avoid undue understatement of their employment value.

Irreversible and Irretrievable Commitment of Resources: We have interpreted the terms irreversible and irretrievable to apply primarily to nonrenewable resources whose value will be lost and cannot be restored. Such resources include things like fossil fuels that are mined or endangered species of animals or plants that would become extinct because of the action. We have considered the basal water in the Hawi aquifer as a renewable resource since it is continually recharged through precipitation. From a use standpoint, one could say that the resource is committed to the amount that it is used. However, in the Hawi aquifer case, it would not preclude the northern North Kohala community from also using water from the aquifer. From the discussion earlier on the need estimate for North Kohala, there appears to be ample supply available to meet the area's foreseeable needs, particularly if the community desires to retain North Kohala's rural characteristic.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

Mark Goodoni
PO Box 1269
Kapaau, HI 96755
August 12, 1995

Governor Ben Cayetano
State Of Hawaii
C/O Office Of Environmental Quality Control
220 South King Street #400
Honolulu, HI 96813

Dear Governor Cayetano,

Thank you for the opportunity to comment on the EIS for the Kohala Water Transmission System (KWTS).

I am concerned that a complete financial plan for funding the KWTS has not been disclosed in the EIS. As it stands, the EIS contains insufficient information on the extent to which the project could impact the individual County of Hawaii taxpayer. The EIS states that the Department of Water Supply (DWS) is planning to recommend the use of Hawaii-County-backed long-term general obligation bonds to finance the construction of the KWTS, at an estimated cost of $80 million at 1993 prices.

If the DWS plans on using public funds to finance this project, it must inform the public of the financial risk and impacts of using those funds; otherwise the EIS is inadequate. Even when public funds or bonding capability are not to be used, an EIS should cover financing, because a bankrupt project can definitely have a social and environmental impact. When bonds guaranteed by the County of Hawaii are to be used, however, it is especially important to include the financial details, since every taxpayer in the county assumes an obligation in the debt-service on those bonds. There should be a discussion of what obligation is taken on by the individual taxpayer when bonds in the amount of $80 million are floated.

As I am writing this response there is an article in *West Hawaii Today* concerning the County Of Hawaii's consideration of a $37 million bond float to finance various mandated and discretionary capital improvement projects that will increase the county's indebtedness 36% to approximately $150 million. According to County Treasurer Frank Manalili, the county this year will make interest and principle payments of $13.5 million on its existing $106.3 million debt, a fiscal burden within an acceptable safety limit. He says a good rule of thumb is to limit indebtedness to 13% of general-fund revenues, which means the county could safely take on another $4 million in yearly debt service.

The added debt for these miscellaneous projects would use up more than half of the $4 million cushion and increase the county's liability into a per-capita obligation of $1,337. This is double the median figure for residents of similiar-sized mainland counties, according to a credit report compiled for the county by Moody's Investment Services. While the additional indebtedness is still within the 13% comfortable repayment cap, Mr. Manalili says it may leave the county without a sufficient safety threshold if it should be forced to fund *unforseen projects* in the near future.

I have emphasized "unforseen projects" because according to the EIS, no financial plan for funding the proposed KWTS has yet been submitted. It is not acceptable for the financial information to be held privately until eventual presentation to county officials after the final EIS is done. It should be part of the EIS process, especially in light of the county's plan to increase its indebtedness to finance various other mandated and discretionary capital improvement projects.

Even if you look only at the $60 million Phase 1 is estimated to cost (and it will likely be more if you factor in 1996 construction costs), the interest alone, at 5.8%, will add another $3.4 million a year. Thus, without any principal reduction at all, we would be over Mr. Manalili's 13% safety limit, and well beyond the median figures for per-capita debt burden of all other Americans.

This is a significant impact, especially considering that the article states that county real property tax revenues, which comprise 55% of the operating budget and pays the largest chunk of debt service, dropped about 1% during the fiscal year ending June 30 --the first such decline in 20 years.

With the closing of the Hamakua Sugar Industry this year and the still-stagnant tourism trade, the island economy is continuing to undergo economic ills, and the outlook for increased county revenues to pay increased debt service does not appear to be positive.

In summary, the EIS as currently drafted does not disclose possible financial impacts to county taxpayers, so it does not allow them to come to an informed decision on the KWTS. It should be redrafted to reflect these impacts, and until this happens, it should be rejected.

I look forward to reviewing and commentng on the final EIS.

Sincerely,

Mark Goodoni

Mark Goodoni

cc Quirino Antonio Jr.
Megumi Kon

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
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November 1, 1995

Mr. Mark Goodoni
P. O. Box 1269
Kapaau, HI 96755

DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for your comments on the DEIS for the Kohala Water Transmission project dated August 12, 1995.

The concerns you have expressed are primarily related to project financing. You are correct that it is our intention to propose to the County of Hawaii that the project be financed with General Obligation Bonds. The County will be the recipient of additional real property taxes due to development made possible by the project.

With respect to the discussions the Department of Water Supply has had with landowners regarding financing of the project, they are ongoing and directed at arriving at a strategy which will be acceptable to the Department of Water Supply and the County Council. The result of these discussions to date is as we have reported at the public meetings in Kohala. There is agreement as to the broad strategy that the users will pay for the capital cost of the project. The current economic situation in Hawaii however prevents them from committing to any specific course of action now. Before the project is formally presented to the Council for consideration, a definitive financing plan must be developed.

We do not agree with you that the EIS is the proper vehicle for discussion of the specifics of a financial plan. The County Council is charged with the responsibility of setting priorities for funding diverse capital improvement projects and weighing the potential risks and rewards. Prior to the County Council acting on any financing plan for the project, they are required to hold hearings on the matter. Full disclosure and discussion about the possible financial impacts of the project, the specific commitments to be given by the users, other competing capital improvement projects, prudent County indebtedness, and other relevant matters may properly be discussed at that time. We would draw your attention to the recent series of hearings conducted by the Council with respect to the $37 Million bond float mentioned in your letter.

We hope the above explanation is helpful.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

... Water brings progress...

Ana Nawahine-Kahoopii
PO Box 1395
Kapaau,HI 96755

August 20,1995

r.Quirino Antonio Jr.
epartment of Water Supply
5 Aupuni Street
ilo,Hawai'i 96720

ear Mr.Quirino,

Enclosed are my comments re:the proposed Kohala water transmission project.
am a kanaka Maoli,active in the Sovereignty Movement.

I am very concerned about the proposed water transmssion project.As you know
ohala is of great cultural significance to our people.It is a rural community and we wish to remain so.The department of water is proposing an irreversible commitment of a source sacred to my people.This project will also create changes in the Kohala area th unforseen consequences.As an indigenous Hawaiian I am committed to otect our natural,cultural and community resources.As a result I am presenting you th my comments and will continue to closely monitor this project.

I look forward to your reply re: my concerns in the final EIS.Mahalo for the pportunity to comment.

Malama Pono,

Ana Nawahine-Kahoopii

Ana Nawahine-Kahoopii

:Nation of Hawai'i
Ka Lahui Hawai'i
O.H.A.
Ahu pua'a Action Alliance
Dr.Kekuni Blaisdell

COMMENTS ON THE DRAFT EIS FOR THE KOHALA WATER TRANSMISSION PROJECT

The EIS does not demonsrate need:
In section 5-1 the consultant refers to major resorts planned for South Kohala stating that "due to an international economic slump development is at a standstill".And in section 6-13 re:HHL at Kawaihae development"water is a necessary, but not sufficent,ingredient for this development" In plain english the entities that are to benefit from this water project do not have the financial resources to implement development.

Assessment of Archaeological sites are inadequate:
In section 5-19 a total of five sites were identified during the field work."The presence of a platform and a habitation complex (sites 19,775 and 19,776) were surprising.Insufficent work was carried out at this site to allow this to be more than conjecture at this point".If all areas have not been identified than related impacts cannot be identified which renders the EIS inadequate."Sufficent work was carried out on sites 19,774,19,777 and19,778 and they can be considered no longer significant."Significance of a site is a subjective decision,and although legal guidelines exist the evaluation criteria is unclear.The rights of the Kanaka Maoli have not been addressed."Site 19,775 a probable burial site should be preserved".The issues of access,sufficent space and privacy to worship are not addressed.Public Law 95-341 clearly state Whereas such laws and policies often deny Native Hawaiians access to sacred sites required in their religions,including cemeteries;Henceforth it shall be the policy of the USA to protect and preserve the Native Hawaiians inherent right to believe,express,and excercise traditional religious practices including and not limited to access to sites, possession of sacred objects and the freedom to worship through ceremonials and traditional rites.Sec 2 provides a provision that states Native Hawaiian religious leaders shall work in consultation with federal departments and other agencies responsible for administering relevant laws in order to evaluate their policies and procedures.They are to determine appropriate changes necessary to protect and preserve Native Hawaiian religious cultural rights and practices. The EIS does not indicate any consultation with Native Hawaiian religious leaders this renders the EIS inadequate.

Social Impact Study Inadequate:
Indirect social impacts are not addressed in the EIS for example:section15 page 20 refers to problem of homelessness particularly among Native Hawaiians as a chronic problem.How will the proposed project impact on this problem?Page 21 states that a dominant trend in the modern era of coastal resorts has been a dramatic increase in the wealthy,elderly caucasian population.With significant

increases in immigration(page 108 the population of Kohala could exceed 50,000 by the year 2015).How will this marginalization of the Kanaka Maoli affect the perpetuation of Native Hawaiian cultural identity?What impact will these plans for development have on our subsistent lifestyle?Page 95 states "the growth of DHHL housing and the resort industry in close proximity has the potential to match jobs with job seekers.This is an assumption that is typical of the exploitive nature of the visitor industry.A ready made labor pool.Visitor industry jobs promise low wages,inconsistent benefits,and unreliable employment.Most hotel employees work at least two jobs just to make ends meet.The lack of diversified employment opportunities has not been addressed although in sec:6-4 it is a stated part of the general plan.Also what effect will the combination of further marginalization,and disenfrancisment have on the Hawaiian population?Public Law103-150 states"whereas the health and wellbeing of the Native Hawaiian people is intrinsically tied to their deep feelings and attachment to the land and whereas the long-range economic and social changes in Hawaii over the nineteenth and twentieth centuries have been devastating to the population and to the health and wellbeing of the Hawaiian people.The Proxmire Act Chapter 50 A part 4 states it is a criminal offense to subject a group to conditions that are intended to cause physical destruction of the group in whole or in part. Section 3 of Public Law 103-150 acknowledges the deprivation of the rights of Native Hawaiians to self-determination.
In section 4 of Public Law 103-150 a provision exists for reconciliation and provides a foundation for redress.This EIS fails to address both secondary impacts and demonsrates at most a superfical awareness of the inherent rights of the Kanaka Maoli.This section of the EIS is inadequate.

4. Native Hawaiian Land and Water Rights
Native Hawaiian rights have not been sufficently addressed in the EIS.For example in section11-3 a brief reference is made re: safeguarding Native Hawaiian gathering,fishing and hunting rights.How specifically will this be accomplished? Also in section 11-3"continuing and expanded emphasis on Hawaiian culture in Kohala resorts"Is this how you would propose to safeguard the culture of the Kanaka Maoli?The EIS also fails to address the rights of Kanaka Maoli to land and natural resources in particular water rights.Surface and ground water are part of the ceded land trust.Diminishment of this natural resource would result in a loss of resources and/or revenues for the Kanaka Maoli and future generations as well.

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
25 AUPUNI STREET • HILO, HAWAII 96720
TELEPHONE (808) 969-1421 • FAX (808) 969-6996

November 1, 1995

Ms. Ana Nawahine-Kahoopii
P. O. Box 1395
Kapaau, HI 96755

DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for commenting on the DEIS for the subject project. The following responses are in order of the comments in your letter of August 20, 1995.

1. Project need.

We believe that the need for the proposed project has been stated in Section 2 of the draft EIS. It has been a major assumption of the EIS that without a committed market for water-that is, water users obligated in some way to pay facility charges that cover the capital costs of the system-the proposed project would not be constructed. In the interim, while this market is developing, the need for the water and the need for the proposed project remain.

2. Assessment of archaeological sites.

The consultant for the archaeological inventory survey, Scientific Consultant, Services, Inc., coordinated its activities with the State Historic Preservation Office (SHPD). Regarding sites 19,774, 19,777, and 19778, the SHPD stated in their report review letter, "We agree that 3 of these sites are significant solely for their information content (19774, 19777, 19778) and that they do not require any further work and are therefore 'no longer significant'."

Site 19,775 is a burial site. It is located approximately 110 feet from the centerline of the proposed access road to the tank site and approximately 70 feet from the closest right-of-way edge of the road corridor. The site does not fall within the project area and there is a 70-foot buffer from the nearest edge of the road corridor. For those reasons, consultation was not carried out with the Burial Section of SHPD.

The consultant evaluated these sites according to the guidelines and appropriate and criterion provided by the state through SHPD. The issues of access, sufficient space, and worship are not addressed because they are beyond the scope this EIS.

3. Indirect social impacts.

Sections 3.3.5 and 3.3.6 of the Socio-Economic Impact Assessment (SIA) deals with the indirect impacts of the project including extensive treatment of cultural issues (see Appendix A, draft EIS).

... Water brings progress...

Homelessness.

Homelessness was not one of the variables considered because it is not related in any systematic way to either water systems or the development they create. This is not meant to downplay the seriousness of the problem or the need to find solutions. On the Big Island, for example, homelessness is a problem throughout the island, and is particularly severe in East Hawaii, where tourism is not prominent.

Effect of socio-economic/ethnic change on native Hawaiian cultural identity and population.

We agree that there is the potential for impact on native Hawaiian culture, both positive and negative, depending on the standpoint of the observer, as a secondary result of the proposed project. For this reason, the SIA attempted a systematic dialogue with groups and individuals in the Native Hawaiian community in Kohala. The results of this are presented on pages 97 to 101 of the SIA.

Subsistence Lifestyle and Hunting and Gathering Rights.

We agree that continuing development has brought increasing conflict over traditional hunting/gathering rights in shoreline and upland areas, particularly on "private" parcels.

Section 3.3.4. discussed the issue of hunting and gathering and proposed the following mitigation measure: "Actions to safeguard native Hawaiian gathering, fishing and hunting rights from direct and indirect encroachment as a result of continued development."

The proposed forum for discussing and implementing these measures arises at the Community Plan level and when individual developments with potentially direct impact on these issues are proposed. Additional protection of such rights is likely to be institutionalized in Hawaii after the PASH vs Nansay decision at the Hawaii Supreme Court.

Lack of Diversified Employment Opportunities.

Despite the reviewer's opinion of jobs created by the visitor industry, many native Hawaiians choose to work in the visitor industry, even when other jobs may be available. For example, a survey by Community Resources, Inc., and Datametric Research in 1987 found that Hawaiians and part-Hawaiians constituted about one-third of the workforce at both the Westin Mauna Kea and Mauna Lani Bay-the largest single ethnic group at either hotel.

The statement that "the growth of DHHL housing and the resort industry in close proximity has the potential to match jobs with job-seekers," (page 97, SIA) should not be construed to mean that working residents of DHHL would be consigned to work only in the visitor industry. Jobs in agriculture, retail, services, industry, teaching, civil service, and the professions also would be created directly and indirectly by the economic activity resulting from the proposed project.

4. Native Hawaiian Land and Water Rights

The safeguarding of Native Hawaiian gathering, fishing, and hunting rights, and of the culture of the Kanaka Maoli are important issues. However, because the secondary impacts discussed in the draft EIS deals only with possible impacts that may or may not occur, we reiterate that the proper forum for dealing with the specifics is at the Community Plan level and when individual developments with potentially direct impact on these issues are proposed.

We believe the draft EIS has been attentive to Hawaiian land and water rights that may be affected by the proposed project. The following are some examples. On water resources allocation, they are based on water needs, using as a guide the county General Plan and where available, land owner's development plans. Although the numbers themselves (20 mgd to South Kohala and 4 mgd for northern part of North Kohala) may appear disproportionate, they reflect estimated foreseeable needs. In addition, irrigation water from the Kohala Ditch would be available to those who desire to pursue diversified agricultural activities in North Kohala.

On providing water supply for Hawaiian homestead development, the proposed project is being considered by DHHL as a possible water source to meet the water needs of the Kawaihae Master Plan development, depending on cost of participation in the project. An allocation of 3.1 mgd is included in the proposed project for the Ten-Year Plan. Although planning for the remainder of the Kawaihae parcel is very generalized and the water source issue is not settled, 4.0 mgd is included for long-term need of Kawaihae. Together, these two allocations make up 35 percent of the water being transported to South Kohala.

On protection of gathering rights, considerable concern about the effect of basal groundwater withdrawal on the opihi and limu populations along the shore makai of the project well sites in North Kohala. There was concern, also, about the effect on nearshore coral communities in South Kohala coast. Studies were conducted specifically to evaluate these concerns. The studies revealed that there appears to be no potential for negative impacts to marine ecosystems in either North or South Kohala from the diversion of groundwater.

On conservation of resources, the withdrawal of basal ground water from the Hawi aquifer is like a harvesting operation because the aquifer is constantly being recharged. The resource is not being diminished as in a mining operation where the supply has a limit. However, development of the basal water must be done with care to avoid any degradation of the aquifer. The Water Department proposes to carry out an intensive monitoring program to avoid such degradation.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

Governor,State of Hawaii
C/O Office of Environmental Quality Control
220 South King Street
Fourth Floor
Honolulu,Hawaii.96813

Dear Sirs,

This letter is in regard to the proposed Kohala Water Transmission System project in the North Kohala and coastal areas of South Kohala. As a resident of the Big Island and a native hawaiian I strongly approve of this project for the following reasons.

1- The water is high quality potable water that at the present time is not used towards any useful purpose.

2- Growth along the "Gold Coast" is undeniable if we are to provide a future for our children and theirs. Having the water pipeline in place will help to quicken this growth.

3- The people of the Kohala area do not hear their own complaint. They will benefit because they will no longer have to use the some what questionable ground water which is what they have use of now.

4- In time all the people of the Big Island will benefit from the pipeline and even though the economy is not that great here now being ready for a boom is a good plan. If the cost of the pipeline can be passed on to minimize the impact on the small guy "taxpayer", then, yes, this pipeline is exactly what we need.

Your Truly,

Deborah Noa

Deborah Noa

Quirino Antonio Water Dept

To: GOVERNOR Ben Cayetano Esq. of Hawaii, as the ACCEPTING AUTHORITY for the DRAFT EIS for KOHALA WATER TRANSMISSION SYSTEM PROJECT
c/o Office of Environmental Quality Control
220 South King St - #400, Honolulu, HI 96813

From: Henry A. Ross, P.O.Box 99, Kapaau, HI 96755

Re: STRONG OPPOSITION to KOHALA WATER PIPE DREAM

19 August 1995

Dear Governor,

THIS DRAFT EIS IS SO RUEFULLY INADEQUATE AND INCOMPLETE THAT YOU CANNOT MAKE ANY JUDGMENT ON THE PRESENTED MATERIAL THAT YOU WOULD NOT LATER REGRET. If we want to squander County, State and Federal money this is the exemplary project. $80 million (preliminary estimate) to build it and many more millions to maintain and repair it if it ever comes into existence. There are no customers, that is: nobody wants to put his name down in writing as a future user at the prices that are now preliminarily projected and that will double before the project can be finished.

NOBODY NOW LIVING IN THE PROJECTED AREA IS DEPRIVED OF WATER AND THE EMPTY SUBDIVISIONS ARE ALSO PROVIDED FOR. SO THERE IS NO NEED FOR THIS PROJECT OTHER THAN TO ATTRACT MORE PEOPLE TO NORTH KOHALA THAN THE AREA CAN EVER SUSTAIN WHILE THERE ARE OTHER OPTIONS TO PROVIDE SOUTH KOHALA WITH MORE WATER IF IT SHOULD BE NEEDED THERE. "GROWTH" IS NOT NECESSARILY A PANACEA ALTHOUGH IT IS UNIVERSILY SO TOUTED BY FLY-BY-NIGHT SPECIAL-INTEREST GROUPS THAT MAKE A QUICK PROFIT AND RUN. AN EXPANDED WATER SYSTEM, THAT WOULD ATTRACT MORE PEOPLE TO AN AREA THAN IT CAN ABSORB, INESCAPABLY ALSO NECESSITATES EXPANSION OF ROADS AND POWER, PHONE, POLICE, FIREPROTECTION, PARKS, SCHOOLS AND OTHER INFRASTRUCTURE. THE DRAFT EIS MAKES NO MENTION OF THIS.

It does mention 1480 full-time jobs created for an initial 2-year construction period, that means 4000 people added to the 4000 in North Kohala right now, where are they going to be housed? And where are their 1500 children going to be educated; build another school maybe? And half of these temporary people will never leave the area while there are no jobs after the pipe line because of remoteness, which must inevitably lead to hundreds more on welfare at public expense and an increase in crime. In 1988 when we had full employment the hotels and other industries imported people to this island even from Mexico. When they lost their jobs many did not leave and a good number became the cocaine pushers of this island that before only knew marijuana. Social disruption of this magnitude is not well treated in the draft and the cost figures do not reflect the above.

Kohala is rather isolated and a peculiar place in economic respect. Remember the infamous Kohala Task Force of the seventies. Ask former Governor Ariyoshi about it, he will cringe at the thought of the total waste of millions that accomplished almost nothing at all.

Based on a lifetime of experience in different environments and many countries I firmly believe that government should not interfere in people's lives if they can handle the problems themselves. In this case it is obvious that nobody is asking for this water. If the hotels in South Kohala will need more water in the future then it is their task to provide for it, otherwise they do not deserve to be in business and in the past they have proved that they can adequately take care of it. Whatever private enterprise can do, the government should not meddle in, even if well-intentioned, which I doubt. Also, private enterprise will find the most economical way to help itself. We do not have to subsidize this with public money, that would be unsolicited welfare for big business. Thank you.

RECEIVED AUG 2 1 1995

I am speaking as a civil engineer and at age 74 have had my share of field experience with development projects and their habitual cost overruns, often many times the original estimates, I will spare you the examples. I also happen to live in the area and am familiar with its geography and geology. Some years ago we encountered a similar pipe dream to bring surplus water from Hilo over the saddle between the volcanoes to Waimea for farming purposes. There were absolutely no takers, and as far as I know that project died because the people woke up out of their dreams. Are we never going to learn?

I will try to kill this phantasy with information in the Draft EIS.

From the very beginning I have indicated that if water must be piped to Kawaihae from elsewhere, the obvious and cheapest solution would be to mine it in "Awini" (an area between Pololu and Waimanu Valleys north-west of Waipio Valley on this Island). One of the project propagators had aestetical objections and would not pursue that at all.

So what have we now? A draft EIS that does not even explore - as an alternative to the action - the much more plentiful water from Awini that would be much cheaper to develop and could serve South Kohala, which is given as its destination on page 1-1 #1 of the draft EIS.

After indicating on a map 3.2-1 page 3-2 that Awini is "Hydrologic Study Area No.1 (Area 2 is the one the EIS deals with) that is then further coveniently forgotten and ignored while Section 4 (p.4-1) on ALTERNATIVES TO THE PROPOSED PROJECT is prefaced with: "The alternatives .. considered .. were the transfer of water from East Hawaii, desalination of brackish water, use of high level ground water, and no action." AWINI SHOULD HAVE BEEN AN ALTERNATIVE IN THE DRAFT.

The reason not to have it considered was no-doubt political (see p.9-16 & p.13-4 Project Statement #7 EIS), as a pipe line along the North Kohala coast line would invite as customers owners of lands who heretofore wanted to develop and upzone lands for speculation but could not because it would have been too expensive to provide water for their ventures. These speculators are usually big contributors of political campaign funds. With the exception of a Mahukona Harbor enclave owned by Chalon that was zoned for minor resort all other shore lands down to Kohala Ranch (with its own water supply) are zoned agricultural and a majority of North Kohala people want to preserve this pristine coastal area and keep the resorts and condominiums in the South Kohala area that ever since the first County General Plan had exclusively (and after many public hearings) been designated for such use by allowing many thousands of hotel rooms and condominiums. Furthermore the Hawaii Constitution mandates preservation of agricultural lands, which regrettably is taken rather lightly by some County politicians, as indicated above.

Chalon has informed me repeatedly, over the years, that they do not need and would not pay for extension of a coastal water line coming from Hawi for its small resort in Mahukona. It has its own water source and the means to bring it down from the mountain. But it now appears that the County Water Department wants Chalon as a customer although Chalon has not signed as an interested party, probably because like others in South Kohala it anticipates too high a price. <u>THE FACT THAT, ALTHOUGH SOLICITED, NOBODY HAS YET SIGNED UP MAKES THIS PROPOSED VENTURE A PIPE DREAM.</u>

So with no political advantage of a pipeline along the shore, the County should certainly have explored Awini as a viable alternative if indeed any water is needed that cannot be developed by the land owners in South Kohala themselves - including the Dept.of Hawaiian Home Lands that certainly must be looking for cheaper water than this project could ever deliver as proposed in the EIS.

All of these considerations are not part of any feasibility study in the EIS which is thus deficient for not fully indicating economical impacts that are very important, especially where taxpayers' money concerned. The obvious preference for a coastal pipeline in the EIS without mentioning the cheaper Awini solution points, in my opinion, to a political influence upon the EIS that must inevitably lead to its rejection until the Awini alternative is duly explored.

I want to demonstrate with numbers taken from the EIS why Awini is a better solution (in case the County must really provide that).

<u>MOST IMPORTANTLY THE AWINI (Waimanu) AQUIFER No.80102 IS FOUR TIMES AS BIG AS THE HAWI AQUIFER. IT FIGURES AS 110 MGD (million gallons a day) ON THE COUNTY'S OWN MAP ON PAGE 5-10, VERSUS 27 MGD FOR HAWI.</u> Add to this that on page 5-11 the EIS tells us that: "... withdrawal of 20 mgd from the Hawi aquifer is feasible but ... if pumping is concentrated, the likelihood of saltwater intrusion is increased. That makes this project dangerously marginal as, qua requirement and costwise, 20 mgd is what the pipeline is sized on as the goal of the project. <u>NO SAFETY FACTOR AT ALL</u>, while the aquifer magnitudes are no more than calculated educated guesses or estimates anyway and should be discounted by 25 percent for sound scientific reasons.

The pipeline as projected is about 24 miles long upto Kawaihae. From Awini the longest pipeline would be 16 miles and if tunneling through the crest of the Kohala Mountain is used would be shorter.

Another advantage is a lot of available surface water in Awini that goes eastwards into Waipio Valley and the Hamakua ditch system and westward used to go to North Kohala until some years ago maintenance and repair of that ditch and tunnel system became too costly and it has been given up by Chalon. I estimate that about 12 mgd is still available that could be used for South Kohala, although a purification plant may be required, which the EIS should have explored.

I further refer to page 7 of a <u>Feasibility Study</u> done in 1988 for the Water Dept. by Consultant W.Y. Thompson (Appendix B of EIS), that gives data for Awini and <u>concludes with: "The potential for water supply is great in this area"</u> (see also data in Appendix F-7)

<u>I STRONGLY SUGGEST THAT THIS ALTERNATIVE BE IMPLEMENTED IN THE EIS.</u>

Henry A Ross

XC Department of Water Supply, County Council - Mayor.

To: GOVERNOR Ben Cayetano Esq. of Hawaii, as the ACCEPTING AUTHORITY for the DRAFT EIS for <u>KOHALA WATER TRANSMISSION SYSTEM PROJECT</u>
c/o Office of Environmental Quality Control
220 South King St - #400, Honolulu, HI 96813

From: Henry A. Ross, P.O.Box 99, Kapaau, HI 96755

<u>Re:</u> <u>STRONG OPPOSITION to KOHALA WATER PIPE DREAM</u>

22 August 1995

Dear Governor,

This letter is supplementary to my response on the Draft EIS for the Kohala Water Transmission System Project, dated 19 August 1995, that I mailed to the above adress yesterday.

I want to call attention to the fact that the 12 test wells drilled for this project in North Kohala were done by the U.S. Geological Survey. Its Report # 95-4113 is 57 pages long and contains most of the technical data used in the Draft EIS issued by Hawaii County. I attach the title page of my copy, and think that you might want to obtain a copy for your files from the U.S. Geological Survey office in Honolulu. The Draft EIS could not appear before this report was published.

It is obvious that federal money was involved in this project and there may be federal land involved where the pipeline passes the former Coast Guard Loran Station in North Kohala, depending on which side of the Akoni Pule Highway the planned pipeline will run, which I think has not been determined yet.

I do not know what the triggers or criteria are for a federal EIS to be required, but it is likely that this is the case, more so because the Draft EIS cannot properly be judged for technical details without the USGS Survey as its backbone.

I also would like to call attention to the exaggerated ideas this county has about "homerule". It even recently invented a "county eis" as a report by developers that the public is not consulted on at all. In this case it wanted to keep the final acceptance of the draft in-house for its political games.

I therefore resent to find my name printed in Attachment A to Appendix A with a denomination as "Resident and <u>activist</u>" in a derogatory sense when viewed in the context of the whole. Why put a label on certain people and what is the purpose and criterium of this distinction versus others on the list?

I do not mind being called an ACTIVIST. After all without activists like Jefferson, Madison, & Co, the U.S. would not exist. But if meant to influence the mind of the originally contemplated County Mayor as "Accepting Authority" I OBJECT. <u>The Draft EIS seems geared to support an unwarranted project.</u>

Henry A Ross.

XC to Dept of Water Supply, County Council - Mayor.

RECEIVED AUG 2 2 1995

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
25 AUPUNI STREET • HILO, HAWAII 96720
TELEPHONE (808) 969-1421 • FAX (808) 969-6996

October 20, 1995

Mr. Henry A. Ross
P. O. Box 99
Kapaau, Hawaii 96755

DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for commenting on the DEIS for the subject project. The following responses are in order of the comments in your letters of August 19 and 22, 1995.

Jobs and Social Impacts.

The jobs and social impacts would be distributed not only in North Kohala but island-and even State-wide. Many residents of North and South Kohala who will be unemployed or underemployed are expected to participate in the construction of the transmission system. Also, workers from around Big Island will commute or temporarily relocate. Neither of these groups would be associated with population change, and the income they earned (and money spent) would be highly positive economic impacts for Kohala and the Big Island.

Awini Section as Alternative.

The Awini Section of the Waimanu Aquifer System [80102] was once a large contributor to the Kohala Ditch flow. According to the attached diagram, the Awini Section streams contributed about 12 million gallons per day (mgd) toward the plantation-era Kohala Ditch flow of 27 mgd. Although the Awini Section is a valuable water source its extremely remote location and resulting high cost of maintenance led to it's abandonment. The present average flow in the Kohala Ditch is estimated at 10-15 mgd.

The State Water Resources Protection Plan (Yuen & Assoc. 1992) reports that the Waimanu Aquifer System is the most water-rich of the Kohala Sector. The System's estimated sustainable yield of 110 mgd is computed on the assumption that none of the groundwater drains to streams and all is developable. However, much of the base flow of the Waimanu System streams is from groundwater discharging from high-level dike compartments. Most of this water is captured by the Upper and Lower Hamakua Ditches and the Kohala Ditch system.

... Water brings progress...

Recapturing the stream waters in the now abandoned Awini Section may appear logical but the Water Department did not consider the development of the Awini Section and related improvements, as an alternative for several reasons.

First, the future of agricultural activities and associated need for irrigation water in North Kohala have not been established. The County General Plan sets out the following courses of action on agriculture in North Kohala:

- Assist in the further development of diversified agriculture in the district..
- Encourage the maintenance of and more intensive utilization of Kohala Ditch irrigation system for agricultural production.
- Support the development of private and State agricultural parks as a means of making agricultural land available for commercial agricultural activities.

Chalon Hawaii, owner of the former Kohala sugar plantation lands, foresees much of the land remaining in agricultural use. The State has been considering an agricultural park in North Kohala. About 4 mgd of irrigation water would be needed for the park. The availability of lower cost irrigation water from the Kohala Ditch would be a major factor in encouraging and maintaining agricultural activities in North Kohala. The Kohala Ditch, currently, provides water to a few agricultural areas and a hydroelectric power plant.

Second, the Kohala Ditch is today estimated to have an average flow of about 10-15 mgd. If the ditch water is to be used as source for both irrigation water for North Kohala and potable water for South Kohala, additional source must be developed to increase ditch flow. Rebuilding the water collection and transport system in the now abandoned Awini Section in the Waimanu System would a logical way.

A water resources management and development study for the Kohala Ditch-Phase III (Akinaka, Bowles, & Mink, 1975) reported that any construction in the Awini Section of the ditch would be relatively costly compared to urban and rural construction. The prices would reflect the high risk factors found in the ditch site due to safety, weather, and logistics. They reiterated that 17 lives were lost in the construction and maintenance of the ditch. The report estimated construction cost then for similar ditch tunnels ranging from $300 to $500 per lineal foot. This was not meant to say that construction of improvements were not feasible. Construction, today, for comparable work is estimated to be very much higher given today's material and labor costs, workplace safety regulations, insurance requirements, and environmental regulations. For the same reasons, system maintenance would also be very high. In addition, the Kohala Ditch system has received little, if any, maintenance since the closing of the plantation in early 70's. Consequently, much of the system may require major reconstruction or new construction.

Third, a large storage capacity must be provided to insure a reliable supply during periods of dry weather. The Akinaka, Bowles, & Mink study mentioned above, analyzed the amount of storage required for a gross irrigation water demand of 26.4 mgd. The water demand model (Alexander) used for the analysis indicated that the optimum storage capacity lies between 1000 and 3000 million gallons. These are huge storage requirements. For example, the Wahiawa Reservoir on Oahu has a capacity of about 2900 mg. The three raw water reservoirs for the Water Department's Waimea-Puukapu system have a total capacity of 150 mg.

Fourth, a large water treatment plant would be required to treat the raw ditch water for potable uses. The EPA federal safe drinking water regulations on treatment of raw water for potable use and monitoring of the process are very stringent. The plant would be expensive to operate and maintain.

Fifth, there are environmental and regulatory concerns that may preclude cost-effective development of stream and ground water sources in the Waimanu System. The more obvious concerns are conservation and protection of natural stream environments, water ownership, and Hawaiian rights that relate to streams such as appurtenant rights and gathering rights.

USGS Report #95-4113.

You are correct in your observation that the draft EIS could not have been completed without USGS Report #95-4113. The report provided the technical information needed to verify the possibility of developing the basal ground water in the Hawi Aquifer System. A reduced copy of the report is appended to the draft EIS as part of Appendix B.

The USGS report is part of a cooperative effort of USGS to assist county water agencies with water resources studies. The Hawi Aquifer study was funded jointly between the USGS and Hawaii County Department of Water Supply. The use of USGS funds on the study does not trigger need for a federal EIS.

Incidentally, the section of the proposed pipeline near the former Coast Guard loran station would be located within the right-of-way of Akoni Pule Highway and other highways. No section of the proposed pipeline is expected to traverse Federal land.

Activist denomination or designation.

We extend our apology if you were offended at the listing of your name as an activist in Appendix A of the Socio-Economic Impact Assessment. The term as used in the document was indeed meant to imply a concerned and active citizen. As you said, Jefferson and Madison are excellent examples of activists as used in this sense.

Milton O. Pavao, P.E.
Manager

Att.

From Water Resources Protection Plan, (CWRM), Yuen & Assoc, 1992

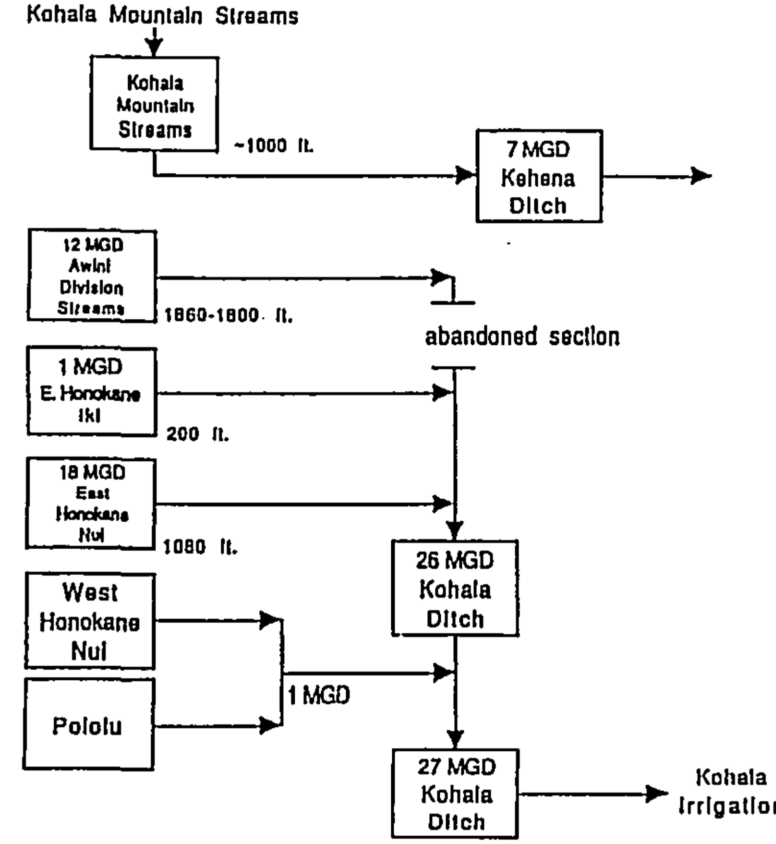
HAWAII

Major Stream Diversions

Kohala Ditch System: Waimanu Aquifer System

Plantation Era

Kohala Mountain Streams



Indicated Flows Are Averages in million gallons/day.

August 20. 1995

Governor. State of Hawaii
C/O Office of Environmental Quality Control
220 South King Street
Fourth Floor
Honolulu. Hawaii 96813

I am opposed to the Kohala Water Transmission Project. The Draft Environmental Impact Statement has down-played the adverse affects of this project. The affects of this project on the people of North Kohala will be adverse. The people will be affected by the loss of water, the quality of the water, the noise and pollution from the 24-hour-a-day diesel generators, the aesthetics of our agricultural community, and perhaps an added financial burden. The USDA Soil Conversation Service states in a letter dated August 10, 1994 that "this project could inflict serious negative impact upon streams and coastal resources of the region."

The future needs for water is in the currently developed areas of North Kohala. The Department of Water Supply has not taken care of its present consumers and has neglected its current assets (source lines and tanks). The DWS has spent $2.9 millions on a grandiose project but has failed to replace a two inch source line to the Makapala-Niulii tank. This line was installed in the 1930's and later given to the DWS by the Plantation. In dry times this line is not sufficient to supply the needs of the Makapala-Niulii residents and the DWS fills the tank with water from the Kohala Ditch. Enclosed is a letter dated June. 1992 pertaining to the use of ditch water as a substitute for potable water. The need to replace this source line was not done at this time, and still has not been done. If we have so much water in North Kohala to send down the coast for future development, why does the Planning Department and DWS deny zoning changes because supply of water is requested. Please see the copy of the clipping taken from West Hawaii Today, August 10, 1995.

Hawaii has many people on catchment and private systems that the DWS has perpetually neglected. Our County Water Department has many projects to pursue in order to serve present residents rather than bring water to land that is currently undeveloped.

This project will be an enormous financial burden at a time when the State, County and people of Hawaii are in the most difficult economic times.

[signature]

David Rotstein
P.O. Box 784
Kapaau, Hawaii 96755

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DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
25 AUPUNI STREET • HILO, HAWAII 96720
TELEPHONE (808) 969-1421 • FAX (808) 969-6996

June 30, 1992

Kupono, Inc.
ATTENTION: MR. DAVID ROTSTEIN, MANAGER
P.O. Box 201
Hawi, HI 96819

Thank you for your kind assistance in supplementing our diminishing water supply to our Makapala-Keokea to Niulii Water System. We were able to curtail hauling water to our Makapala Tank as a result of your quick response.

We understand that we take all responsibilities or liabilities for damages or problems as a result of hooking up to your system. Also, we understand that we will be calling and notifying Mr. Michael Gomes or Mr. William Shontell of Chalon International of Hawaii, Inc., whenever we need to draw water from the Kohala Ditch.

If you have any questions, please call Mr. Kenneth Ikemori at 961-3723.

[signature]
William Sewake
Manager

KI

cc - Chalon International of Hawaii, Inc.
Mr. Richard Ohrstrom, Ohrstrom Farm
Mr. Anthony Gomes
Mr. Samuel Bannister

... *Water brings progress*...

• Waikoloa Sanitary Sewer Co. received a Special Permit to establish a utility base yard on about three acres of land about 1,250 feet south of Waikoloa Road within the company's "village" quarry site at Waikoloa, South Kohala.

• Gary Keller and Robert Watkins received a continuance on a change of zone for more than 15 acres of land from the Agricultural-20 acre to the Ag-3 acre district. The property is located mauka of Akoni Pule Highway, about 2,100 feet east of its intersection with Kynnersley Road at Hanaula, North Kohala.

Both the planning director and the County Department of Water Supply have recommended denial of the zoning change on the basis that there is a supply of water for the request.

• The Ohana Kohala Trust (formerly Richard Weller) received a favorable recommendation for an extension to submit

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
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TELEPHONE (808) 969-1421 • FAX (808) 969-6996

November 1, 1995

Mr. David Rotstein
P. O. Box 784
Kapaau, Hawaii 96755

DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for commenting on the draft EIS for the subject project. The following responses are in order of the comments in your letter of August 20, 1995.

Although the draft EIS could have missed some environmental effects there was certainly no intention to down-play any adverse effects of the proposed project. You were also concerned that the proposed project will affect the people by the loss and quality of water, noise and pollution from the diesel generators, aesthetics of the agricultural community, and negative impacts on streams and coastal resources. The following information from the draft EIS may help to clarify the findings on the items.

Water Resources. The USGS concluded from its study of the Hawi aquifer that the modeling results clearly show that the withdrawal of 20 mgd of basal ground water above the existing withdrawal at the DWS Hawi well is possible, if pumping centers are spaced adequately apart and well depths are limited. The study also said that the pumping could cause some reduction of stream flow near the mouth Pololu Stream. To assess the possible impact on stream flow at the mouth of Pololu Stream the Water Department is arranging to have the USGS obtain the necessary field data and estimate the size of the reduction in stream flow. In the interim, the Water Department will report it as an unresolved issue relative to environmental concerns in Section 12 of the final EIS.

Water Quality. The project is not expected to directly affect any streams or marine waters, except as discussed in the above paragraph on flow at mouth of Pololu Stream. Thus, no significant direct impact to water quality is anticipated. Although the construction contract will require best management practices be followed in controlling stormwater runoff, diligent effort will be necessary to avoid potential stream or marine water pollution problems.

Concerns were expressed about the effect of basal water withdrawal on the opihi and limu population along the shore makai of the project well sites in North Kohala. There was concern, also, about the effect on nearshore coral communities in South Kohala. Studies were conducted specifically to evaluate these concerns. The results revealed that there appears to be no potential for negative impacts to marine ecosystems in either North or South Kohala from the diversion of the groundwater.

Air Quality. The proposed diesel generator units at the well sites are considered relatively small sources of air pollution. Atmospheric dispersion modeling results show that nitrogen oxides emissions from an individual generator unit could potentially exceed ambient air quality standards if a discharge plenum or rooftop stack is used. On the other hand, the dispersion modeling results show that maximum impacts would be well within ambient air quality standards if the generator stack height conforms with good engineering practice. Odorous compounds will likely be present in the generator exhaust gases at low concentrations, but these should not be detectable at or beyond the well site boundaries.

The Water Department will obtain the appropriate class of permit from the Department of Health to operate the diesel-fueled generators. Adverse effects of the emission will be mitigated through the use of good engineering design practice and close adherence to the permit conditions.

Noise. The proposed well pumps are of submersible type and pump noise would not be audible. The portable diesel-fueled power generator stationed at each well site to power the deep well pumps would be enclosed in a container to control noise levels. The predicted noise level of the generators at the nearest existing home (between 1,200 to 1,400 feet from well site) range from 32 to 46 dBA.

In view of the proximity of the well sites to residential areas, the generator enclosure will be designed to have sufficient quieting measures to keep the noise levels at equal to or lower than the ambient background noise at the nearest residential areas during the most quiet hours which are before sunrise.

Visual. After construction is completed, the project area would essentially be returned to or near preconstruction conditions, except at the well sites and the reservoir sites. The well sites would have a permanent control building and above ground pump appurtenances. The three Phase I sites would also have temporary power generators and fuel storage vaults. The visual impacts of these above ground facilities would be reduced with appropriate landscaping and earth-tone finishes.

The placement of the collection and pressure-breaker reservoirs in open pasture areas is unavoidable. The collection reservoir site has been relocated from makai to mauka of Akoni Pule Highway. This mauka location avoids silhouetting the reservoir structure in the ocean and skyline views. The site is now located approximately 2,000 feet mauka from the highway. The pressure breaker reservoir has been relocated further north, placing it approximately 2,400 feet from the Kohala Ranch subdivision and 4,000 feet

from the highway. This location would intrude less on the views of the neighboring homes. Both reservoirs would have minimal visibility from the highway. To soften their appearance in the area vistas, the reservoir structures would be finished in earth tone colors and the site appropriately landscaped.

You stated that the Water Department has not taken care of its present consumers and has neglected its existing sources and lines, and there are many projects to pursue to serve present residents. Unfortunately, the Department does not have unlimited resources that it could use to improve it water systems. Although we may be behind in some areas, the Department schedules system maintenance to the extent allowable by its limited funds. Where system expansions are needed, we have relied on the parties desiring water service to either build the expansion or participate in paying for the expansion. In the case of the proposed project, we anticipate that water users interested in additional water for their projects would be participating in paying for the capital cost of the project.

On your concern about added financial burden, the Water Department is very aware of its fiscal responsibility and intends to take necessary steps to avoid potential problems. The Department foresees the repayment of financial obligations for the project being carried by the users of the water from the project. Present water users of the Department's system would not be required to participate in the repayment.

The financial plan for the project is critical and the Water Department will be working with the County Administration and County Council on a plan that would be acceptable to both the affected water subscribers and County Council. The project will not start until the financial plan is approved by the County Council and financing is in place. The Council will be holding public meetings and hearings at appropriate times during their deliberations on the plan.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

7-7-95

Milton Pavao, P.E
Manager
Dept. of Water Supply
County of Hawaii

Water, S Kohala

In reading the press account of the EIS on the N. Kohala proposal, several unsaid problems and their solution troubles me:

(1) What estimates are available to pay the interest on the 50,000,000 bonds? This could be 4 to 5 million annually -- largely before the high paying consumers in S. Kohala start paying for delivered water.

(2) I highly recommend that you also consider the Waikoloa consumers. I realize they are on a private system which is no reason to be ignored by the County. However -- the Waikoloa consumers are tax paying residents of this island like you and I. They pay more than 50% for water than we do. Residents of upper and coastal region of Waikoloa may exceed the population of N. Kohala and certainly those you intend to supply in the coastal area of S. Kohala.

a - you might inter-connect the Lalamilo system to the Waikoloa well site.

b. you would therefore double the potential paying consumers of [illegible] system for N Kohala

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-2-

(3) I see nothing mentioned in the EIS on Sewage treatment. This has to be carefully considered before new water is introduced into an area. Where and how is sewage resulting from it will be engineered and built?

(4) I discussed this Project at length at the Dedication of the new Honokaa Hospital with Senator Malama Solomon. She appeared very pessimistic and flatly said it will get off the ground due to the fiscal condition of the State and County. I really think this is a "Smokescreen" by the opponents for N. Kohala. Hawaiians say "Hilahila". My Hawn grandmother was born in Puukii in 1857 so I am not a new transplant.

On a vastly different subject, you might consider exploring for new water, mauka of Hiilawe Falls of Waipio along the Lalakea stream bed that feeds that water fall.

When I was Head Luna at Honokaa I supervised the Lower Hamakua Ditch. In our tunnel inspection we knew that at Hiilawe you go thru dense perched dike water. Seepage into the tunnel resembles a Hilo rain storm. A ^new^ tunnel back of this one as well may surprise you with yield. I gave this same data to Mr. Church - retired State Water Mgr. many years ago and your predecessor.

In closing, I hope you can come up with some answers to diffuse the negative minded folks prior to your public hearing. Time is short -- good luck.

Leon A. Thomas Mgr (retired) ex
Honokaa Mill Co.

P.S: I know of the excuses the County is not involved with Waipolu but rational reasoning should prevail - the people deserve equal treatment. They should not be saddled by a Developer's action in perpetuity.

Research Basal H_2O ownership in Hawaii
Land owner? State? OHA? County? Federal?

7-11-95

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Milton Pavao PE
Manager
Dept of Water Supply
County of Hawaii

Water – North to South Kohala.

Thank you very much for sending me a copy of the EIS on this Proposal. I responded earlier, prior to the receipt of this on 7-7-95. This was after a press release on the subject.

The EIS was very well done, professional and educational for all of us. Diffusion of negative static will not be easy -- particularly from those who are here now -- want no more development and care less how our people will gain employment to provide for their families.

There are some added things that trouble me:

(1) In 1974 I was one of a small group who did a very exhaustive study of Kohala S.G. The goal was to make recommendations to keep sugar going in that district.

a - a huge problem was reduced availability of water for irrigation in the dry summer months.

b - early development of wells was a technology dating back to the last century. Why was the Kohala District not salvaged by well water which you claim to be so abundant ?? only 20 years ago. ??

-2-

(2) The comments from the Developers of Waikoloa claim they have water for present and future needs.

a - those Developers do not necessarily represent the thousands of resident taxpayers who pay a high price for privately developed water.

b - Comments from these people should be solicited, and do not accept Developers opinions as final.

(3) The S. Kohala Resort development is nearly stymied over lack of water - Condo development per se and reopening Mauna Kea

a. I as chairman of their advisory committee advised them of this problem and suggested one or more wells similar to those at Lalamilo. Your proposed project will not meet their immediate needs in time.

b. Reopening of the Mauna Kea Beach Hotel in 1996 will compound the existing problem into "orbit".

(4) I often wonder at your proposed 500 KW Diesel generators in this proposal.

a. Why not consider modern Wind Turbines unlike the small ineffective ones currently in use?

b. These type could be effective and cost saving even at the Lalamilo site, with portable Diesel Units.

I also read with interest the section on financing and the Council to provide the answers. I am positive they will have to obtain wisdom similar to that of "Solomon" to cope with '50 000 000 cost forecasts. I shudder over the prospects of large increases due to inflation etc. etc. and necessary changes?

I don't like to appear personally, but admire the efforts of the Water Development by the County. Your goals are noble and a tribute to our good friend Bill Sewake.

You might like to refer to a published article by myself in the July - Kaw Landing newspaper. The theme is to fully exploit existing ground water going to waste. This was meant really for irrigation and conserve existing developed water for domestic purposes only.

Leon A. Thevenin

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November 1, 1995

Mr. Leon Thevenin
104 Puako Beach Drive
Kamuela, HI 96743

DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for commenting on the DEIS for the Kohala Water Transmission project. We are in receipt of your letters dated August 7 and August 11, 1995. Our response to your comments is as follows:

August 7, 1995 correspondence.

(1) The first phase of the project, which will deliver 10 MGD, is estimated to cost $60 million. Depending on interest rates at the time of financing, the debt service is estimated at approximately $5.2M annually for 25 years.

(2) The Waikoloa water system is a private system operated by Waikoloa Land Company. The Department of Water Supply has no authority or jurisdiction over private utilities.

(3) Appendix C of the DEIS, *Effect of Groundwater Discharge Into the Marine Environment of the Proposed Kohala Water transmission System*, looked at the potential sources of discharge in South Kohala including sewage treatment plants. Much of the treated water is reused for irrigation purposes, and permits for treatment facilities must meet strict Department of Health standards.

(4) We anticipate that the project will be financed through General Obligation Bonds backed by the County of Hawaii. Prior to presenting the project to the County Council, a financing plan must be worked out with the system users that will assure the Council that the system will be ultimately paid for by the users. A similar plan was employed in 1978 wherein Mauna Loa Land Inc. (Mauna Lani Resort) and Olohana Corporation (Mauna Kea Properties) underwrote a portion of the cost of the Lalamilo Water System.

August 11, 1995 correspondence

(1) The surface water systems in North Kohala were a source of both agricultural and domestic water at a time when such use did not conflict with government standards. Storage requirements for drought conditions and water monitoring and treatment standards now make ground water the preferred source.

Mr. Leon Thevenin
Page 2
November 1, 1995

(2) As stated above, The Waikoloa water system is a private system operated by Waikoloa Land Company. The Department of Water Supply has no authority or jurisdiction over private utilities.

(3) The use of the Lalamilo Water System to its full, safe, capacity is expected to support the immediate needs of the current users.

(4) Diesel generation was chosen as the most reliable interim power source for phase one of the project.

We hope the above explanation is helpful.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

(POSTED)

59-148 Olomana Rd
Kamuela HI 96743
August 21, 1995

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OFC. OF ENVIRON. QUALITY CONT.

Governor Ben Cayetano
c/o OEQC
220 S. King St. #400
Honolulu HI 96813

Dear Governor Cayetano,

I have read the DEIS on the Kohala Water Transmission System with a growing sense of dismay.

At public meetings on this subject, we were originally told that new water projects are required to pay their own way, and that construction on the pipeline would not begin until there were enough firm commitments from its users to pay for the costs as they were incurred. At least that's the impression that was given.

Gradually--presumably because the commitments never materialized--the rhetoric changed. There was talk of a bond issue, and there began to be hints that the project would not be self supporting. The DEIS contains statements like "facilities charges levied in advance on water users will finance *most* of the project" and "[r]epayment of bonds will *primarily* come from source users" and "[getting some of the money up front from users] minimizes *taxpayer or ratepayer risk*". [emphasis mine]. The amounts taxpayers might have to contribute, and why, are not revealed. I'm not sure whether that reference to ratepayers signals a reneging as well on the promise that rates to existing water users will not be affected, or whether it refers solely to KWTS ratepayers.

A statement is attributed to DWS, on page 106 of Appendix A, that if sufficient guarantees for user-derived funding are not obtained, the project will not be built. If this is the case, it should be stated as a fact, rather than hearsay, in the main text, not just in small print in an appendix, and it should be quantified. How *much* money has to be guaranteed? The lack of this information makes me wonder if the amount won't be decided *ad hoc*, when DWS sees how much money is actually committed.

When I look at the cost breakdown on page 3-9, I see that there is no item for bond interest. In fact, I don't believe it's ever mentioned, anywhere. I can't believe it is included in the individual cost items shown, because 1) that would not be a usual or appropriate way of reporting it, 2) the total cost never changed from the time the discussion was of up-front commitments to the time it became a bond float, 3) it never changed when a weakening of the economy made it clear that target development will probably proceed more slowly than originally anticipated, meaning a much larger interest outlay on a bond float that takes place in the near future, 4) the statement is made that the total cost will be the same, no matter which of the two radically different development scenarios is realized, 5) the amount hasn't changed as interest rates have fluctuated, and 6) the authors claim they didn't discuss financing because they didn't know the details--so how could they have accurately provided for interest?

If interest *is* included, the planners have done an extremely poor job of accounting for it. Maybe a more detailed description of the cost items and how they were arrived at is needed. There should also be an explanation of what the private landowners who will contribute water system easements are expecting in return. If it is free or discounted hook-up or water, that will mean financial impacts to other users. Or maybe we can expect pressure on the county to approve future development proposals by these landowners.

It appears to me that the plan is actually for the taxpayers to pay the bond interest. Whether it is the plan or not, I'm afraid it will be the reality. This could amount to tens of millions of dollars! Not only would the taxpayers stand to take a major beating if paying customers weren't found in a timely enough manner, but the tremendous increase in the county's bonded indebtedness would put a stranglehold on CIP projects of all sorts in the county for years to come. No wonder project proponents don't want to include a discussion of financing methods in the EIS.

There is no justification for leaving an impact of such potential magnitude out of the EIS. The rationale that the authors don't know what the County Council will approve is specious. The whole idea of an EIS is that no one knows--until the impacts of what is proposed and of a variety of alternatives are revealed and deliberated--what action will be taken. The whole purpose of the process, at least in theory, is to aid in that decision.

In this case, project proponents not only know what financing method they will ask for, but they are making the assumption that that is what will be approved, if the project flies at all. It's time they owned up to what is really involved. Better yet, it's time they took the taxpayers off the hook. If there are shortfalls in the funds available to this project, they should be made up in additional facilities charges to the users, higher water rates to them, and/or a property tax surcharge to them. If the liability to taxpayers in general is as inconsequential as the project proponents try to make it sound, then there should be no problem with setting it up this way.

There's no question that financing is a real can of worms. To assuage concerns of North Kohala residents, we are assured that it's possible Phase II will never happen. Regardless of whether the planners seriously consider this a possibility, Phase II could certainly be greatly delayed due to other factors in the general economy. The funding for Phase I therefore needs to be viable independently of Phase II. This may be seen as a problem, because it means that if Phase II *does* materialize, those who committed to the project early on (Phase I) will have to pay more than the latecomers (Phase II).

If taxpayers are not to be soaked for the interest, the reverse problem would exist within Phase I. If it is expected to take 15 years to reach full Phase I capacity, the anticipated interest charges could be apportioned equally to all users, so that early subscribers will be paying interest on the

principal that is carried for 10 or 15 years, or the late subscribers could simply pay two or three times as much for their commitments.

Giving early subscribers a break makes it less and less attractive for latecomers to sign up; not doing so will make it attractive for all potential users to procrastinate as long as possible, as they have been doing all along. This quandary is one indication that the project is premature.

If construction is scheduled to take two years, then accrued interest would add some $5 million to project costs even before any water could actually be delivered. If this were charged to the users, then facilities charges to customers who come on line on Day One would be over $6500 (in 1992 dollars) per thousand gallons of daily capacity. That's if they don't have to share the interest costs for later users. The EIS should estimate the cost if they do share the interest, and the cost to later subscribers if they don't. And the rate of new book-ups should be figured on the basis of present economic realities, not on outdated projections from the various landowners.

When a realistic cost, or range of costs, per thousand gallons is derived, given various assumptions for timing of hook-ups, and including interest, the EIS preparers should contact DHHL and ask what effect that information will have on their plans. Since DHHL is a major player in one of the two scenarios discussed in the DEIS, this information seems crucial to the accuracy of the document.

In discussing why *present* water needs of other parts of the county are not being addressed instead of *future* needs in South Kohala, the DEIS states (p. 6-16) that "there is no party...that will commit to pay the enormous infrastructure costs necessary..." One could point out that, to date, the same is true of South Kohala. And if the decade of effort and several million dollars of public money that have been poured into this project already, plus the tens of millions of dollars I believe the taxpayers may have to absorb in the future, were applied instead to Puna, where the water is available right under foot, the story might be quite different.

Why are the taxpayers being asked to assume such a potentially massive liability? The project proponents have so little idea of what the water would be used for that they don't know whether they're talking about 3600 hotel rooms and 3600 resort residential units or 450 hotel rooms and 12,000 residential units, mostly on Hawaiian Homes lands.

We're told we must have this pipeline because there will be a 20-mgd shortfall of potable water in South Kohala for already planned development, and there is no other good alternative. Yet when asked about the potential for development along the leeward North Kohala coast as a result of the pipeline, DWS representatives admit that this is a possibility. If water can be diverted from the project for development not presently even proposed, what assumptions are we to make about how urgent the need really was, after all, in South Kohala? Clearly, the project has taken on a life of its own. There is pressure for going ahead with it independently of the real need, and therefore any justification for it will be entertained. The county will be pushed into approving any new development, no matter how ill-considered, just to get help with the debt service. And the taxpayers will be left to pick up the pieces.

I am not qualified to analyze the cost benefit information, but to me, it doesn't add up. If development is such a boon, why is the state in so much financial difficulty? Why is there such a strong perception that our infrastructure is falling behind? Why did Proposition 13 in California put such a damper on development? Why do the politicians admit that new development is a drain on county resources? The DEIS doesn't admit to even temporary negative fiscal impacts.

Nor does it point out that resort properties have successfully pressured the county into lowering their tax assessments. I understand Nansay is negotiating with the county right now for a settlement on the taxes it is unable to pay. Because so much is at stake, the government is generally ready to bail out large developers when they get into trouble.

And, of course, cost-benefit analyses are inherently flawed, because they ignore the many intangibles that contribute to the most important thing of all: quality of life.

Most of the rest of my observations are that impacts are unquantified (we are told, for instance, that the North Hawaii hospital will contribute to medical needs in the area and that the new landfill has lots of room, but we aren't told how many new patients or how much garbage to expect, and what effect this will have on the capacity of the facility in question), or distorted (the statement that tourism has proven compatible with a rural lifestyle ignores the fact that most of the tourism has been in South Kohala and most of the rural lifestyle is being maintained in North Kohala--which could be very adversely affected by the availability of water to new portions of the district), or swept under the rug (if leeward North Kohala gets developed, for example, impacts on scenery and natural beauty of this unique area are dismissed with a note that government agencies will suggest mitigation measures, and there is no acknowledgment that such development could negatively affect recreational opportunities; open space is not viewed as a valid use nor is its loss considered an irretrievable commitment of resources).

Including improved water service to North Kohala as a benefit of the pipeline is misleading, since North Kohala residents have been assured over and over that they will get the improvements whether this project goes through or not. The contention that migration within the state won't require significant government expenditure is simply false (you may be able to transfer teachers and social workers, but you can't transfer schools and roads).

It is disingenuous to suggest--especially when pipeline debt service will be such an unrelenting master--that we don't need to worry about the impacts of secondary development because it has to get lots of government approvals. Most of the mitigation measures will be ignored or ineffective or will constitute band-aids on gaping wounds. Some of the statements are dubious--like the claim that there will be no significant deterioration of air quality, in spite of a doubling or tripling of traffic--or downright outrageous--like the assertion on page 10-2 that "all adverse

secondary impacts are potentially mitigable, and therefore the project could proceed without substantial harm to the physical or social environment."

I urge that this DEIS be rejected, and that neither it nor the KWTS be reconsidered until:

1. There are effective guarantees that the project will in no way be underwritten by anyone who is not a user or future user of the pipeline;

2. There is a plan in place for protecting the coastline and various other open spaces in North Kohala from major development;

3. The Waimea bypass route and its linkage to Queen Kaahumanu Highway have been satisfactorily negotiated and all needed construction funds for it appropriated;

4. DWS completes its long-overdue task of refining the 600 gpd standard for residential water, so we can have a better idea of what will actually be needed (when state personnel checked water usage at Kohala Ranch, for example, it exceeded the standard by almost an order of magnitude: close to 5600 gpd per home).

Sincerely,

Kelly Pomeroy

Kelly Pomeroy

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
25 AUPUNI STREET • HILO, HAWAII 96720
TELEPHONE (808) 969-1421 • FAX (808) 969-6996

December 21, 1995

Ms. Kelly Pomeroy
59-148 Olomana Road
Kamuela, HI 96743

DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for your comments on the Draft Environmental Impact Statement (OEIS) for the Kohala Water Transmission project dated August 21, 1995. Our late response to you is a result of no copy having been forwarded to us.

The concerns you have expressed are primarily related to project financing. You are correct that it is our intention to propose to the County of Hawaii that Phase I of the project be financed with General Obligation Bonds. We point out in this regard that the County will be the recipient of substantial additional real property taxes due to development made possible by the project. Projected Net Tax Revenues/Expenses is shown on page 68, Table 3.23, of Exhibit A of the OEIS.

With respect to the discussions the Department of Water Supply (DWS) has had with landowners regarding financing of the project, they are ongoing and directed at arriving at a strategy that will be acceptable to the DWS and the County Council. The result of these discussions to date is as we have reported at the public meetings in Kohala. There is agreement as to the broad strategy that the users will pay for the capital cost of the project. The current economic situation in Hawaii however prevents them from committing to any specific course of action now.

Prior to the County Council acting on any financing plan for the project, they are required to hold hearings on the matter. Full disclosure and public discussion about the possible financial impacts of the project, the specific commitments to be given by the users, other competing capital improvement projects, interest and debt service payments, prudent County indebtedness, and other relevant matters will properly be discussed at that time.

With respect to your comments regarding State of Hawaii Department of Hawaiian Home Lands (DHHL), please refer to correspondence from DHHL in Section 14 of the OEIS.

... Water brings progress...

Regarding the Department's comments about the possibility of development along the leeward North Kohala coast as a result of the proposed pipeline, the General Plan and zoning amendments necessary for such development are the sole purview of the County Council. The Department is, therefore, not in a position to deny the possibility.

We hope the above explanation is helpful.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

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August 18, 1995 '95 AUG 24 P4:36

OFC. OF ENVIRONMENTAL QUALITY CONTROL

Governor Ben Cayetano
C/O Office of Environmental Quality Control
220 South King Street #400
Honolulu, Hi. 96813

re : North Kohala Water Transmission Line Project

Dear Sir,

Hypothesis = an *interpretation* of a practical situation or *condition* taken as a ground for action.

Megumi Kon, the EIS preparer, bases the need for the North Kohala Water Transmission Line Project on a flawed hypothesis, drawn up by W.Y. Thompson & Co. and referred to throughout the EA & EIS. In the W.Y.Thompson report, *A Feasibility Study for a Kohala Coastal Water System*, it states that West Hawaii was targeted for resort development as far back as 1959. Later on, on page one, it states that the opening of the world class Mauna Kea Beach Hotel followed by the Waikoloa Resort and the Mauna Lani Resort signaled the start of a premier resort destination area. That may have been true then but the actual history tells quite a different story.

The Mauna Kea Beach Hotel, presently closed for renovations, owes nearly one and a half million dollars in real property taxes. This figure comes from Blue Skies Hawaii, a public information agency based in Hilo. The Hapuna Beach Hotel (with the same owners as the Mauna Kea Beach Hotel) is running at below 50% occupancy and is negotiating with Hawaii County on it's real property tax bill. . The Waikoloa Resort originally opened by Hyatt was sold for nickels on the dollar to Hilton. Hilton is doing ok because they have a manageable debt service. The Ritz Carlton Mauna Lani Resort was sold in early 1995 to O.M.K.D. (O.M.K.D. is a corporation owned by the Dai Chi Kongo Bank which financed the project). The three original Japanese investors and one American investor bailed out with nothing for their equity and OMKD paying off some bills and assuming the mortgage. The Mauna Lani Bay Hotel is facing a similar financial crisis. Kohala Ranches' sales have been at a veritable standstill for two years. Individual owners have been selling at fire sale prices. Nansay Hawaiis' Puako development is dead in the water and they are listed as a 'user' of the proposed pipeline.

Chalon International, under court order, has been selling lots at Maliu Ridge, at a third of the asking price two years ago. One has to ask ' who would be fool enough to want to build a new hotel or any type of resort development?' The point here being that the need for a Water Transmission Line from North Kohala to South Kohala may have seemed real in 1988 when W.Y. Thompson presented his hypothesis for the growth of tourism but the realities are drastically different today.

The big players in resort development in Hawaii have been the Japanese. Presently Japan is in deep financial trouble. Optimistic projections say it will be at least five to eight years before they reverse the downward slide. Whether they ever become major players again in Hawaii is the subject of much speculation. Presently they are unloading property in Hawaii and worldwide. The United States and the rest of the world are in a recession and no one knows how long it may last. So who is going to build all these resort hotels and other properties that need the water and more importantly who will stay in them even if they are built ?

The State of Hawaii is in deep financial straits, due at least in part, to overdevelopment. The County of Hawaii also faces a difficult financial future. Yet the Department of Water Supply seems bound and determined to forge ahead on this $80 million dollar project. There is an immediate and present need for water on this island. However it's not in South Kohala. The need is in Puna, Ka'u and South Kona. If the transportation of water is based on present and urgent need, then the DWS should be studying ways to get water to these dry and drought stricken areas of the Big Island. It should not spend $80 million on a project that at best is a roll of the dice on the future.

I thank you for the opportunity to respond to and comment on the EIS.

Very truly yours,

Richard Boyd

Richard Boyd
P.O. Box 368
Hawi, Hawaii 96719

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
25 AUPUNI STREET • HILO, HAWAII 96720
TELEPHONE (808) 969-1421 • FAX (808) 969-6996

December 21, 1995

Mr. Richard Boyd
P.O. Box 368
Hawi, HI 96719

DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for your comments on the Draft Environmental Impact Statement (DEIS) for the Kohala Water Transmission project dated August 18, 1995. Our late response to you is a result of no copy having been forwarded to us.

The concerns you have expressed are primarily related to the current economy, here and abroad, and skepticism as to whether South Kohala will experience the growth projected in the DEIS.

While it is true that additional large scale resort development is not proposed in the near future, it is also true that the market influences which drive tourism have a cyclical history. This lack of apparent immediacy is referred to in Section 2.2 of the DEIS.

> 2.2 NEED FOR THE PROJECT
>
> The Hawaii County Water Use and Development Plan, a component of the State Water Plan, points out that proposed development plans in the South Kohala coastal area would require more water that is available in the area's groundwater aquifers. This imbalance between need and supply is not expected to occur immediately. However, because of the large volume of anticipated water needs and long lead time necessary to construct a major water system, the proposed project is being considered now to assure that water will be available when needed. The Hawaii County Department of Water Supply (DWS) will construct and operate the proposed water system.
>
> South Kohala is the only district in the island where the estimated future water needs are higher than the estimated capacity of the water supply available from sources within the district.

The inadequacy of its underlying aquifer, the willingness of the user to pay for the project and the onsite distribution systems, and the economic and job creation benefits of the South Kohala resort region set it apart from other districts on the island which you refer to in your closing paragraph. A similar, but smaller,

project was completed in 1978 wherein Mauna Loa Land, Inc. (Mauna Lani Resort) and Olohana Corporation (Mauna Kea Properties) underwrote their share of the cost of the Lalamilo Water System.

We hope the above explanation is helpful.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

To: Office of Environmental Quality Control

RECEIVED
'95 AUG 22 P2:42
OFC. OF ENVIRONMENTAL QUALITY CONTROL

Re: DEIS Kohala Water Transmission System Project

From: John A. Broussard
59-148 Olomana Road
Kamuela HI 96743
(808) 880-1033

Date: August 22, 1995

"Economists have sometimes been lampooned as people who measure the value of love by the price of prostitution. The value of some things is easy to assess in terms of money, and the temptation is strong to count only such things in cost-benefit calculations and to ignore everything else."

This statement by the Nobel Laureate, Murray Gell-Mann, well describes what I feel is the underlying flaw in this Environmental Impact Statement. In that document those values which can be easily translated into dollars and cents are its centerpiece, while those which cannot be readily quantified have been either ignored or denigrated.

I am not saying that the creators of this EIS have consciously set out to determine the value of this project solely in terms of economic costs and consequences, but I do see in these pages a mind-set which makes tax revenues, jobs, infrastructure, hotel occupancy, etc., of paramount importance, and regards quality of life as being as amorphous and incommensurable as the value of love. Even the prospect of loss of scenic open-space along the North Kohala coastline is viewed with comparative equanimity because of the offsetting windfall profits for resort owners and developers.

As a former Peace Corps instructor in community development I have seen over and over again such sacrifices of traditional values to the idol of progress, and many of those cases have become part of the corpus of sociological and anthropological publications. I would be happy to pass these on as references should they be deemed of interest. I rather suspect they would not be, however, since if the mind-set I refer to above exists it would render the value of such readings incomprehensible or simply amusing.

Incidentally, that mind-set shows in the use of the word "activist" as applied to several informants. Presumably,

that term means something special to the authors, since it is applied only to some residents while others are listed as just that—"residents." Why the distinction? The only common quality I see among those labeled as "activists" is a concern for the environment. If so, then I guess the authors feel no separate designation is needed for those whose concern is solely monetary—since that is an acceptable viewpoint.

Or, perhaps, "activism" applies to anyone who speaks out on social issues. It then becomes a handy label to distinguish trouble makers from "progressive" elements whose concerns "really matter."

Whatever the ostensible reason for the singling out of certain informants, it is clear that they are regarded as being somehow different. It is that perceived difference, and what it reflects about the attitude of the authors, which is the EIS's basic flaw. That document in reality is basing its findings on the "solid" recommendations of developers, land owners, corporate representatives—people who count, who have sensible economic values—and therein lies the fundamental problem with the EIS.

To again put it in the words of Murray Gell-Mann: "All our lives are impoverished by decisons based on that kind of thinking."

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
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December 26, 1995

Mr. John A. Broussard
59-148 Olomana Road
Kamuela, HI 96743

DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOHALA WATER TRANSMISSION SYSTEM

Thank you for your comments on the Draft Environmental Impact Statement (DEIS) for the Kohala Water Transmission project dated August 22, 1995. Our late response to you is a result of no copy having been forwarded to us.

The Draft EIS was not restricted to or primarily focussed upon economic impacts. Archaeology, hydrology, biology, and other areas of concern were thoroughly addressed. Even within the Socio-Economic Impact Assessment (SIA), far more space and research was devoted to social rather than economic impacts. Topics of concern included population, housing, outdoor recreation, social structure, social well-being, community values, and Hawaiian culture.

The SIA repeatedly emphasized that the social impacts of further development in Kohala would be far-reaching, if difficult to determine precisely. Through personal knowledge, public meetings, interview, surveys and review of literature, our research determined that many individuals oppose allowing the scale of development that would be facilitated by the proposed project. The SIA directly quotes many of their statements concerning coastal access, urbanization, Hawaiian culture, hotel jobs, historic sites, and other issues.

Not everyone, however, shares these values. Many residents of North Kohala appreciate hotel jobs, however demeaning critics of the resort industry may find them. Many native Hawaiians expressed at public meetings, during interviews and on surveys that the project represented the best chance to supply the Kawaihae Department of Hawaiian Home Lands project with water, and they were in favor of it for this reason. Some people stated that they find the resort atmosphere to be pleasant, and that resorts are not only economic but also aesthetic and cultural assets to the Kohala community. The EIS did not attempt to fabricate a consensus on the impacts to quality of life but rather to simply portray the diversity of opinion.

The term activist was intended to convey the deep and active concern that individuals so labeled have expressed for their community. We apologize if anyone was offended.

Milton D. Pavao, P.E.
Manager

copy - Governor Benjamin J. Cayetano, c/o Director, Office of Environmental Quality Control

... Water brings progress...

SECTION 15
LIST OF REFERENCES
TECHNICAL APPENDICES

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APPENDIX A

SOCIO-ECONOMIC IMPACT ASSESSMENT

FINAL

SOCIO-ECONOMIC IMPACT ASSESSMENT

KOHALA WATER TRANSMISSION PROJECT

Prepared by
Y.K. Hahn & Associates, Hilo
for Megumi Kon, P.E.,

October, 1995

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Project Description

This report analyzes the social and economic impacts expected to result from the Kohala Water Transmission System (the project). The Hawaii County Department of Water Supply (DWS) designed the project to recover 20 million gallons per day (mgd) of potable ground water from North Kohala aquifers and transmit this water via an underground pipeline to South Kohala. The purpose is to supplement the Kawaihae-Hapuna-Puako Water system. A secondary purpose is to upgrade the existing county water systems in North Kohala to all-ground water, which would economically improve supply reliability and to meet safe drinking water regulations.

Detailed description and maps of the facilities and construction can be found in the Environmental Impact Statement (EIS) to which this report is an appendix. In overview, the project is expected to cost approximately $80,000,000. Design and construction of the first phase, during which the pipeline, several reservoirs, six wells and interconnection components are to be constructed, would occur between 1995 and 1999 and is projected to cost $60,000,000. The second phase, involving six additional wells and two reservoirs at a cost of $20,000,000, would be initiated when dictated by demand.

Of direct interest to the study of social and economic impacts are those aspects of the project that may cause construction-related community disruption, and the secondary impacts, i.e., impacts to population, economy and social life that come about as a result of project-induced development. These aspects will be described in detail in appropriate sections of this report.

1.2 Alternatives

Section 4 of the EIS has identified four alternative courses of action including the proposed project.

1.2.1 Proposed Project

The proposed project is an outgrowth of a DWS study on the water resources of in the Northwest Hawaii Region (Thompson 1988). The study determined that a hydrologic area between Pololu Valley and Upolu Point in North Kohala was the most suitable area in which to develop water for South Kohala.

The advantages of this area as cited in the study include the following:

- Quantity and recharge characteristics of resource
- Maximum 600-foot well depth
- Lack of conflicting uses for the groundwater
- Convenient pipeline easements
- Pipeline route passes other potential users

1.2.2 Transfer Ground Water From East Hawaii/Waimea High Level Ground Water

The State Department of Land and Natural Resources (DLNR) has been investigating the feasibility of recovering 20 mgd from the Hilo Aquifer system and transmitting it to the upper South Kohala region (Hawaii DLNR 1992). The price of water in this alternative under current and foreseeable conditions is prohibitively expensive for use in domestic potable water supply.

Another potential ground water source is high-level aquifers in the Waimea region. Cost estimates for this source are similar to the proposed project. However, reserving this water for the coastal area would pre-empt later use by the Waimea water system.

1.2.3 Desalinization of Brackish Water

Desalinization of brackish water offers a possible source of unlimited fresh water; however, current technology produces water of a cost approximately three times greater than the normal price of well-water. Also, because this technology is highly dependent on fossil fuel input, it has considerable air pollution implications and is subject to fluctuation according to the price of oil. Desalinated water may be a rational alternative if it is produced as a seasonal or emergency supplement to fresh water.

Because the socio-economic impacts are very similar among this and the former alternative, they are treated as a unit for most categories of impacts.

1.2.4 No Project

Large-scale resort and residential development in South Kohala has been for decades been a fundamental objective in State and County plans. Most of the supporting elements, such as road, harbor and airport infrastructure, land ownership, and appropriate State Land Use Districts and County zoning, are in place.

Government policy clearly supports the development of water system infrastructure as necessary to support existing and planned needs.

Private developers would be able to implement their plans for resort hotels and housing within the areas served by the water system. Development plans for the Department of Hawaiian Homes Lands (DHHL) Kawaihae project would also be furthered by the presence of water. Expansion of Hapuna State Recreational Area and other parks in the area would benefit by secure water supply prospects. The provision of water is a key element in the unfolding of the development concepts envisioned for Kohala in the Hawaii County General Plan, in the West Hawaii Plan, and more generally in the Hawaii State Plan. Therefore, setting aside for a moment the consideration of environmental impacts, failure to support a new source of water would clearly be inconsistent with planning policy.

Even without the proposed action, given the current land ownership and land use designation patterns, it is unlikely that the area would remain without water. Private interests could supply their own water through limited draws on potable aquifers (see EIS for discussion), desalinization, or even importation - but a higher price and potentially greater impacts to the physical environment.

Without the project, development of resort properties in South Kohala might be slowed or geographically uneven, but it would probably continue to occur. It is therefore unrealistic to assess the impacts of the no-project scenario as a continuation of the status quo. For the purposes of discussion in this report, it is assumed that growth of approximately 50 percent of with-project levels will occur. This will lead to similar levels of growth in jobs, revenues, population and housing demand.

1.3 Regional Introduction

For the purposes of the Environmental Impact Statement, the study region has been defined as the districts of North and South Kohala. However, it is recognized that certain secondary impacts may also affect portions of North Kona and Hamakua. Limited effects will be felt throughout Hawaii County and statewide.

1.3.1 Physical Geography

The reader is encouraged to refer to Section 3.5 of the EIS for detailed information on the physical environment. For the purposes of this discussion it is important to note that the landscape of Kohala offers a dramatic setting for the towns, villages, resort communities, ranches and farms that occupy the region. Traditional Hawaiian uses of this region were keenly attuned to small variations in resources and environmental variables. Today, the dry and rocky seacoasts, moist and fertile slopes, and cool and misty uplands offer distinctive environments for social and economic activity. There are also immense undeveloped tracts

virtually devoid of population. The physical landscape of Kohala is a key element of the region's history, economy and future potential.

1.3.2 History

At the time of Western contact, settlement was concentrated in along the leeward coast, where fishing played a major role, on the well-watered slopes, where irrigated and dry agriculture prevailed, and in the well-watered stream valleys of North Kohala, where irrigated taro was the mainstay.

Depopulation associated with disease and social disruption after 1778 devastated all of Hawaii, including Kohala. In the void, Western settlers and entrepreneurs founded cattle ranches and sugar plantations. These ventures economically dominated the region for well over a century and also largely dictated the settlement pattern.

In the last thirty years, the visitor industry has transformed the land use, economy and demographics of the region.

1.3.3 Basic Human Geography of Kohala

The mainstays of the economy and social structure throughout the last century have been sugar in North Kohala and cattle ranching in South Kohala. In North Kohala this created a society based on small villages of laborers imported from Japan, the Philippines, China, Korea, Puerto Rico and Portugal, as well as native Hawaiians. The cattle ranches of South Kohala, while never large employers, created their own communities, which tended to include many Hawaiians. It is important to note that native Hawaiians living more traditional lifestyles centered on fishing, hunting and farming have also been an important if numerically small element of the population.

The closure of Kohala Sugar in 1974 coincided with the growth of the visitor industry in West Hawaii. Today three times as many Kohala residents are employed in the service sector, many in tourism. The visitor industry began an economic and social transformation that now involves in some way all of Kohala and continues to accelerate. Key trends include economic diversification, immigration of mainlanders, population growth, and the opening of new lands for settlement.

The human and natural landscape of Kohala reflects all these influences. Major towns with roots in plantation and early ranching days include Waimea, Kawaihae and Hawi-Kapa'au. Towns whose layout dates from modern times include Waikoloa Village and the condominium/resort communities of the Waikoloa coastline.

Altogether, the population of Kohala stood at 13,431 in 1990. A community of people with diverse (and often mixed) ethnic backgrounds, including Caucasians, Hawaiians, Japanese, and Filipinos, is present. The full range of income levels is also present.

Away from the towns and villages, Kohala still retains its rural character, such as the scattered farms surrounding Waimea, the enormous pasture lands of Parker and Kahua Ranches, and the former plantation lands of North Kohala. Large areas of wilderness are also present along the coastline, in the deep and roadless windward valleys, and on the upper slopes of the Kohala Mountains.

1.3.4 Key Issues

Kohala residents are currently grappling with a number of socioeconomic issues. One is the tradeoff between the benefits of economic expansion and the ensuing problems of population growth and pressure on natural resources. A related issue is the growing interest in preserving tradition and the "local" flavor of the region. Also desired by many residents is a greater degree of autonomy for individual communities. Last but not least is the continuing struggles of the native Hawaiian community to define and implement some form of sovereignty.

1.4 Methodology, Data Sources and Consultants

1.4.1 Consultants

The social and economic analyses were conducted separately and integrated for this report. Dr. Youngki Hahn of Y.K. Hahn and Associates in Hilo, Hawaii, performed the economic impact analysis. Dr. Ron Terry of GeoMetrician Associates in Kea'au was responsible for the social impact analysis. Of great assistance in facilitating community contacts was Herb Lee of Lee Communications in Honolulu.

1.4.2 Published Data

Data and description concerning the design and operation of the project were supplied by the County of Hawaii Department of Water Supply, Okahara and Associates Engineering, and Megumi Kon, P.E., the chief author of the Environmental Impact Statement.

Demographic, social and economic information of a quantitative nature was obtained from U.S. Census Data, the *Hawaii State Data Book* and the *Hawaii County Data Book* for various years, publications of the Hawaii State Department of Labor and Industrial Relations, and the Hawaii Tax Foundation, Hawaii Visitors Bureau, and economic publications of First Hawaiian Bank.

A number of other published studies including Environmental Assessments, Environmental Impact Statements, surveys and regional plans were consulted for data, ideas and opinions concerning the impact of tourism in rural areas of Hawaii. Of particular importance was the *Revised EIS for Lalamilo Water System, South Kohala, Hawaii* (Belt, Collins 1980), the *Northwest Hawaii Open Space and Community Development Plan* (Townscape 1992), a survey of hotel workers performed as part of the Ritz-Carlton EIS (CRI and Datametric 1987), and the *1988 Statewide Tourism Impact Core Survey* (1989). These sources are cited individually in the text.

1.4.3 Public Meetings

The Hawaii County DWS conducted a series of four informational meetings concerning the project in Kapa'au, Waimea, and Puako. Representatives from the DWS, the consulting engineers and the EIS team were present at each meeting. A presentation with maps and diagrams preceded a question-and-answer session at each meeting. Sign-up sheets provided an opportunity for members of the public to receive project updates from the DWS and to be contacted by the EIS team and provided with copies of the EIS. This was also an opportunity for the EIS team to identify concerned community members and initiate consultation with them.

Subsequent to these initial meetings, members of the EIS team met with smaller groups focussed on the general project or specific issues. Topics for these meetings included Hawaiian Home Lands, coastal recreation, Hawaiian cultural issues, and other subjects.

1.4.4 Social Impact Questionnaire

The Social Impact team developed an open-ended questionnaire to elicit opinions about the project, particularly with regard to secondary impacts (see Attachment B for sample). Every individual and organization listed on the informational meetings sign-up sheet was either handed or mailed a questionnaire. Respondents were asked to mail or fax back the responses directly to the consultants, and were encouraged to call or write if they had any concerns they could not address in the format of the questionnaire. Questionnaires were also brought to the smaller focus meetings. Respondents were encouraged to reproduce or request additional copies of the questionnaires and distribute them to other concerned members of the community.

Approximately 25 questionnaires were received either by mail or fax. The responses contributed to scoping the range of issues and the range of attitudes concerning these issues. Selected portions of the responses are quoted or paraphrased in this document to provide a "feel" for public opinion.

1.4.5 Key Informant Interviews

Personal or phone interviews were conducted with key informants who were consulted because of their knowledge of and/or stake in the community. A genuine attempt was made to solicit views of individuals with varying opinions about the project, in order to gain a balanced view of the community. A list of informants is provided as Attachment A. Also included in this list are those questionnaire respondents who chose to list their names on their responses and certain individuals who wrote letters to the DWS concerning the project.

Spoken and written statements from these individuals are quoted in Section 3, which concerns impacts from the proposed project.

1.4.6 Policy Regarding Impact Disclosure/Discussion

It is the policy of this assessment team to attempt to include the full range of concerns and opinions in a Socioeconomic Impact Assessment. This contrasts with approaches that exclude discussion of opinions because of their inherent subjectivity, or which repeat only those opinions that appear "reasonable" to the authors. We believe that full disclosure is the best policy because it promotes a thorough general understanding of a project and its impacts for the public and government officials, who ultimately must decide whether and how to grant requested approvals.

Further discussion of methodology is contained within individual sections of this report.

1.5 Monitoring and Implementation of Mitigation Measures

Mitigation measures are suggested in various portions of this report, particularly in Chapter 3. These measures have been formulated by the authors, in consultation with the principal investigator for the EIS and the DWS.

A common belief among readers of an EIS is that suggested mitigation measures are essentially conditions that have been agreed to by government agencies and are thus enforceable through legal or administrative means. We wish to clarify this misconception. The responsibility to modify, adopt, codify, monitor and enforce these mitigation measures is in the hands of the County, State and federal government. Those members of the public who wish to be involved in the mitigation "bargaining" process or want to ensure that certain provisions have adequate means of enforcement should address their concerns to County and State agencies.

2 EXISTING SOCIO-ECONOMIC CONDITIONS

2.1 Existing Economic Conditions

Historically agriculture, especially sugar and ranching, has been the economic backbone of the Kohala region. However, the era of sugar in Hawaii has nearly ended. In Kohala as elsewhere in the State, the contraction of sugar acreage has been accompanied by the conversion of former sugar lands to alternative agricultural uses, and in some instances, to urban residential use, each with varying economic effects. The end of sugar on the Hamakua Coast will now force all of Hawaii County to undertake long-term adjustments to the ever-changing and evolving economy.

The introduction of additional water resources to Kohala would further enable the region to diversify its economy in order to maintain its long-term economic viability.

The initial economic impacts of water resource and pipeline developments are those directly related to the construction activities and its assessments are rather straightforward. The assessment of the secondary social and economic impacts, however, poses a considerable challenge both in scope and level of analysis. This study defines the range of future economic and community development scenarios that are presumably the consequence of water development based on the historical trends and also on the private sector's long term strategic plans.

2.1.1 State Economy

A combination of events, including the Gulf War of 1991, recession on the mainland, changing economic conditions in Japan, and Hurricane Iniki, have contributed to an economic slowdown since 1991. Visitor arrivals, the primary barometer of the health of the tourism industry, declined steadily since 1991 and the recovery have only begun to recover in 1994. Statewide, 1994 westbound visitor arrivals were up by 4.5 percent and eastbound visitors up by 1.5 percent from that of 1993.

Statewide civilian unemployment rates in 1994 have also risen 1.1 percent from an average of 5.8 percent to 5.9 percent for the first six months of 1993. The County of Hawaii, which typically has the highest unemployment rates of all the counties, logged an increase in unemployment from 7.3 percent in 1993 to 8.8 percent in the six-month period in 1994. Job counts statewide have fallen slightly, with much larger decreases registered in the sugar industry. Sugar production is off both statewide and for the County of Hawaii, falling by 2.7 percent and 12.3 percent, respectively. Construction permit value, measuring construction activity, has decreased statewide but shows a gain for the County of Hawaii, primarily the result of a single, large hotel construction project.

According to the Economic Department of Bank of Hawaii, "the post-hurricane reconstruction boost was followed by a steady stagnation of Hawaii real personal income all through 1993" (Bank of Hawaii 1994:5). This stagnation in real personal income has made Hawaii's economic recovery slower than the overall U.S. economic recovery since 1993. Hawaii's real personal income increase from mid-1993 to mid-1994 was only 3.6 percent, compared to 5.6 percent for the overall U.S. personal income increase over the same time period.

For both the State and County of Hawaii, the structure of the economy has changed from a producer of commodities to a producer of services. Table 2.1 shows the shift toward service production during the period from 1980 to 1992, using the distribution of civilian jobs by industry as an indicator.

Table 2.1
Job Counts by Industry and Percent Distributions

HAWAII COUNTY	1980 JOBS	1980 %	1992 JOBS	1992 %
Total Jobs	38,200	100	59,550	100
Contract Construction	1,950	5.1	2,900	4.9
Manufacturing	2,850	7.5	2,300	3.9
Trans., Comm., Utilities	1,900	5.0	2,600	4.4
Trade	7,000	18.3	12,700	21.3
Finance, Insurance & Real Estate	1,200	3.1	2,450	4.1
Services & Miscellaneous	6,950	18.2	14,800	24.9
Federal	600	1.6	800	1.3
State	4,100	10.7	6,700	11.3
Local	1,800	4.7	2,100	3.5
Agriculture	3,300	8.6	3,700	6.2
Non-Agr. Self-employed	3,550	9.3	5,900	9.9
Agriculture Self-employed	2,850	7.5	2,550	4.3

STATE OF HAWAII	1980 JOBS	1980 %	1992 JOBS	1992 %
Total Jobs	448,300	100	540,550	100
Contract Construction	23,950	5.3	31,100	5.8
Manufacturing	23,350	5.2	19,500	3.6
Trans., Comm., Utilities	31,200	7.0	43,400	8.0
Trade	105,250	23.5	135,300	25.0
Finance, Insurance & Real Estate	32,850	7.3	37,650	7.0
Services & Miscellaneous	98,450	22.0	162,450	30.0
Federal	30,000	6.7	33,400	6.2
State	45,150	10.1	62,600	11.6
Local	13,900	3.1	15,250	2.8
Agriculture	10,800	2.4	9,300	1.7
Non-Agr. Self-employed	28,300	6.3	38,050	7.0
Agriculture Self-employed	4,600	1.0	4,350	0.8

Source: Hawaii State Department of Labor and Industrial Relations, _Labor Force Data Book_, as updated annually.

2.1.2 Hawaii County Economy

Beginning in 1990, Hawaii County's economy has taken a downturn, as have all other island economies. In addition to the drastically declining tourist trade, the island economy is undergoing a further economic ill, faced with the closing of a number of sugar operations.

Statewide, lands under sugar cane production fell from 224,617 acres in 1960 to 161,991 acres in 1990, a contraction of 38 percent. Two-thirds of this contraction occurred in the decade from 1980-1990 alone. During this decade, lands under sugar production in Hawaii County shrank from 91.2 to 57.9 thousand acres, a contraction of 37 percent. In the Hamakua region, sugar cane lands shrank from 59.5 to 45.1 thousand acres, a contraction of 24 percent. (Hawaiian Sugar Planters Association, various years)

In the Hamakua producing region, both the Hamakua Sugar Company and Mauna Kea Agribusiness have suffered financial setbacks resulting from low yields. In August 1992 Hamakua Sugar Company filed for Chapter 11 bankruptcy and closed its operation permanently in June 1994. The closure of Hilo Coast Processing Corporation followed in August 1994. Ka'u Agribusiness has scheduled a phase out of its operations by 1996. Together this will eliminate 1,600 jobs and release 48,000 acres of former cane land.

For Hawaii County, the share of jobs representing contract construction and manufacturing fell from 12.6 percent in 1980 to 8.8 percent in 1992. The slowdown in the construction industry continued throughout 1994. Agricultural job share fell from 16.1 percent in 1980 to 10.5 percent in 1992. Recent closing of sugar companies will further reduce the agricultural share. Decrease of jobs in agricultural sector, however, has been at least partially offset by rebound of visitor industry employment. As noted above, the Hawaii County recorded an unemployment rate of 8.8 percent in 1994 - the highest in seven years.

The long-term economic outlook for the county does not appear to as upbeat as what was predicted during the 1980's. The next decade is expected to be a "slow growth" period, basically reflecting the slow recovery of the global economy by which the U.S. and Hawaii economies are largely impacted.

2.1.3 Regional Economic Setting 1970-1994

The 1990 census data indicate that the population of North Kohala is 4,291 and of South Kohala is 9,140, of which 5,972, or 65 percent is in Waimea town. The 1980 population was 3,249, and 4,607, respectively. Thus, the North Kohala district gained 32.1 percent whereas the South Kohala district, which includes Puako and Waikoloa, experienced a 98.4 percent increase; Waimea town grew as much as 406.5 percent over the same ten-year period.

Historically, agriculture has been the traditional source of jobs, income, and population base for Kohala. Ranching and small-scale truck farming comprise a large proportion of the farm activities here. Livestock production (primarily cattle) occupies 119,000 acres and diversified small vegetable crop farming takes place on 800 acres.

Recently the rapid expansion of tourism has significantly impacted the North and South Kohala districts, particularly along the coastal areas makai of the Queen Kaahumanu Highway. Tourism activity has had a positive impact on the growth of Waimea (Kamuela) town and the emergence of new communities, such as Waikoloa. Waimea town in particular has been undergoing rapid development, with an expanding population tied to tourism, second homes, "gentlemen ranches" and economic components of a resort community. Thus, the traditional agricultural industry is in strong competition with urban activities for land, water, labor and other resources which are limited in supply.

2.1.3.1 Employment

As of 1992, the districts of North and South Kohala have a civilian labor force of 8,200, of which 7,750 are employed. Table 2.2 shows employment by industry. Employment characteristics of the impact area are also presented in Table 2.2.

Not surprisingly, the largest number of residents, 46 percent of the total work force, is engaged in agricultural and related activities, followed by personal service, 32.2 percent, which includes hotel workers, and professional and related services, 13.2 percent. The unemployment rate in the district for 1994 was estimated at 5.2 percent.

2.1.3.2 Income

Table 2.3 presents 1990 census data for annual household and family income for the Kohala districts along with that of Hawaii County. Family income for South Kohala was $41,805, $34,653 for North Kohala and $33,186 for Hawaii County. The higher family income in South Kohala reflects the larger proportion of its residents engaged in professional service occupations.

Table 2.2
North and South Kohala: Employment by Industry, 1992

INDUSTRY	NUMBER
Agriculture/Forestry/Fishery	3,565
Construction	132
Manufacturing	496
Transportation/Communications/Utilities	101
Retail Trade	558
Finance/Insurance/Real Estate	295
Business & Repair Service	101
Personal Service	3,118[1]
Professional and Related Service	1,023
Public Administration	295

[1] Personal service includes hotel employees. Figure given here assumes 75% of total hotel employees employed by major hotels within Kohala reside within these districts. Source: Hawaii State Department of Labor and Industrial relations, Research and statistics Office, 1993.

Table 2.3
Household and Family Income of North and South Kohala, 1989

AREA	PER CAPITA INCOME	MEDIAN INCOME HOUSEHOLD	MEDIAN INCOME FAMILY	MEDIAN INCOME NON-FAMILY
Hawaii County	$13,169	$29,712	$33,186	$17,375
North Kohala	11,423	31,026	34,653	15,272
South Kohala	16,286	39,857	41,805	31,525

Source: U.S. Bureau of the Census, 1990 census STF 3A, 1990 CPH-L-81 (1992), Table 3; and 1990 CPH-L-82 (1992), Table 3.

2.2 Social Characteristics

2.2.1 Population and Settlement Patterns

2.2.1.1 Population

The following table presents recent and historic population data for Hawaii County and the North and South Kohala Districts.

Table 2.4
Population Trends

	1960	1970	1980	1990
Hawaii County	61,332	63,468	92,053	120,317
North Kohala	3,386	3,326	3,249	4,291
South Kohala	1,538	2,310	4,607	9,140

Sources: U.S. Bureau of the Census: "1990 Census of Population. General Population Characteristics," 1990 CP-1-13; Hawaii County Data Book.

The population of the two districts, which remained nearly stable for many decades, grew steadily after 1965 as a result of the expanding visitor industry, especially in South Kohala. The year 1965, when the Mauna Kea Beach Hotel opened and brought with it 775 jobs, inaugurated the era of large-scale resorts. By 1982 there were over a thousand jobs available at South Kohala resorts, a figure which grew to 4,000 by 1990 and to almost 5,000 by 1994 (Hawaii County, R&D var. years). The trend continues until today.

De facto population is a measure of the number of people who are actually present at any given time. It is derived by subtracting from the resident population the number temporarily absent and then adding the number temporarily present (e.g., tourists, military personnel, guest workers). In Hawaii, de facto population is largely determined by the number of visitors staying in hotels, condominiums or resort homes, and is an important consideration in planning recreation and transportation facilities.

De facto population is not recorded on a district by district basis. However, it can be very roughly approximated by multiplying the de-facto-minus-resident figure by the proportion of visitor accommodations present in a district, and then adding this to the district's population total. The results of estimating de facto population by this method are shown below in Table 2.5.

Table 2.5
De Facto Population Trends

AREA	1980	1990
Hawaii County De Facto Population	98,700	135,100
Kohala Average Daily Visitor Population	545	4,507
Kohala De Facto Population	8,401	17,938

Source: 1993 Hawaii County Data Book: Tables 2 and 106; Visitor Plant Inventory 1993, Hawaii Visitors Bureau.

Between 1980 and 1990 the spectacular growth in the visitor plant in Kohala led to an equally large increase in visitors and therefore de facto population. South Kohala clearly has a large and growing share of the visitors to the island and consequently the de facto population. At any given time, up to one-fourth of those present in Kohala are visitors.

The following section briefly explains the history and current configuration of the settlement pattern.

2.2.1.2 Settlement Patterns

Kohala is still a dominantly rural area, with great tracts of land dedicated to agriculture or ranches, such as in the scattered farms surrounding Waimea, the enormous pasture lands of Parker and Kahua Ranches, and the former plantation lands of North Kohala.

Large areas of wilderness are also present along the coastline, in the deep and roadless windward valleys, and on the upper slopes of the Kohala Mountains.

However, the population of Kohala is rapidly growing, and a number of villages present and one true urban area (Waimea) are present (see Figures in main EIS). Settlements have historically been concentrated in three basic regions:

1. Sugar plantation slopes;
2. Dry, leeward coast;
3. Moist to semi-arid upland cattle country.

The first is entirely contained within North Kohala, and the other two are found mostly within South Kohala but also to some extent in North Kohala. The location and layout of towns within these areas strongly reflect their economic origins. Some of the newer housing subdivisions in Kohala are not located within these three areas and instead owe their placement to tradeoffs between the demand for "sunbelt"-style subdivisions and the price and availability of land. The regions are discussed separately below:

Sugar plantation slopes

This area stretches from subhumid, windy Hawi to Niuli'i, on the border of the steep, almost inaccessible Kohala Valley region. During prehistory it was the site of magnificently productive irrigated agriculture including taro, sugar cane, sweet potatoes, bananas, yams, gourds and coconut. Early Western explorers praised the richness of the produce and the meticulous fields of the inhabitants.

During the late 19th century sugar cane began to dominate the landscape, and over time a number of plantations and mills covered nearly all the arable land below the 2,000-foot elevation in cane. Impressive irrigation systems and a railroad were built to support the crop.

The villages that developed were classic examples of the "plantation community" familiar to residents of most of the Hawaiian islands. Academic sociologists (e.g., Lind 1959) long ago identified these towns as unique community types. They evolved from their beginnings as separate clusters of ethnically segregated "camps" through a process of consolidation and relocation into today's mixed communities, a microcosm of Hawaii.

Settlement is now concentrated near the main highway, where the linear clusters of houses bear witness to their origin as plantation camps. A string of villages associated with the centers of former plantations provide modest commercial districts and still exhibit the frontier architectural flavor of the rough-and-ready early days of sugar in Hawaii.

Hawi and Kapa'au are the only towns with any significant number of business or government offices, while Hala'ula, Makapala, Union Mill and Niuli'i are basically residential. Population for these areas is listed in Table 2.5 below.

Although sugar cane cultivation ceased in Kohala in 1975, many residents still pursue agriculture as owners or workers on small farms (mainly nursery or truck crops) or ranches. Most of the rest of the population commutes to the resort areas of South Kohala or is retired.

Table 2.6
Population of Kohala Towns and Villages

Location	1990 Population
Hawi	924
Kapa'au	1,083
Hala'ula	496
Puako	397
Waimea	5,972
Waikoloa	2,248

Source: U.S. Bureau of the Census: "1990 Census of Population. General Population Characteristics.

Dry, leeward coast

From Upolu Point southward to Anaeho'omalu was a region of small fishing villages in the era before 1778. Lapakahi State Park recreates features typical of such a village, where trail systems connected the coastal villages with each other and the agricultural uplands that supplied taro and other crops. The coast was also favored for important ceremonial features such as Mookini and Pu'ukohola Heiau.

During the 19th and early 20th centuries, most of the arid coastal villages were slowly abandoned. Until the advent of the resort era in the 1960s, very little use of the coast was made except at Kawaihae Harbor, although native Hawaiians continued to practice traditional fishing at many locations. Even now the coastline is mostly uninhabited and little-visited. Commercial, resort and industrial uses predominate over residences except at Puako, which is by far the largest village with 545 inhabitants. Aside from this, there is light settlement at Kawaihae and the makai portions of the newer subdivisions in the Kohala Ranch area. The plans for Hawaiian Home Lands development at Kawaihae, if fulfilled, will create a major modern settlement at Kawaihae.

By far the dominant socio-economic entity in this area is the resort area, which consists of six hotels and related condominiums and resort homes, golf courses, tennis centers, retail facilities and restaurants. The area encompasses 36,814 acres of discontinuous development along and adjacent to ten miles of coastline between the Mauna Kea Beach Hotel at the north and the Waikoloa hotels at the south. As of September 1994, a total of 3,359 rooms were available, including 162 1- or 2- bedroom suites, 23 oceanside villas, and 5 luxury bungalows. A measure of the

celebrated status of the South Kohala resort area is that its hotels are consistently rated among the best tropical resorts in the world.

As extensive as current development is, plans call for considerable expansion in the future. The completion of the resort development along the Waikoloa coastline will essentially double existing development.

Moist to semi-arid upland cattle country

The largest urban area in the region is located on the crest of the Waimea Plateau, which also housed a significant population during prehistory where the plains meet the stream-carved Kohala Mountains.

Captain George Vancouver's gift to Kamehameha of five cows and a bull in 1793 set the foundation for the region's economy for two centuries to come. At first the wild cattle were simply hunted on the Waimea Plain. One of the early hunters was John Parker, who would later found the giant ranch that would dominate South Kohala for over a century and still bears his name.

The last twenty years in Waimea have produced dramatic growth, which has annexed to the charming cattle town the features of a wealthy resort area and bedroom community for resort workers. The 1990 census enumerated 5,972 inhabitants in greater Waimea. Aside from Waimea, several other locations are situated around actual ranches or in horse country. Waikii and Kahua Ranch have very small populations but rich ranching traditions and high scenic value. Waikii has been subdivided for high-priced "gentleman ranches." Also taking advantage of the upland plains is the modern planned community of Waikoloa, which had 2,248 residents in 1990, and Kohala Ranch, another planned resort community currently sparsely populated but with potential for several thousand residents.

The heritage of farming, ranching, hunting and fishing is strong in Kohala and the preservation of rural and wilderness values is an issue of high priority. Particularly sensitive are issues of expansion of urban, resort areas into pristine areas, particularly coastal areas of North Kohala. Although individuals and groups have diverse opinions about the level of growth consistent with conserving this resource, at least one group ((Hui Lihikai, formerly Citizens to Protect North Kohala Coastline) was specifically chartered to deal with the issue.

2.2.2 Socioeconomic

Table 2.2 illustrates socioeconomic characteristics of the population in North and South Kohala.

Table 2.7
Selected Socioeconomic Characteristics

CHARACTERISTIC	GEOGRAPHIC AREAS		
	Hawaii Island	North Kohala	South Kohala
Total Population	120,317	4,291	9,140
Percent Caucasian	39.9	34.0	52.3
Percent Asian/Pacific Islander	57.1	60.3	45.2
Percent Born in Hawaii	71.9	79.3	60.1
Percent Under 18 Years	28.7	29.4	29.7
Median Age	34.3	34.5	32.0
Percent Over 65 Years	12.6	12.7	7.4
Percent of Family Households With Children Under 18	50.3	46.8	55.6
Percent Over 25 Years With High School Diploma	77.7	68.0	88.2
Percent Over 16 Years in Labor Force	64.2	66.0	66.3
Median Family Income	$33,186	$34,563	$41,805
Percent in Poverty	14.2	7.2	10.3
Percent Whose Home Was Built After 1980	35.1	30.4	59.2
Percent Rental Homes Vacant	10.3	12.5	21.7
Median Home Price	$113,000	$123,300	$200,800
Percent Whose Home Was Built Before 1939	10.8	27.2	5.9
Percent Relocated Since 1985	46.9	37.8	62.6

Source: U.S. Bureau of the Census: "1990 Census of Population. General Population Characteristics," 1990 CP-1-13 and "1990 Census of Population. Housing, Summary Population and Housing Characteristics," 1990 CPH-1-13.

Even a casual assessment of the data contained in the above table indicates that North and South Kohala are quite different in many respects. For some data measures one or the other is near the extremes in Hawaii County. For example, South Kohala has the highest family income of any of the nine judicial districts on the island. Only in North Kona is there a higher proportion of white residents or a lower proportion of residents born in the State of Hawaii. As a group, the residents of South Kohala are richer, more likely to relocate households (this is a truism in a rapidly expanding population), better educated, and economically better off than the district to the north.

However, much of the apparent difference is simply a product of a bimodal population in South Kohala - long-time local residents mostly concentrated in Waimea, versus newer arrivals (many wealthy and/or retired) living in Puako and Waikoloa as well as Waimea. This accounts for apparent inconsistencies in the data. For example, although South Kohala has a median family income over 20 percent higher than North Kohala, the proportion of residents living in poverty in South Kohala is considerably greater than for North Kohala. South Kohala also has a greater percent of family households with children under 18 years old.

Examination of the data on a finer spatial scale clarifies this point. For example, the 1990 median home price within South Kohala varied significantly by location, from as high as $500,000 in Puako, to as low as $171,900 in Waimea, which compares roughly with Hawi in North Kohala.

South Kohala has also periodically suffered from a housing shortage, particularly for affordable housing, although current market conditions are depressed and many affordable condominiums in Waikoloa are sitting empty. Homelessness, particularly among native Hawaiians, has also been a chronic problem. It is thus interesting to note the extremely high rental vacancy rate in South Kohala in 1990, at a time when demand for housing was still high. In Waikoloa, the rate was 31 percent; in Puako, almost 44 percent of rental units were vacant. Such rates are typical of resort areas with an abundance of vacation units (e.g., Keauhou-Kahaluu in Kona has similar rates) and are not necessarily indicators of an unhealthy economy. Nevertheless, the situation demonstrates that vacancy rates are not necessarily indicators of available housing for the least well-off socioeconomic groups.

2.2.3 Sociocultural

Table 2.8 details the ethnic structure of both districts and for all Census Designated Places (CDP) within each district for which data are available.

Table 2.8
Ethnic Composition of Population

	Jpnse	Hawn	Filip	Cauc	Other
Hawaii Island	20.8	19.2	12.9	39.7	7.4
North Kohala	13.5	24.0	18.7	34.0	9.8
Kapa'au CDP	20.0	22.6	16.9	26.8	13.7
South Kohala	10.4	24.2	7.3	52.2	5.9
Waimea CDP	12.6	31.0	6.3	42.3	7.8
Waikoloa CDP	6.1	9.9	3.5	73.7	7.3

Source: U.S. Census Data: Table 6, "1990 Census of Population. General Population Characteristics," 1990 CP-1-13.

Some of this diversity is expressed on a fine geographical scale. For example, wealthy, retired Caucasians born outside the state predominate in the coastal resort areas. The Japanese and Filipino components are most numerous in North Kohala, a remnant of the plantation era. Hawaiians are most numerous in and around the cattle country of Waimea.

It should be noted that according to State Department of Health figures from the *State of Hawaii Data Book*, almost half of all marriages for Hawaii residents involve partners of different ethnic groups. Tallies of ethnic groups in Hawaii may be thus be criticized as somewhat inaccurate - and to some extent meaningless.

The dominant trend in the modern era of coastal resorts has been a dramatic increase in the Caucasian population both numerically and proportionally (Table 2.9). This has occurred in virtually every location of the district but has been particularly prominent in the resort communities. Many (but by no means all) of these new in-migrants are wealthy, older and retired or semi-retired.

A survey of resort workers at the Mauna Lani and Westin Mauna Kea Beach hotel provides data on the ethnic breakdown of resort workers in Kohala (CRI and Datametric 1987). Although the survey is somewhat dated, there is no reason to believe that current conditions are substantially different from those in 1987.

Table 2.9
Ethnic Transformation of Kohala

	Jpnse	Hawn	Filip	Cauc	Other
NORTH KOHALA					
1970	23.8	15.3	29.2	25.6	6.1
1980	17.6	23.3	22.4	27.9	8.8
1990	13.5	24.0	18.7	34.0	9.8
SOUTH KOHALA					
1970	24.4	26.5	6.6	39.2	3.3
1980	14.5	27.8	5.8	43.4	8.5
1990	10.4	24.2	7.3	52.2	5.9

Note: Figures are given in percentages. Source: U.S. Census Data: Table 5, "1990 Census of Population. General Population Characteristics," 1990 CP-1-13.

Table 2.10
Ethnic Identity of Kohala Residents Versus Workers
At Mauna Lani and Mauna Kea Beach Hotel, 1987

	ETHNIC IDENTITY				
CLASSIFICATION	Jpns	Hawn	Filip	Cauc	Other
Kohala Residents	11	24	11	46	7
Resort Workers	11	32	20	26	11

Note: Figures represent percentages and are rounded. Source: CRI and Datametric Research, 1987.

The representation of ethnic groups within these resorts is not substantially different from the region's distribution, although Filipinos are over-represented and Caucasians somewhat under-represented in the total work force. Particularly at the Mauna Kea Beach, many workers came to the hotel after Kohala Sugar closed in the 1970s and it is thus unsurprising to find a large Filipino group.

2.2.4 Indicators of Social Well-Being

Measures of social well-being or disruption include educational levels, family disorders, child and spouse abuse, divorce, alcohol and drug abuse, crime, juvenile crime, vandalism, mental illness, suicide, and similar problems.

Although every social researcher recognizes that such measures are important components of social profiles and key variables for examining social change, their analysis over time is problematic. For one, there is a lack of consistency in definition or even recognition of particular social problems between modern and former eras. Widespread changes in values may define new problems (e.g., child abuse) and dismiss others as irrelevant or trivial (e.g., teenagers who listen to rock and roll). Statistics, especially those comparable between different eras, are often lacking.

Furthermore, although there may be consensus that certain social phenomena are undesirable, it is often impossible to trace cause and effect relationships among variables such as urbanization and population growth and social problems. Several social thinkers (e.g., Kelly 1974 for Hawaii; MacNaught 1982 for Pacific islands; Duffield and Long 1981 for Scotland) maintain that the urbanization and class differentiation of the local population that accompany the growth of tourism foster racial and social tensions, leading to increased crime, violence and family problems. In opposition to this argument was a study in Hawaii by Knox (1978) that indicated social tensions were not especially exacerbated by tourism and that residents generally perceived visitor interaction in a positive light. The issue is complex in that undesirable trends in drug use, suicide, child abuse, teen pregnancies, and divorce are common in communities throughout the U.S., whether they are urban or rural, rich or poor, white or non-white, or increasing or declining in population.

In any case, there are historical statistics for at least several categories of social problems. Some of these are available at the District level, others for the entire County only. The following table illustrates recent trends in several categories.

Table 2.11
Incidence of Selected Social Problems, Hawaii County

Characteristic	1970	1980	1990
Divorce	2.6	5.1	4.0
Births to Unwed Mothers	120.5	210.7	351.9
Suicide	n/a	9.6	16.6
Families Living in Poverty	97.0	103.0	109.0
Juvenile Arrests	9.2	13.7	20.4
Child Abuse	n/a	n/a	1.2
DUI Arrests	3.6	2.0	6.5
Serious (Part I) Crime	2.5	5.5	6.2
Adults Without H.S. Diploma	532	311	223

Note: All figures are reduced to incidence per thousand population. Sources: Hawaii County Data Books. Some figures refer to year previous. Juvenile arrests include all Part I (Serious) and Part II crimes. DUI arrest figure for 1970 is actually for 1975 and is an estimate based on estimated 1975 population.

Several measures have shown improving trends over the last twenty years, including the percentage of adults with a high school diploma and the incidence of driving while intoxicated (to the extent that arrests are an index). However, most indicators of social well-being showed an undesirable trend from 1970 to 1990, whether in Hawaii or anywhere else in the United States. Of particular significance are the rates births to unwed mothers, which are unfortunately correlated with juvenile crime, undereducation and child abuse.

Such trends probably should not be viewed as simply a collection of temporary problems that can be ameliorated by properly funded and administered programs. They are indications of a fundamental and still-evolving transformation of American society, part of a complex that includes such diverse factors as television, double-income households, the loss of the extended family, urbanization, persistent racism and a host of other factors. It is clear that along with Westernization and modernization in its economy, transportation systems, education and media, Hawaii also has inherited all the social problems of the modern, Western world. What is unclear and probably unanswerable is the extent to which the visitor industry plays a role in social disruption of the local population.

Of interest in this regard is a comparison of the crime rate in 1979 and 1990 for the districts of South Kohala, North Kohala and South Hilo (listed in descending order of the visitor industry influence) (see Table 2.12).

Table 2.12
Crime Rate for South Hilo, North Kohala and South Kohala

Offense	South Hilo		North Kohala		South Kohala	
	1979	1990	1979	1990	1979	1990
Murder	18.9	9.0	0	0	43.4	0
Neg-Mansl.	16.5	2.2	61.6	0	65.1	0
Rape	35.5	58.2	0	23.3	21.7	65.6
Robbery	49.7	87.4	0	0	0	21.9
Ag-Assault	87.5	192.7	30.8	93.2	108.5	207.9
Burglary	1473.6	1498.7	738.6	629.2	1367.4	1203.5
Larceny	3621.2	5423.5	1785.2	1444.9	3255.9	4978.1
Auto Theft	276.7	454.7	123.1	116.5	217.1	448.5
Assault	633.8	1283.1	61.6	699.1	217.1	1389.5
DUI	210.5	403.2	92.3	279.6	217.1	1116.0
Narcotics	579.5	454.8	1200.4	256.4	976.8	295.4

Note: All figures are reduced to incidence per 100,000 population. Sources: Hawaii County Data Books.

In general, it is evident that rates of crimes are increasing in all districts, as has been the national and statewide trend. Also, for most categories, either Hilo or South Kohala has the highest rate. North Kohala - which now employs a large percentage of its population in resort business but maintains a rural lifestyle - is consistently lowest. Some categories are perhaps largely tied to the visitor industry: e.g., the rate of DUI is artificially high in South Kohala because of the high de facto population of tourists as well as the lifestyle of some resort employees.

It should be noted that inferring trends based on a one-year sample is not valid, especially for uncommon crimes such as murder. For example, one double murder during the year in Ka'u would turn the district - statistically speaking - into the "murder capital of Hawaii," at least for that year.

2.2.5 Community Identity, Values and Visitor Interaction

Less amenable to quantification but vitally important to an accurate characterization of the social fabric of an area are a series of concepts that comprise social well-being and community. Included are characteristics

that fall into two main groups:[1]

- *Sense of Community.* Community decision-making processes and local power structures, tendency to relocate away from community, relocation of strangers into district, socio-economic harmony, socio-economic polarization, community and regional character or spirit, codes of conduct among and between various social and ethnic groups, etc.

- *Relationship with Visitors and Tourist Industry.* Participation through work or recreation in industry; harmony or conflict based on crowding, presence of visitors at favorite spots, desired or undesired attention to island culture, restoration of archaeological sites, personal interaction with tourists, exposure to different life styles, feeling of self-worth based on comparison between visitor and local, etc.

Sense of Community

Kohala's rich and proud history has forged a strong sense of community identity that is evoked in both the people and the landscape. Kohala was an area of intensive, pre-contact Hawaiian settlement and activity. Mo'okini Heiau, said to have been constructed in the 12th century A.D. by the foreign priest, Pa'ao, is an example of an enduring and richly symbolic tie to Hawaiian prehistory. Hawaiian historians cite Kohala as the birthplace of Kamehameha, arguably the most important figure in all of Hawaii. He was brought up until the age of five at Halawa in North Kohala, and both North and South Kohala continued to figure prominently in his military and political career. He built Pu'ukohola Heiau at Kawaihae and there sacrificed his cousin Keoua Ku'ahu'ula and proclaimed himself chief of Hawaii Island. His chief adviser in the conquest of all the Hawaiian Islands was John Young, who resided at Kawaihae.

It was also here that Captain George Vancouver presented Kamehameha with five cows and bulls, a gift which would dramatically transform the landscape and economy of the entire island chain. Ranching and later sugar plantations came to dominate both the economy and the social structure of Kohala. Ranches and plantations were more than sources of jobs, they were the centers of a way of life. Such phenomena as burial societies, lending organizations, religious groups and labor movements were closely related to the everyday life of the plantation camp and the ranch (Lind 1938).

This heritage continues till today, and most kama'aina families trace their roots to such beginnings and share many deep and wide-ranging bonds. Newer residents of the area, particularly those from the mainland, do not share such bonds. Nevertheless, the celebration of this heritage in such events as hula festivals, plantation days and rodeos is enthusiastically supported by oldtimer and newcomer alike. There is also a deep concern for preserving and restoring historic sites.

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[1] The authors are indebted for the basic organization of this discussion to the treatment of the subject by Community Resources, Inc., in the EIS for the Lalamilo Water Project (Belt, Collins & Assoc. 1980).

At the same time, however, the sense of community is evolving as new residents (and their values) from outside the Big Island are gradually incorporated. Long-time Kohala residents often express a longing for the old days and a fear of being disenfranchised. This is particularly true in Waimea, which has been transformed from a sleepy and charming ranching village to a bustling community where there are more half-million dollar homes than traditional ranch cottages, where resort workers outnumber cowboys. At the crossroads of routes well-traveled by tourists in buses and rental cars, Waimea is destined for continuing change.

Relationship with Visitors and Tourist Industry

The central role held by the visitor industry in Kohala continues to grow. Over 20 percent of Kohala residents are currently employed in tourism-related jobs; in 1988 it was estimated that 30 percent had worked in the industry at one time or another, and that even more had a family member who had done so (CRI 1989). The growth of the resort region that would be encouraged by the proposed project - whether it ultimately took the form of mainly hotels or resort residential as planned - would only increase the dominance of this economic sector.

Attention is usually focussed on the economic contribution of the visitor industry, but the effects are far more pervasive and include significant social and cultural aspects. Jobs stand for more than economic sustenance. They also frame a person's identity and status, and they provide a structure for social and family life as well. Hotels and other elements of the physical plant transform the visual landscape. Tourists interact with residents at beaches and parks, stores and restaurants, and even on the highway, changing the social milieu.

Perhaps partially because of a strong sense of regional identity and pride, the relationship with visitors has been and remains remarkably free from overt signs of conflict. Car break-ins are regular but muggings rare, and island people have been generous in welcoming visitors to such spots as Hapuna, Waimea, Pu'ukohola and Lapakahi. When John Kelly observed in 1974 that:

> "Tourist industry executives live in fear of further outbreaks of mounting anti-tourism hostilities. Nightly bus tours returning from Windward O'ahu to Waikiki now move in police-escorted caravans as a result of repeated stoning by hostile residents," (1974:8)

he believed that this signalled the beginning of a trend in local-visitor relations. Considering the perception of high crime rates that plagues the tourist industry in Miami and elsewhere, Hawaii has the image of a veritable paradise, with friendly inhabitants and negligible violent crime.

Most agree, however, that after a certain point, serious discord may arise. The trigger for this "saturation point" may not be reducible to a simple concept such as population, visitor numbers or density. Such factors as the wealth and nationality of visitors and attitudinal changes internal to Hawaii society may also be key.

A valuable source of detailed data for attitudes concerning the visitor industry is the *1988 Statewide Tourism Impact Core Survey* (1989), which was undertaken by Community Resources, Inc., on behalf of the State Department of Business, Economic Development and Tourism to provide baseline data for planners, visitor industry specialists, and social researchers.[3]

Geographically, the smallest sample unit was a county subdivision. One such unit was the Kohala area, where over 150 people were surveyed. Table 2.13 presents selected questions and compares statewide versus Kohala responses.

Most people in both Kohala and the state of Hawaii believe that several aspects of tourism enrich their lives. Jobs are clearly seen as the principal benefit of tourism. Other aspects of tourism with a positive perception are the new opportunities for shopping, dining and entertainment, improvements to regional beautification and beach parks, and the preservation of Native Hawaiian culture. Surprisingly, at least in view of certain beliefs about the effects of tourism in Kohala (see Smith 1972 for discussion), most respondents believe that the overall standard of living and the quality of family life generally improve as a result of tourism.

On the other hand, Hawaii residents generally believe that crime, traffic and higher prices for housing, food and clothing accompany tourism. Kohala residents tend to view tourism in a slightly more positive light than the state as a whole, but less positively than residents of certain other areas of the island, e.g., Hilo, Hamakua, Ka'u and South Kona. One interpretation of this phenomenon is that Kohala residents have less stressful contact with tourists than some oversaturated resort areas, but more experience than rural areas where tourism has not yet approached a level that produces noticeably negative effects.

The tourism survey also published information on a statewide basis about possible differences among the various ethnic groups with respect to the impacts of tourism (Table 2.14)

At least according to the information obtained in the telephone survey, very little difference exists in perception among ethnic groups. It must be cautioned that this information is based on a statewide sample and is not specific to Kohala. It has been hypothesized by some that attitudes towards tourism are conditioned by one's employment. There are two basic (and contradictory) hypotheses: that working in tourism inclines one more favorably to tourism because it provides one with a source of income, and that involvement in the visitor industry makes one jaded about tourists. Data testing these hypotheses are available in the *Statewide Tourism Impact Core Survey* (Table 2.15).

[3] Based on phone survey of almost 4,000 residents, one of the largest ever taken in Hawaii. Values +/- 8 percent are accurate with a 95 percent level of confidence. As with any social research, the degree of validity is more difficult to determine.

Table 2.13
1988 Statewide Tourism Impact Core Study Responses

Has tourism made ___ better or worse for your island?	Better (%)		Worse (%)		No Effect (%)	
	State	Koha.	State	Koha.	State	Koha.
Job Availability	82	86	12	6	4	4
Shopping, Restaur., Entertain. for Residents	60	64	18	11	18	19
Overall Standard of Living	63	68	20	14	11	9
Quality of Family Life	41	47	20	16	29	27
Beauty of Your Area	33	45	22	17	41	36
Preserv. of Native Hawaiian Culture	47	52	36	26	8	15
Relations Between Long-Time Residents and Newer People	33	40	31	26	21	22
Quality of Beach Parks	44	42	40	32	10	17
Number of People Living in Your Area	27	37	30	28	35	25
Preserv. of Ocean and Natural Areas	33	40	45	36	14	15
Speed or Pace of Life	32	37	42	32	17	23
Cost of Food and Clothing	20	21	56	46	16	24
Cost of Housing	8	7	67	73	17	13
Crime Situation	6	10	70	52	11	26
Traffic Situation	4	10	83	69	11	17

Notes: Data from CRI 1989, Tables III-B1-32. "Koha." refers to North and South Kohala. Margin of error is approximately +/- 7.6 percent with a 95 percent level of confidence.

Table 2.14
Perception of Tourism by Different Ethnic Groups

QUESTION	ETHNIC GROUP				
	Jpnse	Hawn	Filip	Cauc	Other
When you see tourist, is it usually pleasant [or unpleasant]?	82	81	83	82	83
Have there been any recent situations when tourists have interfered with your life?	5	9	5	10	7
In the past thirty days, how many times have you helped a visitor who needed something?	42	61	54	62	58
In the past 5 years, have you ever stopped going to a favorite spot because you felt it had been taken over by tourists?	23	26	28	28	25
Overall, has tourism been mostly good [or bad] for you and your family?	61	59	64	58	59

Note: Figures represent percentages of "YES" answers and are rounded. Some questions are phrased slightly differently (original phrasing in brackets) to simplify response category. Source: CRI 1989, Vol. 3, Tables in Series II-A and II-B.

Despite the close match in answers on most specific questions regarding the impacts of tourism, those who do not depend on the visitor industry for income are somewhat less inclined to view tourism, overall, in a totally positive light. It should be noted that for the last question, only 3 percent of those who depend and 5 percent of those who do not depend on the visitor industry responded that tourism was mostly bad for themselves and their family. Many respondents chose the "no effect" in response.

Social and Cultural Offerings of the Resort Region

Resorts offer a number of social and cultural attractions to residents either directly or as a spinoff of visitor-oriented aspects (e.g., restaurants and special "kama'aina" hotel rates). Many of the same attractions offered to visitors often appeal to the local population. This is particularly true in a rural area such as Kohala, where entertainment has tended to be more humble and homespun. Big Island residents now have regular (and formerly unheard-of) opportunities to attend performances by world-class entertainers such as Liza Minelli, a yearly chance to travel in the golf gallery with Arnold

Palmer and Jack Nicklaus (as well as to golf on these designer courses), and the choice of tasting the creations of world-famous chefs.

Table 2.15
Perception of Tourism by Those Working in Visitor Industry

QUESTION	WORK CATEGORY	
	Family income depends on tourism	Family income does not depend on tourism
When you see tourist, is it usually pleasant [or unpleasant]?	87	81
Have there been any recent situations when tourists have interfered with your life?	10	8
In the past thirty days, how many times have you helped a visitor who needed something?	68	52
In the past 5 years, have you ever stopped going to a favorite spot because you felt it had been taken over by tourists?	27	26
Overall, has tourism been mostly good [or bad] for you and your family?	77	54

Note: Figures represent percentages of "YES" answers and are rounded. Some questions are phrased slightly differently (original phrasing in brackets) to simplify response category. Source: CRI 1989, Vol. 3, Tables in Series II-A and II-B.

Some members of the local community feel that although such events may be enjoyable to those who can afford them, they supply yet another potential source of inferiority feelings to less wealthy residents and also may tend to devalue local entertainers and customs. Even when local culture such as music, hula or crafts is promoted, some feel that such demonstrations may be unauthentic or even a prostitution of culture.

Regardless, many local residents opt to utilize resort attractions. Over half of Kohala residents surveyed in 1988 said that they had spent at least one night in a resort hotel or condo in the last year. About 20 percent had gone to a nightclub and 70 percent to a restaurant in the previous thirty days (Ibid, Tables II-B).

Table 2.16 lists a sampling of activities and events cited by the Kohala Coast Resort Association in its promotional literature for the region.

Table 2.16
Cultural Attractions and Events Cited by Kohala Coast Resort Association

ATTRACTION	DESCRIPTION
Restaurants	Currently more than 25; great variety of cuisine
Annual Festivals	Big Island Bounty Festival (local food products); Hula Festival; Winter Wine Escape; New Year's Eve Galas; Aloha Festival activities
Sporting Events	Senior Skins
Charity	United Cerebral Palsy: Waikoloa Rubber Ducky Race
Hawaiian Culture	Local crafts demonstrations at most resorts; Hula (sometimes as part of tourist luau; May Day programs; Hawaiian Heritage Week; Aloha Fridays; Ethnobotanical and environmental tours; Kupuna demonstrations.
Arts	Art galleries and special showings; Laurance Rockefeller Asian Art Collection.

2.2.6 Outdoor Recreational Resources

Kohala is renowned for its fine scenery and outdoor recreation opportunities. Sweeping views of the ocean and the volcanoes of Mauna Kea, Mauna Loa, Hualalai and Kohala are common from many locations. Kohala provides excellent coastal fishing opportunities for residents and visitors. Many residents also hunt, hike, and gather resources along the coast or in the upland areas.

Table 2.17 lists and describes public recreational areas in Kohala, stressing outdoor recreation. Much of the information was gathered from the *Northwest Hawaii Open Space and Development Plan* (Townscape, Inc. 1992). Additional public facilities include the Kawaihae Small Boat Harbor, with 33 slips and 12 moorings (due to expand). Almost a dozen private golf courses exist, with many more in planning or construction, but no public course has yet been built. There are also several private rodeo and polo facilities present in South Kohala.

Table 2.17
Recreational Areas in Kohala

Recreational Site	Description
TRAILS. 30 major trails in area, including:	
Ala Kahakai-Awini Trail	Kailua Village to Windward Kohala Valleys, coastal trail with fishing spots.
Lapakahi-Paoo-Koaeae	Ancient mauka-makai & stone-lined trail
Waikoloa Stream Trail	Proposed for biking, hiking, equestrian
PARKS. State, federal and county historical, beach and community parks, including:	
Hapuna Beach State Recreation Area	Major recreational site in West Hawaii, due to expand from 62 to 500 acres
Spencer Beach State Park	Popular park for local residents: 13.4 ac.
Pu'ukohala Heiau National Historical Site	One of major heiau in State, serves as interpretive and event center
Lapakahi State Historical Park	Outstanding display of coastal habitation site
Mahukona County Park	Small-boat launching and diving
Kapa'a Beach Park	Small portion of 28.3 ac. is developed
Kamehameha Birthsite and Mookini Heiau St. Mons.	Mostly undeveloped but highly significant historical parks
Kamehameha County Park	Ballfield, swimming pool in Kapa'au: 18 ac.
Keokea Beach Park	Pavilion, surfing: 7.1 ac.
Waimea Park	Ballfield and designer playground: 10.5 ac.
Waikoloa Village Neighborhood Park	
NATURAL AREAS	
Pu'u O Umi	Includes upper Kohala Mountain and a host of endangered species
Pololu/Akoakoa (proposed)	Preliminary planning for State Park and Wildlife Sanctuary
PRIVATELY DEVELOPED PUBLIC PARKS	
'Anaeho'omalu Beach Park	Waikoloa Dvpt. Co.

2.2.7 Public Services and Infrastructure

A complete inventory of the roads, utilities, schools and government services in Kohala is beyond the scope of this EIS. The following summary highlights those areas in which expansion or improvement is likely to be necessitated by the general increase in population and use expected as a result of the proposed project.

Roads and Highways

The Kohala region is served by over 75 miles of State Highways and an even greater length of County roads. Major roads are listed in Table 2.18 below (see EIS for maps).

Table 2.18
Major Highways in Kohala

HIGHWAY NAME	STATE NO.	ADT AT ENDPOINTS & SELECTED MIDPOINTS
Kawaihae Road	19	Waimea: 13,838 Kawaihae: 6,200
Queen Kaahumanu Hwy.	19	Kawaihae: 7,273 Keahole: 7,240
Akoni Pule Hwy.	270	Kawaihae: 4,914 Hawi: N/a
Kohala Mountain Road	250	Waimea: 19,815 Hawi: N/a
Mamalahoa Hwy.	19, 190	Mud Lane: 13,491 Waimea: 6,492 Waikoloa: 3,782

Source: ADT (Average Daily Traffic) is from 1992 and is derived from Hawaii State DOT (Department of Transportation). 1992. *Traffic Summary, Island of Hawaii*. Honolulu. N/a means not available.

Traffic conditions on all roads are currently acceptable, in large part due to forward planning by State and County agencies in anticipation of resort development. A declining Level of Service (LOS) because of increasing traffic congestion is being experienced in urban Waimea, where a Bypass Road has been in discussion for over a decade.

Utilities

Electrical service is provided by the Hawaii Electric Light Company (HELCO) through overhead lines from HELCO's plant in Waimea.

Peak electrical load on the island of Hawaii more than doubled between 1965 and 1985. HELCO's 1994 forecast called for a 164 megawatt (MW) peak. Ideally, firm generating capacity would supply this level plus a reserve margin of 30 percent. Periodic shortfalls in electric supply, exacerbated by difficulties with geothermal energy development, litigation between potential producers and HELCO over the right to develop power plants, and the collapse of the sugar industry, have plagued electrical service to the island.

Telephone service by Hawaiian Telephone Company (HTCO). Central switching station functions for the region are handled through the Kailua-Kona station.

Sewage Treatment and Solid Waste

No public sewage treatment facilities currently operate in Kohala, although the resort hotels and several resort and condominium complexes between Waikoloa and Kawaihae operate their own STP's (Sewage Treatment Plants). Sewage systems within the Kawaihae-Puako area consist of individuals cesspool system. Concern over aquifer and coastal water protection has led the State and County to act with caution in approving developments in order to avert contamination to waters. Domestic sewage in North Kohala, a rural area with little coastal settlement, is considered to be adequately treated using cesspools and septic tanks.

Solid waste is handled through Solid Waste Transfer Stations located in Waimea, Puako, Kaauhuhu and Halaula. A landfill was opened in 1993 at Pu'u Anahulu, just south of the South Kohala District boundary, which is expected to serve the needs of West Hawaii for the foreseeable future.

Schools and Libraries

The Kohala High and Elementary Complex services North Kohala's student population, which stands at 1,076 according to DOE officials. Waimea School accommodates a total of 1,177 students in grades K-8 and Waikoloa has 345 in grades K-5. High school students in South Kohala attend Honokaa High School, some 16 miles distant.

Several private schools, notably Hawaii Preparatory Academy and Parker School, both located in Waimea, serve a student population estimated at 861 (all figures from DOE records for August of 1994).

Based on statistics provided in the *Hawaii County General Plan* (Hawaii County, Planning Department 1989:53-54), this represents an increase of 44 percent in student enrollment between 1989 and 1994.

The Bond Memorial Public Library in Kapa'au and the Thelma Parker Memorial Public/School Library in Waimea meet the library needs of the districts.

Fire and Police Protection

Fire protection is provided by the Kohala (Kapa'au), Waimea, South Kohala (Puako) and Waikoloa stations. Three shifts provide round-the-clock service, and certified Mobile Intensive Care Technicians (MICT) are assigned to each station except Waikoloa. Waimea and South Kohala each have six firemen on duty at all times, with additional support at South Kohala from a three-man helicopter crew. Kohala has four personnel on duty at all times and Waikoloa three. Emergencies are taken to Lucy Henriques Medical Center, Kona Hospital or Hilo Hospital. Firemen at the station are also trained in rescue procedures and many have various levels of water safety training up to certified lifeguard.

Police stations in Kapa'au (three officers per shift) and Waimea (five per shift) provide round-the-clock service in Kohala.

Government Agency Offices

County and State agencies are for the most part centered in the Aupuni Street complex and at other locations in Hilo. One County satellite center is located in Kailua-Kona.

Services offered in the other districts (including Kohala) are primarily recreational (see Section 2.2.6), agricultural (crop marketing, resource management, etc.) or medical.

Kohala Hospital is a 26-bed community hospital located in Kapa'au. The North Hawaii Community Hospital in Waimea, currently scheduled for completion in March 1996, will have 50 beds and will take over emergency room services currently supplied by the Lucy Henriques Medical Center.

Public and community facilities are also found in Waimea and Kapa'au, where some combination of mental health, vital statistics, disability and public health services are offered.

A small number of Department of Human Services (DHS) programs such as Child Protective Services and Income Maintenance also have offices in either Waimea or North Kohala.

3 SOCIO-ECONOMIC IMPACTS AND MITIGATION MEASURES

This section discusses and quantifies where appropriate the direct and secondary impacts of the proposed project on the study region, and then suggests measures to mitigate adverse impacts. The discussion begins with a review of the Lalamilo Water Project, which helped enable the rapid development of the coastal resort region.

3.1 The Lalamilo Water Project, 1980

3.1.1 Relevance to Current Project

The Lalamilo Water Project was undertaken by the Hawaii County Department of Water Supply between 1978 and 1983 to address a shortage of water in the coastal South Kohala area. Although the Waikoloa Resort had private groundwater supplies to support a great deal of future development (current use stands at approximately 2.9 mgd, with reservations to use as much as 16 mgd), resort development for adjacent parcels that was in the planning stages and had been encouraged under County zoning and State Land Use law required a source of potable water for completion. The Lalamilo project was planned to provide approximately 5.2 mgd via four wells using a high-quality groundwater source.

The large increase in water supply in the area was expected to engender substantial secondary impacts to land use, population, employment, housing, and social quality that could be attributable directly or indirectly to the water made available by the project. An EIS conducted for the project attempted to predict these impacts. In the words of the authors:

> "[The project] would allow private developers to implement their plans for resort development within the area served by the system. This, in turn, would bring with it extensive secondary growth as workers and their families area are attracted to (or retained in) the region by the employment opportunities that would be generated. Impacts, both physical and social, would accompany this growth and far outweigh those effects related directly to the construction of the water line" (Belt, Collins & Associates 1980 III-1).

The authors of this report consulted the Lalamilo EIS and compared its predictions with the actual patterns that resulted. This exercise had several goals:

- o to determine the extent to which the availability of water influenced the extent of development;
- o to observe the predicted versus the actual pace of development;

A brief review of selected findings of the former EIS follows the above themes in mind follows.

3.1.2 Lalamilo Impacts to Jobs, Population and Housing

The authors of the Socioeconomic Impact Assessment prepared for the Lalamilo project developed a series of econometric and population models to calculate secondary effects of the expanded water system. Readers interested in methodology may consult the original document. In the end, analysis resulted in a series of estimates of the increase in labor force, residents and households.

Table 3.1 is a result of compiling data in the Lalamilo EIS with 1980 and 1990 census data and housing inventories in order to compare predictions with the patterns that emerged in reality.

It is quickly apparent that predicted versus actual employment, household and population increases match very well. Although we acknowledge the basic soundness of the methodology employed in the Lalamilo study, the congruence is to some degree accidental.

The Lalamilo EIS was not consistent about assessing the cumulative impact of the development in relation to other possible developments in the immediate area. For example, whereas the EIS explicitly mentioned that some 2,400 visitor units were likely to be constructed at Waikoloa (Ibid: III-13), it assessed the potential "non-project" employment growth (which included Waikoloa along with all other Kohala sources) as only 800 potential new jobs. In fact, most of the growth in the resort area in the 1980s was derived from the Waikoloa Resort area, which with its private water source was not dependent on Lalamilo.

The first entry in Table 3.1 above contrasts predicted hotel/condo inventory growth resulting from the Lalamilo Water System and "non-project-related" sources. Table 3.2 below illustrates the actual timing and magnitude of hotel construction, hotel units and jobs, and condominium unit development. As is apparent, project-related inventory growth never approached the predicted magnitude. Even total inventory growth did not attain the predicted level, although the Waikoloa developments were considerable.

Clearly the dominant source of operational hotel jobs during the 1980s was the Waikoloa Resort Area.

Another discrepancy between the actual versus predicted pattern was the location of population growth within Kohala. As explained in the Lalamilo EIS, the precise location of project-related housing is hard to predict in the absence of clear-cut government or private plans. The authors discussed several growth options in the context of existing County plans and policies, and concluded that:

Table 3.1
Predicted Secondary Socioeconomic Impacts of Lalamilo Water System, Kohala

IMPACT CATEGORY	IMPACT
Existing Hotel/Condo Inventory (1980)	310/<20 units
Project-Related H/C Inventory Increase	2,500/2,250 units
Non-Project-Related H/C Inventory Increase	1,500/900 units*
Total Predicted Increase in H/C Inventory by 1990	4,000/3,250 units
Sum of Existing Units and Predicted Increase	4,310/3,270 units
Actual Hotel/Condo Inventory in 1990	3,071/256 units
Existing Labor Force (1980)	3,200 workers
Project-Related Labor Force Increase	2,900 workers
Non-Project-Related Force Increase	800 workers
Total Predicted Increase in Force by 1990	3,700 workers
Sum of Existing and Predicted Increase	6,900 workers
Actual Force in 1990 Census	6,945 workers
Existing Households (1980)	2,700 households
Project-Related Households Increase	2,000 households
Non-Project-Related Households Increase	550 households
Total Predicted Increase in 1990 Households	2,550 households
Sum of Existing and Predicted Increase	5,250 households
Actual Households in 1990 Census	4,446 households
Existing Resident Population (1980)	7,856 persons
Project-Related Resident Population Increase	6,600 persons
Non-Project-Related Resident Population Increase	[not calculated]
Total Pred. Increase in Resident Population by 1990	6,600 persons
Sum of Existing and Predicted Increase	13,856 persons
Actual Resident Population in 1990 Census	13,290 persons

Source: 1980 and 1990 U.S. Census of Population; Hawaii County Data Book; Hawaii Visitors Bureau Visitor Plant Inventory, var. years. Notes: *Authors of the Lalamilo EIS predicted increase in Kohala inventory only for Waikoloa Resort Community (Belt Collins 1980: III-13).

Table 3.2
New Resort Jobs and Condominium Units in Kohala, 1980-1990

HOTEL	OPENING DATE	PEAK NUMBER OF UNITS	PEAK NUMBER OF JOBS
Lalamilo Water Related:			
Mauna Lani Bay	1983	363	680
Ritz Carlton	1990	541	1,000
Waikoloa Water Related:			
Royal Waikoloan	1981	545	360
Hyatt (Hilton)	1988	1,241	2,000
CONDOMINIUMS	OPENING DATE	PEAK NUMBER OF UNITS	
Lalamilo Water Related:			
Mauna Lani Terrace	1982	42	
Mauna Lani Point	1986	58	
Bay Club	1991	66	
Waikoloa Water Related:			
Waikoloa Shores	1987	65	

> "...about 70 percent of the resident population growth in the Kohalas associated with the proposed project is likely to occur within the Kawaihae-Puako area that would be served by the system" (Ibid, p. III-32).

This translated to a predicted growth of 4,200 in Kawaihae-Puako, which would cause its population to swell from its 1980 figure of less than 500 to a 1990 total of almost 5,000. Puako has grown to over 500, but Kawaihae still remains too small to be counted as a Census Designated Place and contains probably less than 300 residents. Population instead grew most rapidly in Waikoloa and Waimea and to some extent in North Kohala.

As stated in the Lalamilo EIS:

> "It must be stressed that the actual population distribution that would be achieved is so dependent upon specific County planning initiatives, the arrangements for support housing made by prospective resort developers, and relative land and development costs at various sites that the estimated

distribution used in this report may not be realized" (Ibid: p. III-3).

The failure of the support communities to emerge was an important lesson for all future EIS's dealing with resort development.

3.1.3 Lalamilo Socio-Cultural Impacts

The authors of the Social Impact Assessment viewed the following outgrowths of resort development as having the most social impact:

- Transforming open space to occupied space
- Growth of economic opportunity
- The accelerated growth of visitor and resident population

On the beneficial side, they cited that the commercial, cultural and entertainment facilities would be open to public and provide a source of social enjoyment.

A mixed impact was the projected rise in house values. Entry into the housing market for first-time buyers would be difficult, but some current homeowners might reap windfall benefits upon sale. A particularly disturbing outcome was the likelihood that children of current residents would have to relocate out of Kohala to find affordable housing. For those in Puako, which might be most directly affected, these mixed blessings would be even more pronounced. There was concern that those living on fixed incomes might find it difficult to pay their property taxes. This latter impact has to an extent been mitigated by County tax policies, particularly for owner-occupants.

More subtle would be the indirect effects of the new employment opportunities: broadened opportunities; new workers with different values integrating into the community; different wages/social status/working conditions of new jobs; workers enticed away from existing jobs; reduction in food stamps clients; and the need for job training.

Because much of the growth was expected to consist of newcomers to the region, social adjustment problems were expected. Examples cited included disturbances to traditional social and political group decision making; takeover by newcomers of small businesses; anti-haole tensions; and the growth of a "two-tiered" community of wealthy newcomers and struggling, working locals.

There was also concern that growth in public and community services might lag behind population growth, leaving the public inadequately served in terms of public safety, health, education and social services.

Finally, the authors identified the possibility that recreational resources, especially beaches, might experience crowding and consequent tension.

3.1.4 Lessons from the Lalamilo EIS

The authors carefully emphasized that the extent to which an action has a social or economic impact is difficult to ascertain, since social actions never occur in isolation from ongoing trends and other actions. The outcome of the Lalamilo Water Project demonstrates this.

In the big picture, the predictions made in the EIS have largely come true. Jobs were created, employees required (and found) housing, and the social composition of Kohala changed, bringing both tension and beneficial interactions. It was also true that the growth in public services and recreational facilities failed to keep up fully with demand at all times.

At the same time, the more specific was each prediction in the Lalamilo EIS, the less likely was it to be accurate. Assumptions in such a study must always be made and are always risky. There are a number of methodological approaches, and no matter which is used, there is a great deal of uncertainty. No one can predict with certitude the future financial climate, the actions of entrepreneurs largely responsible for particular developments, or outside developments such as wars, changes in fashion, or alternative destinations that profoundly affect the fickle resort market. If anything, the very carefully executed Lalamilo EIS serves as a reminder about the virtual impossibility of accurate two-decade forecasts and the need to take EIS predictions as first-cut estimates in continual need of reworking.

3.2 Economic and Fiscal Impacts of the Proposed Project

3.2.1 Economic Impacts

Significant primary and secondary economic impacts are anticipated from the proposed project. Primary impacts are those economic impacts resulting directly from planning, design and construction activities for the project. Secondary impacts would be those impacts associated with the anticipated economic development that would occur in the region due to the availability of water.

3.2.1.1 Development Timetable

Construction of the water pipeline would begin during 1996, assuming that all necessary conditions have been met by that time. Once construction begins, the first 10 million gallons per day (mgd) of water is expected to be available as early as mid-1998.

It is reasonable to assume then that the earliest development of resort-related projects relying on the newly-developed Kohala water resource would be sometime in the year 1998, assuming that user groups are ready with financing prior to construction of the project. It is expected that secondary development will continue to occur during the 20 years following this date. Resorts and other developments expected to depend upon the water will likely materialize at a pace largely determined by prevailing economic and financial conditions.

3.2.1.2 Projected Employment And Income Impacts From the Construction of the Proposed Water Project

3.2.1.2.1 Methodological Notes

There are a number of alternative analytical approaches used to measure primary and secondary economic impacts resulting from water resource development. In order to capture the "ripple" effects of the initial water resource development, this study uses multiplier analysis based on the State of Hawaii Department of Business and Economic Development and Tourism's most current Input-Output model (1988). Direct impacts represent the initial expenditure or job creation; indirect impacts represent inter-industry purchasing effects; induced impacts represent household spending effects.

The proposed water development project generates three types of employment opportunities, which occur during both construction of the transmission line (primary) and construction/operation of resorts and other development (secondary):

- o Direct Employment: jobs created directly by the project, such as construction worker or resort staff.
- o Indirect Employment: jobs created as the development project begins to buy goods and services from local business entities.
- o Induced Employment: jobs created as project-related employees begin to spend their money.

The project also creates employment in two phases: short-term employment during construction of the transmission lines and resorts and long-term employment during operation of the resort complexes.

3.2.1.2.2 Employment Impact During Construction of Transmission Line

Construction of the proposed water transmission project will generate employment both within the impacted area as well as outside the impacted area, island-wide and statewide. Employment from construction of water wells, reservoirs and the transmission main will be generated during a construction period of over two years for Phase I. Further employment will be generated during construction of additional wells during Phase II of the project.

Primary economic impacts begin with the estimated cost of $60.4 million 1992 dollars to be expended for developing 10 mgd of the water resource. This includes well-drilling in addition to construction of permanent well sites, pipelines and reservoirs. As demand for water increases, additional water wells capable of producing an another 10 mgd will be developed to meet the demand. The estimated cost for the Phase II is $19.6 million, also in 1992 dollars.

Direct, Indirect, and Induced Employment

Direct employment resulting from construction of water wells and pipelines was estimated based on the island-wide employment experience of similar construction projects. Construction employment includes both construction crews at job sites and other technical, managerial and administrative personnel who may be located throughout the island or even throughout the state. Table 3.3 below summarizes the assumptions and computations of employment generation resulting from construction of wells, transmission, and reservoirs.

According to the construction industry multiplier analysis (DBEDT 1988) approximately 24.5 labor-year jobs are generated by every $1.0 million construction expenditure. This means that for the proposed project approximately 740 full-time construction jobs will be generated per year for two years totaling 1,480 full-time jobs over the construction period.

Using the same methodology, an additional 480 full-time jobs are estimated to be created during Phase II of the project.

Table 3.3
Direct, Indirect/Induced Employment Generation From Construction of Wells, Pipelines and Reservoirs

	EMPLOYMENT PER $1 MILLION	CONSTRUCTION PERIOD	EMPLOYMENT PER YEAR	TOTAL
First Phase				
Direct Indirect and Induced	24.5	2[1]	740	1,480
Second Phase				
Direct Indirect and Induced	24.5	1[2]	480	480

[1]Construction is to begin in 1996.
[2]The construction period of Phase II is assumed to be one year, and is expected to begin in 2010.

Of the total 1,960 jobs generated, 616 or 31% are estimated as the direct jobs by using the input-output multiplier model. It is estimated that 914 or 46.6 percent of total jobs will be on the island, whereas the other 1,046 jobs will be off-island (statewide).[3]

Direct, Indirect/Induced Income Impact

During Construction

Table 3.4 summarizes computation of estimated income generated by the proposed project. Generally, part of the direct construction expenditure consists of wages and salaries to construction crews and related employees. In the Kohala Water Transmission System, $50.3 million of the total of $60.4 million will be earned by construction-related workers and workers who are supporting the construction industry over the two-year construction period, or $25.2 million per year for two years. This figure is the sum of the direct, indirect and induced income from the project.

[3]The number of on-island jobs was calculated as following:
(Direct jobs) x 90% x (1 + 0.65).
Source: Ritz-Carlton EIS (Belt-Collins 1987:IV-63).

During the second phase of the project, the total construction expenditure of $19.6 million will result in $16.3 million of income earned by construction workers and workers supporting the industry.

All together, a sum of $66.6 million will be generated as a result of construction of the water transmission system.

Table 3.4
Projected Direct, Indirect/Induced Income During Construction ($000)

	MULTI-PLIER	FIRST PHASE	SECOND	TOTAL
Original Expenditure		60,400	19,600	80,000
Income				
Direct Indirect/Induced	.832[1]	50,253	16,307	66,560

[1]Uses income/output ratios from State of Hawaii Input-Output Model (1988).

3.2.1.3 Impacts During Operation of the Water Transmission System: Secondary Economic Impacts

The economic impacts during the "operation" phase of the water resource development entail a general economic development process of the region as a result of water availability. This growth process can be viewed as secondary impacts of the proposed project.

3.2.1.3.1 Assumptions Regarding Future Economic Development of the Region Due to Water Availability

Historical observation reveals that the shortage of water presents considerable constraints to general economic expansion of the region. Therefore, it has been often argued that making water resources available to the area where it is lacking will surely bring about an economic boom. This view is appealing because it is true that in the long run, water is a **necessary** condition for any development. Unfortunately, however, the mere availability of water is a poor predictor, at least in the short run, of the emerging population and community pattern. This is because growth and development require other **sufficient conditions** such as favorable conditions in the domestic and/or global economy, the financial and investment climate, and the state and county regulatory environment.

The relationship between water availability and actual economic and community development patterns in the short run is not at all clear.

The actual historical pattern of growth in West Hawaii reveals a number facts. 1) Prior to the 1960s there had been virtually no growth, although the lack of water was not the binding constraint to such growth. 2) Starting from 1965 hotels and resort residential units (condos, single and multi-family residential units) were developed at an average rate of 1,900 hotel rooms and 720 resort residential units per every ten years. 3) New additions to resort residential units have been declining rapidly since 1985.

These historical trends contrast markedly with a scenarios presented in "planning studies" or "planned projections." It is important to note that actual development has proceeded at a much slower pace than the rate projected by most planning scenarios. For example, according to one often-cited planning study, the "maximum build-out scenario" for West Hawaii would witness 11,600 additional hotel units and 20,000 residential units by the year 2000; by the year 2005, an additional 7,850 hotel and 10,000 resorts units would be built.[4] A study based on a time trend regression model (1965-1993), however, indicates that if the past trends continue, the region would not have more than 3,600 hotel units and 3,840 resort units by 2020, a significantly lower projection.

For this study we established a range of probable development based on **Historical Trends** and the **As-Planned** scenario, which is based on private and public sector projections. Table 3.5 indicates the type and number of units planned by the major property owners in the service area, including the Department of Hawaiian Home Lands (DHHL) project at Kawaihae. These figures were obtained by the Hawaii County Department of Water Supply in consultation with affected large property owners in potential service area.

Table 3.6 compares the number of hotel and residential units envisioned in the two scenarios. The number of hotel units varies from a minimum of 450 units (**As-Planned**) to a maximum of 3,600 units (**Historical Trend**) during the planning horizon. Resort residential units range from a low of 3,600 (30 percent of build-out rate of privately planned total) and a high of 12,073 units (total planned units). Additional support communities and urban expansion activities would also be expected.

[4] *See West Hawaii Regional Plan*, Office of State Planning, 1989.

Table 3.5
Private Sector/DHHL Development Plans

	1996-2004	2005-2009	2010-2014	2015 2019	TOTAL
Hotel Rooms	275	0	175	0	450
Single Family Residential					
DHHL	720	1,028	0	2,118	3,866
Others	470	403	333	838	2,067
Multiple Family Residential					
DHHL	720	1,028	0	2,118	3,866
Others	483		558	748	2,270
Total	2,393	2,942	916	5,822	12,073

Source: Hawaii County Department of Water Supply.

Table 3.6
Range of Hotel and Residential Development Scenario

	1996-2004	2005-2009	2010-2014	2015 2019	TOTAL
Hotel					
Historical	1,350	750	750	750	3,600
Planned	275	0	175	0	450
Residential					
Historical	1,350	750	750	750	3,600
Planned	2,393	2,942	916	5,822	12,073

Historical trends assume that 750 hotel units are built for every five-year period, and that 750 residential units, or 30% of the planned total, are built every five years.

3.2.1.3.2 Employment Impacts

As water becomes available we anticipate that resort development will gradually take place. Development will generate jobs in two ways: 1) resort construction work, and 2) the more permanent jobs impacts as resorts swing into a full operation.

Employment Impact During Construction

Computation of employment impacts utilizes a number of conversion factors which have been empirically derived from Hawaii construction projects. These are summarized in Table 3.7. To illustrate, construction of one unit of hotel (one room) is assumed to require one-half of one labor per year. The construction period is two years. Thus, one hotel unit requires one labor-year. Applying the same logic, the construction of a single family home is assumed to require two labor-years.

Table 3.7
Conversion Factors Used For Computation of Employment Generation

TYPE OF FACILITY	LABOR REQUIRED PER UNIT	CONSTR. PERIOD (MONTHS)	FTE LABOR PER UNIT
Hotel	0.5	24	1.00
Condominium	0.7	18	1.05
Single Family Lot	0.02	12	0.02
Single Family Home	2.00	12	2.00
Commercial	N/A	N/A	0.6

Source: Kukio Beach Resort EIS and Phillips, Brandt, and Reddick and Associates, 1986.

Based on the factors in Table 3.7 above, computations are carried out and the results summarized in Table 3.8 below. The total employment (combined impact of direct, indirect, and induced) generated by hotel construction ranges from a low of 371 labor-year equivalent to a high of 1,816 during the first nine-year period. Or in annual bases, it ranges on average from 41 labor-year to 202 labor-year per year for the first nine-year period. The lower end of the range corresponds to the **As-Planned** scenario (hotels built according to the private sector's long-range strategic plan) and the upper end assumes the **Historical Trends**.

Total jobs generated during construction of residential development range from a low of 9,217 to a high of 16,339 in the first nine years (1996-2004), or a low of 1,024 to a high of 1,815 jobs per year. The lower figure based on the **Historical Trends** and the upper figure reflects the **As-Planned** scenario. As build-out continues, it is estimated that by the year 2015 and beyond, construction employment could reach as much as 7,950 per year or 39,700 for five years.

Employment Impact During Operation of Resort

Once hotel units are in place, hotel operation will generate permanent employment. The estimate of employment generation is computed using the assumption that on the average 1.54 direct employees are hired per hotel unit. It is further assumed that approximately 25 percent of single- and multiple- family residential units will be on the rental market with one permanent employee per 10 rental units for administrative/maintenance duties.

Results of estimates for employment generation are shown in Table 3.9. Again the employment impacts have lower and upper ranges, depending on the development scenario. The lower range (the **As-Planned**) indicates that 484 direct jobs will be generated in Kohala and an additional 492 jobs, or a total of 976, will be created as the indirect and induced employment multipliers spread throughout the island and state during the years 1998-2009. In terms of annual bases, the lower range of the total jobs created will be on average 81 jobs per year for the first twelve-year period of the operation. Even in the lower range scenario, cumulative employment can reach 2,008 by the year 2020. Should hotel development follow historical patterns, total employment expected for the same period is estimated to be 4,262 or 355 per year during the years 1998-2009. Under this scenario total resort-related employment can reach over 11,360 by the year 2020.

Table 3.8
Projected Employment for Construction of Hotel and Residential Units (Labor Years)

	JOBS/UNIT	1996-2004	2005-2009	2010-2014	2015 2019
Hotel					
Direct					
Historical[1]	0.5	675	375	375	375
Planned	0.5	138	0	88	0
Indirect/Induced[2]					
Historical	1.69	1,141	634	634	634
Planned	1.69	233	0	149	0
Total Hotel					
Historical		1,816	1,009	1,009	1,009
Planned		371	0	237	0
Residential					
Direct					
Planned[3]	2.02	4,834	5,943	1,850	11,760
Historical[1]	2.02	2,727	1,515	1,515	1,515
Indirect/Induced					
Planned	2.38[4]	11,505	14,144	4,403	27,989
Historical	2.38	6,490	3,606	3,606	3,606
Total Residential					
Planned		16,339	20,087	6,253	39,749
Historical		9,217	5,121	5,121	5,121

[1]750 units per five-year period, 3,600 units total.
[2]Indirect and induced impact multiplier is based on 1988 State DBED&T's most recent input-output model.
[3]The number of planned residential units includes both single-family and multiple-family houses.
[4]The average between SF and MF construction multipliers (2.067 and 2.69 respectively).

Table 3.9
Projected Direct, Indirect, and Induced Employment for Operation of Resort Hotels Per Year (Labor Years)

	JOBS/UNIT	1998-2009	2010-2014	2015-2019	2020-2024
Historical[1]					
Direct	1.54	2,113	1,173	1,173	1,173
Indirect/Induced	1.017	2,149	1,193	1,193	1,193
Total (Cumulative)		4,262	6,628	8,994	11,360
New jobs Per/year		355	473		
Planned					
Direct	1.54	484	74	292	146
Indirect/induced	1.017	492	75	297	148
Total (Cumulative)		976	1,125	1,714	2,008
New jobs Per/year		81	30	118	59

[1]Assumed 1.54 employees per hotel unit. Actual employee/unit ratio within the impact area ranges from 1.0 to 3.0. Assumed that 25 percent of resort residential units are rental units and 1 employee per 10 such units are needed.

3.2.1.3.3 Income Impact from Construction of Resort Development

As development takes place, enormous amounts of investment are expected to pour into the area. These investments will be expended upon construction of hotels and resort residential, commercial, and other related activities. These activities not only generate employment but also generate income for both residents of Kohala and residents outside the area (statewide). In addition, such activities also generate a stream of tax revenues, which will be treated in a later section of this study.

Just how much income will be generated depends on the scale of development. As before, a range of low and high estimates are made based on the **Historical Trends** and the **As-Planned** scenario.

Table 3.10 summarizes the projected build-out hotel and residential units along with the dollar costs of such build out for each five-year period. It is expected that new hotels will be upscale resort hotels following the leads of Mauna Lani, Mauna Kea, Hapuna Prince, Ritz Carlton, and Four Seasons hotels. Construction cost estimates are based data from the Ritz Carlton Mauna Lani, the latest figures available. The **Historical Trends** scenario predicts 750 units of hotel will be built per five years (150 units per year), leading to a total of 3,600 units by 2020. Under this scenario direct construction expenditures are estimated to be an average of $48.5

million annually. Total cumulative construction expenditure could reach $1,162 million by the year 2020.

The **As-Planned** scenario would produce only 275 units during the 1996-2004 period. There is no further planned hotel construction until the 2010-2014 period, at which time an additional 175 units are planned. Under this scenario only $6.04 million per year will be spent for a total of $145.3 million over the twenty-four-year period.

For resort residential development, the **As-Planned** scenario has 12,073 units built over a twenty-four-year span starting in the year 1996. Historical trends, however, indicate that only about 25 percent of those units planned by the private sector have actually been built. Thus, in this study we set the **Historical Trends** as the lower end of the range and the **As-Planned** scenario as the upper limit.

Table 3.10
Projected Expenditure for Construction of Resorts ($ Million)

	1996-2004	2005-2009	2010-2014	2015-2019	TOTAL
Hotel					
Historical[1]					
Units	1,350	750		3,600	
Cost[2]	$436	242		1,162	
Planned					
Units	275	0	175	0	450
Costs	$89	0	57	0	145
Residential[1]					
Historical					
Units	1,350	750		3,600	
Costs[3]	$304	169	169	811	
Planned[4]					
Units	2,393	2,942	916	5,822	12,073
Costs	$502	574	275	1,111	2,462

[1] 750 units per five-year period, 3,000 units total.
[2] An average of $323,000/unit for hotel construction is assumed (*Hawaii Monthly Cooperative Report of Local Construction*).
[3] The historical cost per unit was assumed by taking the average of the cost of the luxury unit and non-luxury unit. Per unit construction costs of $300,000 and $150,000 were assumed for the luxury unit and the non-luxury unit, respectively.
[4] DHHL Kawaihae units were assumed to be non-luxury. DWS-Kawaihae and Puako, Nansay-Puako Golf Cmm., and Mauna Lani Resort units were assumed to be luxury.

The lower limit is an average of 750 residential units built for every five years (150 units per year) for a total of 3,600 units over the 24-year period. Expenditure under this scenario is $168.8 million per five years, or $33.8 million annually, totaling $811 million over the 24-year period.

The upper limit is 2,393 units of single- and multi-family residential units, and other resort-related commercial units are to be built during the first nine-year period at an estimated cost of $500 million or $55.6 million per year for the same nine-year period. An additional 2,942 units, 916 units, and 5,822 units will be built during three subsequent five-year planning periods, respectively, totalling 12,073 units over the 24-year period. Total construction expenditure will be $2.5 billion for the same period or, on average, $103 million per year.

3.2.1.3.4 Income Impact During Construction and Operation

Table 3.11 summarizes the result of computation of income generated during the construction of resorts over 24 years. If the development scenario follows the **Historical Trends**, the lower limit of the range, $1.3 billion of income is expected to be generated over the 24-year construction period or $54.3 million annually.

On the other hand, should development occur as envisioned in the **As-Planned** scenario, the income impact will be much greater. The income from such stepped-up construction activities will amount to $370.8 million for the first nine years, or $41.2 million annually. The second five year's total income impact is estimated to be $353.6 million, $208.8 million for the third five years, and it may reach as high as $684.4 million for the last five years, or in annual terms $70.7 million, $41.8 million and $136.88 million per year for each respective five-year period. The total expected income generated under this scenario amounts to $1.6 billion.

When resort hotels are in operation, they will generate permanent income to the workers hired by the resort complex. Table 3.12 summarizes the income impacts from resort operation. It is assumed, as was in the case of employment impacts, that hotel units generate most of the permanent income and the resort residential units generate less income since the employment is limited to the rental units' portion of the total residential units. The study further assumes that the hotels would employ workers whose classification would match the current visitor industry mix of 89 percent unionized and 11 percent salaried workers.[5]

[5] Source: Ritz-Carlton EIS (Belt, Collins 1987:IV-47).

Using the **Historical Trends** as an upper limit and the **As-Planned** scenario as the lower limit of the range, it is estimated that hotels will generate a low of $191.3 million to a high of $834.3 million per year of the total income during the first twelve years of operation or $15.9 and $69.5 million, respectively, annually. The income generation range for the year 2020 and beyond will be a low of $78.7 million to a high of $185.4 million annually.

Table 3.11
Projected Direct, Indirect/Induced Income from Construction of Resorts ($ Million)

	MULTIPLIER	1996-2004	2005-2009	2010-2014	2015-2019
Direct, Indirect and Induced Income					
Historical					
Hotel	.692[1]	$301.7	167.5	167.5	167.5
Residential	.616[2]	$187.3	104.1	104.1	104.1
Total		$489.0	271.6	271.6	271.6
Planned					
Hotel	.692	$61.6	0	39.4	0
Residential	.616	$309.2	353.6	169.4	684.4
Total		$370.8	353.6	208.8	684.4
Total Hotel/Residential					
Historical		$489.0	271.6	271.6	271.6
Planned		$370.8	353.6	208.8	$684.4

[1]Direct, Indirect and induced impact multiplier is based on 1988 State DBEDT's most recent input output model.
[2]The average between SF and MF construction multipliers (.656 and .575, respectively).

3.2.1.4 Availability of Labor Supply

Whether or not there is an adequate labor supply to meet demand depends on a number of factors. First of all, the size and the rate of growth of the civilian work force for the region and within the county will greatly influence the size of labor supply. Population growth can have two sources; 1) natural growth and 2) net in-migration. A particularly important factor for determining the labor supply for the region is the second source. The proposed residential development has a large number of DHHL housing units (7,732 units or 64 percent of the total at full build-out) along with traditional resort-type luxury units. It is not likely that the residents of those luxury units will be a source from which we can expect to draw labor supply. However, the residents occupying the DHHL units may have a large pool of potential workers.

Table 3.12
Projected Direct, Indirect/Induced Income for Resort Hotel Operation of Resorts ($ Million)

	1998-2009	2010-2014	2015-2019	2020-2024
Income				
Historical				
Union Worker(89%)	$722.8	468.3	635.4	802.6
Salaried Worker(11%)	$111.5	72.6	98.8	124.4
Total	$834.3	540.9	734.2	927.0
Planned				
Union Worker (89%)	$165.6	190.8	290.7	340.6
Salaried Worker (11%)	$ 25.7	29.6	45.1	52.8
Total	$191.3	220.4	335.8	393.4
Total Income				
Historical	$834.3	$540.9	$734.2	$927.0
Planned	$191.3	$220.4	$335.8	$393.4

Note: Median income of $14,870 for union workers and $18,650 for salaried workers for 1988 have been adjusted to 1992 dollars (Environmental Impact Statement on the Ritz-Carlton resort development).

The expected employment requirements were computed and are shown in Table 3.8 and 3.9. Table 3.13 provides the latest labor pool and employment situation in the region. It appears that if the region's population, civilian labor forces, and employment rates follow historical patterns, labor requirement for the years 1996-2004 can be met without much difficulty under the lower range of resort development (**As-Planned** scenario).

Should development occur according to the upper range (**Historical Trends**), labor demand could rise rapidly. Again, the first twelve years should not pose a tight labor market; however, from the second five-year growth period onward, demand for labor rises, perhaps much faster than the natural growth of the civilian work force. On the other hand, should the DHHL's planned residential units result in a large number of residents moving to the region, it may be possible that the demand can be met largely by these potential new residents to the region.

Table 3.13
Employment Status of the Civilian Labor Force 1994

	CIVILIAN LABOR FORCE	EMPLOYMENT	UNEMPLOYED	UNEMPLOY-MENT RATE
Hawaii County	65,400	59,700	5,750	8.8
N. and S. Kohala(1992)	8,200	7,750	400	4.5

Source: First Hawaiian Bank, *Economic Indicators*, September/October 1994. State Labor and Industrial Relations, 1993.

3.2.2 Fiscal Impacts Analysis

The development that will ensue from the water transmission system will surely bring about an increase in the number of residents and visitors in Kohala region. This will impact, among other things, government operations. This section analyzes the project's fiscal impacts at the county and state levels.

3.2.2.1 Methodology

In general the fiscal benefit/cost ratio (FBCR) computations are based on a series of economic assumptions. Changes assumptions would obviously change the resulting ratio. In this study, the principal assumptions are the values for two major factors: 1) the number of hotels and resort housing units that may be built over next twenty to thirty years time horizon and 2) increases in the number of visitors and new residents to the state of Hawaii (in migration) and to the Island of Hawaii because of such developments.

With respect to the first assumption, there are two build-out scenarios, namely, the Historical and As Planned. For each scenario, a benefit/cost computation is made for every five year interval (largely because build-out rates are different over time). Then these benefit/costs ratios are averaged to arrive at a single FBCR ratio. In our draft report the FBCR ratios for both scenarios were computed to reflect the impact of resort development with an additional assumption that all jobs created would be met by using the locally available labor supply. Thus, the net increase in population was assumed to be from 1) increase in visitors and 2) increase in residents residing within the residential units.

The project will generate State government revenues from various sources. However, two major sources are: 1) Direct excise taxes on visitor expenditure and 2) Income tax on earnings by residents from the project. County government revenue will be derived primarily from 1) Property taxes on the improvements and 2) Water facility

charges. The state and county fiscal benefit/cost ratios use only major revenue sources and thus underestimate B/C ratios because they do not include additional revenues from miscellaneous taxes. However, for the sake of simplicity, this study limited revenue source to those identified above.

Per capita government expenditure for both residents and visitors is computed based on visitor expenditure data from the Hawaii Visitors Bureau and visitor-sensitive components of State and County operating budgets. Finally, using total revenue and expenditure for each period, fiscal benefit/cost ratios for County and State governments are computed.

3.2.2.2 State Fiscal Impacts

3.2.2.2.1 Computation of Tax Revenue

Tax revenue during the construction phase of the project will result from general excise tax on the direct costs of construction and from income tax revenue from earnings by construction workers.

A summary of the tax revenue computation is shown in Table 3.14. The revenue from excise taxes from construction of resorts and housing is estimated to range from a low of $23.6 million to a high of $29.7 million over the first nine-year period (1996-2004), or $2.62 million to $3.3 million per year for the same nine-year period, depending on the extent of development. The $2.4 million in excise tax from the first phase of the construction of the water transmission system is included in the first nine-year period (1996-2004), and the second phase's $0.8 million in the fourth period (2015-2019).

During resort operation, excise taxes on visitor spending will generate $9.9 million to $12.8 million annually during the seven-year period 1998-2004. Annual excise tax revenue from visitor spending is expected to reach as high as $60.8 million by the year 2020.

In addition to excise taxes, there will be income tax and other taxes generated as part-time and full-time employees will pay income taxes, excise taxes, inheritance tax and other taxes. The revenue from these taxes for the same period is estimated to range from $39.6 million to $76.4 million over the nine-year period 1996-2004, or $4.4 million to $8.5 million per year for the nine years, again depending on the extent of development. Combining excise and income taxes, total tax revenue could range between $134.9 million to $198.2 million for the first nine-year period or $15 million to $22.0 million per year. By the year 2020, total state revenue is expected to range from $327.7 to $333.2 million for the five-year period or $65.5 million to $66.6 million per year.

3.2.2.2.2 State Expenditure

Table 3.15 summarizes state operating expenditure by categories of services provided. The state per capita resident expenditure was $4,441, and the per capita expenditure for visitors was $912.

Table 3.16 estimates increase in de facto population in the region as a result of proposed development. It should be noted that planned residential development has two components: DHHL residential development and other resort (single and multiple family dwelling units). Increase in de facto population arises from three sources: first, increase in hotel units which result in increase in visitor population; second, from DHHL residential development which includes resident population; and third, increase in resort type residential units. Using this increase in de facto population, Table 3.17 computes increase in annual state expenditure (increases in resident and visitor population are treated more fully in Section 3.3.1).

For the computation of annual state expenditure, the following specific assumption are made: 1) DHHL units are all occupied by state residents, 2) the resort residential units have a 50 percent occupancy rate, and 3) the remaining resort-residential units are divided into one half occupied by visitor and the other half by permanent resident in-migrated from out of the state.

For the first twelve years state expenditure due to the increase in de facto population in the region ranges from a low of $5.1 million (**Historical Trends**) to a high of $6.7 million (**As-Planned**), annually. By year 2010, the annual state expenditure would range from $8 million to $12.6 million, respectively. By year 2020, it would range from a low of $13.7 million to a high of $38 million, annually.

3.2.2.2.3 Computation of State Fiscal Benefit/Cost Ratio

Based on the projected increase in State revenue shown in Table 3.14 and the increase in State expenditure estimated in Table 3.17, fiscal benefit/cost ratios of the project were calculated and presented in Table 3.18. Should development take place according to the **Historical Trends**, the State benefit/cost ratio is estimated to be 5.5 during the first nine-year period of 1996-2004. The ratio rises to 8.4 for the period 2005-2009, and then drops to 6.7 during 2010-2014. In the year beyond 2020, the ratio drops to 4.8. On the other hand, if development proceed along the planned development scenario, the ratio ranges from a high of 5.2 during year 2005-2009 to low of 1.7 for the years after 2020.

It should be noted that the benefit/cost ratios are relatively high in some of the computations partly because of the assumption that the increase in Kohala's population will be due to intra-state in-

migration and therefore net increase in state expenditure is largely from the visitor population, which is much lower than that for state residents. Needless to say, should such assumptions change and the resort development attracts migration from out of state in greater quantity than assumed, the benefit/cost ratio may rise or fall depending on whether or not the new residents will be gainfully employed.

3.2.2.2.4 FBCR For Cumulative Impact

Additional sets of FBCRs are computed for the year 2010 and 2020, reflecting "cumulative effects" of the resort development. Here, it is assumed that some jobs will be taken up by the newcomers who, along with their families, become new residents and thereby increase the resident population. It is also assumed that one half of those occupying the resort units are treated as visitors who are renting the units, and the other half are new inmigrants. The net effect of this is to increase visitor population and decrease resident population. Table 3.18A provides expected visitor arrivals and new inmigrant resident population under the two alternative scenarios.

The results of the new computations at two selected point in time along with non-cumulative ratios are summarized below.

Fiscal Benefit/Cost Ratio For the State Government

	For Year 2010	For Year 2020
Historical Build-out Scenario		
Project Only	6.7	4.8
Cumulative	4.7	2.4
As Planned Build-out Scenario		
Project Only	3.4	1.7
Cumulative	7.9	3.4

For the Historical Trends Scenario the "cumulative" FBCR is much smaller than the "project only" ratio, as expected. Also, the ratios decline in the year 2020 as the number of new resort developments approaches maximum. For the "As Planned" scenario, the cumulative ratio is larger than the "project only" ratio. These unusual results are traceable to the fact that under the "As Planned" scenario the ratio between visitors and new state residents is higher, leading to lower state expenditures per capita. <u>It is important to note from this exercise that the important determinant of the FBCR lies in the division of net increase in population between "visitors" and residents. The larger the proportion of the residents relative to visitors, the lower will be the FBCRs.</u>

Table 3.14
Projected Net Increase in Excise Tax and Income Tax Revenues from Construction and Operation[1] ($Millions)

	1996-2004	2005-2009	2010-2014	2015-2019	2020 Plus
Excise Taxes					
Construction of:					
Pipeline/Well	2.4			0.8	
Resort/Development					
Historical	29.7	16.4	16.4	16.4	
Planned	23.6	23.0	13.3	44.4	
Operation of:					
(Visitor Expenditure)					
Historical (Cumulative)[2]	89.7	153.8	189.4	225.0	260.6
Planned (Cumulative)	69.3	118.8	169.3	190.3	303.9
Total Excise Tax Revenue					
Historical	121.8	170.2	205.8	242.2	260.6
Planned	95.3	141.8	182.6	235.5	303.9
Income Taxes[3]					
Construction of:					
Well	3.7			1.2	
Hotel and Residential					
Historical	36.4	20.2	20.2	20.2	
Planned	27.6	26.3	15.6	51.0	
Operation of:					
Hotel					
Historical	36.3	25.9	40.3	54.7	67.1
Planned	8.3	5.9	16.4	25.0	29.3
Total Income Tax Revenue					
Historical	76.4	46.1	60.5	76.1	67.1
Planned	39.6	32.2	32.0	77.2	29.3
Total Excise and income					
Historical	198.2	216.3	266.3	318.3	327.7
Planned	134.9	174.0	214.6	312.7	333.2

[1] The average state excise tax rate of 4.0 percent is used for construction of water transmission system and resort developments. For the operation, the average state excise tax of 7.37 is used and the figure includes 6.0 percent room taxes.
[2] Average daily visitor expenditure of $170 per day is assumed (Visitor Expenditure Survey of 1992, Hawaii Visitors Bureau).
[3] The average state income tax rate was assumed to be 7.45 percent.

Table 3.15
State of Hawaii Operating Expenditures, 1992[1]

	TOTAL ($000)	PER RESIDENT	VISITOR
General Government	$ 438,192	$379	$ 0
Public Safety	158,512	137	
Highways	114,516	99	
Natural Resources	40,363	35	
Health & Sanitation	171,209	148	
Hospital & Institutions	271,018	235	0
Public Welfare	657,728	569	0
Education	1,333,918	1,154	0
Recreation	40,118	35	
Utility & Other Enterprises	265,340	23	0
Debt Service	301,937	261	0
Retirement and Pension	163,137	141	0
Employees' Health and Hospital Insurance	1,076	1	0
Unemployment Compensation	134,692	117	0
Grant-in-aid to Counties	825	1	
Urban Redevelopment and Housing	416,931	361	0
Miscellaneous	94,915	82	0
Cash Capital Improvements	528,510	457	
Total	$5,132,936	$4,441	$912
State Population, 1992[2]		1,155,700	

[1] Tax Foundation of Hawaii, 1992 Government in Hawaii, Table 35.
[2] Federal-State Cooperative Program for Population Estimate.

Table 3.16
Estimated De Facto Population Increase in the Region Due to the Development

	1998-2009	2010-2014	2015-2019	2020 PLUS
Historical				
Hotel				
Units	1,350	2,100	2,850	3,600
Population[1]	1,796	2,793	3,791	4,789
Residential				
Units	1,350	2,100	2,850	3,600
Population[2]	2,025	3,150	4,275	5,400
Planned				
Hotel				
Units	275		450	
Population[1]	366		598	598
Residential				
Units				
DHHL	1,440	3,496	4,412	7,732
Others	953	1,839	2,755	4,341
Population				
DHHL[3]	4,320	10,488	13,236	23,196
Others[2]	1,430	2,759	4,133	6,512
Total (Population)				
Historical	3,821	5,943	8,066	10,189
Planned	6,116	13,613	17,967	30,306

[1]Visitor presence was converted to a de facto population using an average occupancy rate of 70 percent, 1.9 occupants per room, and an average length of stay of 8.6 days.
[2]An occupancy rate of 50 percent with 3 occupants per unit was assumed.
[3]An occupancy rate of 100 percent with 3 occupants per unit was assumed.

Table 3.17
Annual State Expenditures Due to the Development ($000)[1]

	1998-2009	2010-2014	2015-2019	2020 plus
Historical				
Hotel[2]	1,638	2,547	3,457	4,368
Residential[2,3]	3,498	5,442	7,385	9,329
Planned				
Hotel[2]	334	334	545	545
Residential[2,4]	6,351	12,253	18,355	28,920
Total				
Historical	5,136	7,989	10,842	13,697
Planned	6,685	12,587	18,900	38,249

[1](De facto population increase) x (State expenditure per capita).
[2]State expenditure of $912 per visitor and $4,441 per resident were used.
[3]((Total planned units) - (DHHL planned units)) / (Total planned units) = 38.9% was assumed as the portion of the net increase in the state population, which exclude the residents in the DHHL units.
[4]Excludes DHHL residents.

Table 3.18
Projected Net Tax Revenue/Expenditure to the State from the Development ($Million)

	1996-2004	2005-2009	2010-2014	2015-2019[1]	2020 PLUS
Historical					
Revenue	198.2	216.3	266.3	318.3	327.7
Expendi-ture	46.2	25.7	39.9	54.2	68.5
Rev./Exp. Ratio	4.3	8.4	6.7	5.9	4.8
Planned					
Revenue	134.9	174.0	214.6	312.7	333.2
Expendi-ture	46.8	33.4	62.9	94.5	191.2
Rev./Exp. Ratio	3.0	5.2	3.4	3.3	1.7

[1]Assumes all planned construction for the year "2015 plus" ends by the year 2019.

Table 3.18A

Cumulative Effects of Visitor Arrivals and New Immigrants

	Island of Hawaii 2010	Island of Hawaii 2020	State 2010	State 2020
Historical Trends				
Visitors	3,120	6,240	--	--
Residents 1/	2,838	5,735	1,888	3,805
Non-Worker	938	1,875	938	1,875
Inmigrant workers	1,900	3,860	950	1,930
As Planned				
Visitors	1,745	3,853	--	--
Residents	12,175	26,337	1,150	2,712
Non-Worker	1,150	2,712	1,150	2,712
Inmigrant workers	0	0	0	0
DHHL	11,025	23,625	--	--

1/ Assumes .67/.33 split of inmigrant labor to the Island of Hawaii and the State.

3.2.2.3 County Government Fiscal Impacts

3.2.2.3.1 County Government Revenue from the Project

Expected county revenue is generated primarily from property tax levied on new resort development and from the fee charged on water facility uses. Table 3.19 summarizes the projected annual County revenue from property taxes, and Table 3.20 summarizes the revenue from water facility charges.

The property tax schedule indicates that improved residential lots are taxed at $10 per $1,000 assessed value, whereas $9 per $1,000 of assessed value is assessed for hotel buildings and improvements. Table 3.19 shows that for the first five years, expected annual property tax revenue for the County ranges from $6.185 million to $6.962 million per year for the first twelve-year period, depending on the development path taken. For the years after 2020, expected property tax revenue ranges from $18.565 million to $28.291 million annually.

As shown in Table 3.20, County government revenue from water facility charges is expected to be $2.6 million annually for the first twelve-year period. After the year 2020, revenue is expected to be $4 million annually. The collection of the facility charge is expected to end in the year 2023. Figures for facility charges are not subject to change by the different scenarios.

Total expected revenue to the County government ranges from $3,133,750 to $3,198,500 annually for the first twelve years. After the year 2020, expected revenue ranges from $6,913,000 to $8,858,200 annually.

3.2.2.3.2 County Government Expenditure Due to the Project

The primary increase in County expenditure during the resort community expansion is expected to come from the increase in visitor population to the resort. Annual County expenditures and per capita expenditures are provided in Table 3.21. The County government spent $121 million or $929 per resident in 1992, and it also spent an average of $527 per visitor per year. The estimated

increase in population is calculated and provided in Table 3.16 above. Combining Table 3.16 and Table 3.21, the expected increase in County expenditures due to resort expansion is estimated and the results are summarized in Table 3.22.

Table 3.19

Projected Annual Property Tax Revenue to the County[1] ($ 000)

	RATE	1998-2009	2010-2014	2015-2019	2020 PLUS
Historical					
Hotel[2]	9/1000	3,924	6,105	8,285	10,465
Residential[3]	10/1000	3,038	4,725	6,413	8,100
Total		6,962	10,830	14,698	18,565
Planned					
Hotel[2]	9/1000	800	800	1,308	1,308
Residential[3]	10/1000	5,385	12,005	13,883	26,983
Total		6,185	12,805	15,191	28,291

[1]Assumes (Assessed Value) = (Mkt Value).
[2]Market value per unit was assumed to be $323,000.
[3]Market value per unit was assumed to be $225,000.

Table 3.20
Projected Revenue to the County from Water Facility Charge ($000)

	1998-2009	2010-2014	2015-2019	2020 PLUS
For both Historical and Planned	31,420	17,200	19,440	16,000

Source: Department of Water Supply, County of Hawaii

As a result, total annual County government expenditure on account of resort expansion is expected to range from $1,521,000 to $2,827,000 for the first twelve years, and $6,365,000 to $7,541,000 after the year 2020.

3.2.2.3.3 Computation of County Fiscal Benefit/Cost Ratio

Based on estimated County revenue and expenditures due to the project development in the region, fiscal benefit/cost ratios of the project were calculated and presented in Table 3.23. Again, should the development follow the **Historical Trends**, the estimated county benefit/cost ratio is 3.4 for the year 1998-2009. The ratio declines as farther development proceeds. By year 2010, the ratio becomes 3.2, by 2015 the ratio farther declines to 3.1, and finally in the year 2020, the ratio is 2.9.

On the other hand, should development proceeds along the **As-Planned** scenario, the county benefit/cost ratio is estimated to be 5.8 for the year 1998-2009, 5.9 for year 2010, 4.6 for year 2015, and 5.1 by year 2020.

3.2.2.3.4 FBCR For Cumulative Impact

Additional FBCRs for year 2010 and 2020 are computed for the county government. The results are shown below. Here we assume that most of DHHL residents are Island of Hawaii residents moving into Kohala region and thus impact of DHHL resident population would have no effects in terms of fiscal impacts of both county an state government.

Fiscal Benefit/Cost Ratio For the County Government

	For Year 2010	For Year 2020
Historical Build-out Scenario		
Project Only	3.2	2.9
Cumulative	3.3	2.5
As Planned Build-out Scenario		
Project Only	5.9	5.1
Cumulative	7.2	7.0

Patterns similar to those observed for the state FCBR are seen for the county government benefit/cost ratios. Again (and as expected) the cumulative ratios for both periods are smaller than the "project only" scenario. However, for the "As Planned" scenario the cumulative ratios are greater.

Table 3.21
County of Hawaii Operating Expenditures[1] ($000)

	TOTAL ($000)	PER RESIDENT($)	PER VISITOR($)
General Government	$ 14,662	$112	$0
Public Safety	46,830	359	
Highways	5,409	41	
Health & Sanitation	6,433	49	
Public Welfare	12,051	92	0
Public Schools	262	2	0
Recreation	8,299	64	
Interest	6,138	47	0
Bond Redemption	3,026	23	0
Pension and Retirement	6,912	53	0
Salary Adjustment	---	---	---
Economic and Urban Development	---	---	---
Mass Transit	658	5	
Miscellaneous	9,330	72	0
Cash Capital Improvements	1,169	9	
Total	$121,179	$929	$527
State Population, 1992[2]		130,400	

[1]Tax Foundation of Hawaii, 1992 Government in Hawaii, Tables 24-27 and 36-39.
[2]Federal-State Cooperative Program for Population Estimate.

Table 3.22
Annual County Expenditures due to the Development[1]
($000, per year)

	1998-2009	2010-2014	2015-2019	2020 PLUS
Historical				
Hotel[2]	946	1,472	1,998	2,524
Residential[2]	1,881	2,926	3,971	5,017
Planned				
Hotel[2]	193	193	315	315
Residential[2]	1,328	2,563	3,840	6,050
Total				
Historical	2,827	4,398	5,969	7,541
Planned	1,521	2,756	4,155	6,365

[1](De facto population increase) x (County expenditure per capita).
[2]The County expenditure of $527 per visitor and $929 per resident were used.

Table 3.23
Projected Net Tax Revenue/Expenditure to the County
from the Development ($000)

	1998-2009	2010-2014	2015-2019[1]	2020 PLUS
Historical				
Revenue				
Property Tax	83,544	54,150	73,490	92,825
Water Charge	31,420	17,200	19,440	16,000
Sub-total	114,964	71,350	92,930	108,825
Expenditure	33,924	21,990	29,845	37,705
Rev./Exp. Ratio	3.4	3.2	3.1	2.9
Planned				
Revenue				
Property Tax	74,220	64,025	75,955	144,915
Water Charge	31,420	17,200	19,440	16,000
Sub-total	105,640	81,225	95,395	160,915
Expenditure	18,252	13,780	20,775	31,825
Rev./Exp. Ratio	5.8	5.9	4.6	5.1

[1]Assumes all planned construction for the year "2015 plus" ends by the year 2019.

3.2.2.4 Impact on Property Value and Tax

As development advances, both property values and taxes will rise. The level of the tax burden will be different depending on the class of land/property ownership. Those who own the land or property largely for investment purposes in expectation of capital gains through rising land prices fully anticipate rising taxes. Owner occupants and renters, however, particularly those on fixed incomes, may suffer from the tax burden.

As discussed in Section 3.1.3, although the impacts as a whole may be mixed, some outcomes can be socially undesirable, such as the possibility that children of current residents would have to relocate out of Kohala to find affordable housing.

Adverse impacts of rising property taxes can be partially or wholly mitigated by County tax policy. There is a genuine need for this issue to be addressed by County government **before** the impacts actually occur. Given the lead time before expected impacts, this is entirely possible.

3.2.3 Summary of Economic Impacts

Economically, the proposed project would provide a substantial benefit to Kohala, the County of Hawaii and the State of Hawaii. The $66 million in income and $3 million in State revenues associated with construction of the water transmission system alone represent a sizeable benefit.

More important, however, are the secondary economic impacts that would be produced by resort construction and operation, by housing construction, and by visitor and resident spending. When direct and indirect impacts are totalled, between 1,000 and 6,000 permanent jobs would be generated by the year 2010 and between 2,000 to 9,000 by 2020. These figures do not include resort and housing construction, which are expected to require as many as 20,000 labor years. Benefit/cost ratios of over 4:1 would be associated with state and county revenues, which are projected to rise to over $300 million and $70 million, respectively, by the year 2020.

Adverse economic impacts are essentially limited to property tax increases, which could be mitigated for targeted individuals by County policies.

3.3 Social Impacts

3.3.1 Population Impacts

Increase in population engenders a wide range of indirect impacts to housing, social conditions and public services. This section is solely concerned with quantifying and characterizing actual numerical increase. Later sections deal with the far-reaching indirect consequences.

3.3.1.1 Temporary (Construction)

The construction of the pipeline would be accomplished in two phases and is expected to occur during 1996-1999, with an additional short construction period commencing approximately five to ten years later. During peak periods, as many as 500 workers may be employed on the project. However, there is a sufficiently large construction labor force within commuting distance of the pipeline that increases in population during the construction period would probably be negligible if they occurred at all.

3.3.1.2 Secondary

The total increase in resident population in developments of this type is the sum of four components:

- o New residents (whether part-year or permanent) who occupy resort lots or condominiums;
- o New residents of the Department of Hawaiian Homes Lands at Kawaihae who are drawn to the area primarily for the opportunity to settle a Hawaiian Homes lot;
- o New employees of the resort complex or other locations in Kohala and their immediate families who choose to relocate to South or North Kohala as a direct result of job availability from direct, indirect or induced jobs. This component may overlap with the DHHL group;
- o Those who choose to relocate to South or North Kohala as an indirect, non-economic result of the resort complex or DHHL project.

Also of interest is the effect on the number of visitors, which contributes to the de facto population, or the number of people present at any given time on the average.

The **As-Planned** and **Historical Trend** scenarios entail quite different population impacts. In the former, population increase would be derived primarily from in-migration to Kohala by those filling jobs generated directly or indirectly from resort hotels. In the latter scenario, new residents to the resort areas and the Kawaihae DHHL project account for most of the population increase, with a secondary boost from direct (but mostly indirect and induced) jobs generated as a result of new communities. The maximum-minimum estimates listed below for each component reflect this distinction.

Population growth would be a continual process, powered principally by job creation and the increase in resort, DHHL and other homes. In this treatment, population impact is analyzed by determining the cumulative increase up to two separate years, 2010 and 2020.

New Residents of Resort Area

As shown in Table 3.5 in Section 3.2.1, a total of between 1,500 and 4,340 resort condos or homes is expected to be constructed. The upper and lower limits of this range are determined by the **As-Planned** (more condos and homes) and **Historical Trend** (more hotels) assumptions.

The proportion of actual "residents" versus visitors (whether for a few days, weeks, or months) in these units is impossible to predict. Indications of residency include voter registration, school enrollment, driver's license, and "home of record" for tax purposes. For various reasons, however, accurate data ascertaining the level of residency is difficult to obtain. For the purposes of this analysis, it is assumed that occupancy rates for resort housing will be approximately 50 percent, with half (25 percent) being "residents" of Hawaii and the other half (25 percent) being visitors. This proportion is based on discussion with knowledgeable West Hawaii real estate professionals.

Table 3.24
Potential Increase in Resort Resident Population

SOURCE OF GROWTH	AS-PLANNED		HISTORICAL TRENDS	
	2010	2020	2010	2020
New Resort Units	1,839	4,341	1,500	3,000
Units Occupied by Hawaii Residents	460	1,085	375	750
Total Increase in Residents of Resort Area	1,150	2,712	938	1,875

Notes: Unit figures are cumulative and are based on projections supplied by developers and detailed in Appendix H of EIS. Calculations of population assume average household size of 2.5 residents per occupied resident unit, based on comparison with household size in other resort areas of Hawaii.

New Residents of Kawaihae DHHL Lots

As depicted in the EIS for the project (R.M. Towill 1992), preliminary plans for the 10,000 acre area call for 3,500 residential units over a ten-year initial period and accommodation for an additional 4,000 units after that. This ambitious scheme would create a major new "all-Hawaiian" community on the Big

Island. According to officials from DHHL, this vision is certain to evolve over the next three decades in response to availability of funding and potable and non-potable water, as well as other factors.

Current planning and construction efforts are focussed towards providing infrastructure for some 195 lots awarded during the 1980s (Unit 1).

Population impacts from the project thus range from modest to substantial, depending on the level of development achieved. Planned growth, calculated by assuming a figure of 3.5 persons per household (midway between mean household size and mean family household size on the Big Island in 1990), leads to as many as 12,250 residents by the end of the 10-year period and another 14,000 residents ultimately.

It is thus clear that the Kawaihae DHHL development would represent the primary source of secondary impacts from the proposed project should the plan be fulfilled. However, at this point it is far from clear whether the project will be implemented as planned or on schedule.

According to DHHL officials, the majority of current Kawaihae awardees and applicants for future DHHL awards currently do not reside on the Big Island. It is likely that less than 10 percent of the residents would be relocating from within Kohala itself. Therefore, most of the increase in population in Kawaihae would be from people new to Kohala. For the purposes of this analysis, it is assumed that 90 percent of the new DHHL residents would be adding to the population of Kohala.

Table 3.25
Potential Resident Population of Kawaihae DHHL Project

SOURCE OF GROWTH	AS-PLANNED		HISTORICAL TRENDS	
	2010	2020	2010	2020
DHHL Units	3,500	7,500	0	0
Total Level of DHHL Population	12,250	26,250	0	0
Consequent Increase in Kohala Population	11,025	23,625	0	0

Notes: Calculation of population based on 3.5 members per household. Increase in population is calculated as 90% of total, with remainder accounted for by current Kohala population.

Employee Households Who Relocate to Kohala

For over twenty years, the Kohala Coast region has been the source of construction-related jobs that have provided sustenance for local workers and commuters from Kona and East Hawaii. Construction of the pipeline would involve a labor force of approximately 500 jobs per year (see Table 3.3) during the years 1996-1998 and for one year at approximately 2010 from the local population and will represent a continuation of this trend. Thus, there will be little or no construction-related change to the population of Kohala.

Job creation from the secondary impacts of the water project, however, might be substantial. Table 3.26 was derived by summarizing the job creation data developed for the economic analysis in Section 3.2.

Table 3.26
Number of Jobs Available in Kohala as A Result of Secondary Impacts of Project

	YEAR 2010		YEAR 2020	
JOB CATEGORY	HISTORICAL	AS-PLANNED	HISTORICAL	AS-PLANNED
Construction Jobs	378	780	378	1,370
Resort Jobs	2,113	484	4,459	848
Induced/Indirect Jobs	749	582	1,345	1,029
Total Jobs	3,240	1,849	6,182	3,247

Source for job figures is Tables 3.8 & 3.9, based on average number of permanent jobs present by that year. One hundred percent of direct jobs are included, and 25 percent of indirect/induced jobs, based on estimate that 75 percent are distributed state- and County-wide). For jobs derived directly or indirectly from construction activity, figure used is an average for the preceding ten years of "temporary" jobs (as measured by labor years) created as a direct, indirect or induced result of temporary construction activity. Indirect/induced jobs include retail, service, transportation, finance, government, agricultural and other job types, and may include additional construction and hotel jobs as well.

The relationship between jobs and population increase is conceptually simple but exceedingly difficult to calculate with any certainty. Simply put, jobs will be filled by the local population up to a point limited by the availability of the effective size of the labor force, after which in-migration will be necessary to fill jobs. A large number of unknown factors influence these numbers, including:

- Current and future demographic characteristics of Kohala.
- Unemployment rate in Kohala over next 25 years.
- Availability and attractiveness of alternative employment opportunities.
- Population growth in adjacent districts, along with unemployment rate in these areas and willingness/ability of those residents to commute to Kohala jobs.

Assuming that these factors can somehow be accounted for, the additional need for workers can be calculated. Given another assumption - that housing can be made available - these jobs can be filled by in-migrants to the region. If reliable figures for average workers per household and average non-workers per household can be obtained, then the total population increase as a result of jobs can be calculated. The list of assumptions is so extensive and the resulting uncertainty factor so large that any such calculations should be judged with a great deal of caution. Despite these inherent limitations, an attempt to measure such population increase has been made (Table 3.27 below).

One significant unknown is the growth in the labor force that might be expected without in-migration. Because Kohala currently has nearly full-employment (4.5% in 1992), and the proportion of the population under 18 is not excessively large (less than 30 percent, very near the County average), it is assumed that virtually no growth in the labor force from households already present in Kohala can be expected. This judgement is made in the knowledge that the natural growth of the population would, even in the absence of the project, produce new workers; however, these workers might also be employed in jobs created during the natural growth of the economy, again without the project. Another source of new labor, called "Non-Induced In Migrants" in the EIS for the Ritz Carlton resort (Belt, Collins & Assoc.: 1987: IV-72), might also be considered. According to the authors of the Social Impact assessment, this group is a diverse one comprised of, for example, Asian immigrants coming to join family members, young Mainland transients, and "urban refugees" from Honolulu. It was estimated that this group might be nearly as significant in adding to the local labor pool as local persons, considering that growth due to in-migration was 200 percent of birth-minus-death increase in Hawaii County in the last twenty years. However, because this group would add to the population of Kohala, they are not considered in this assessment as part of the natural labor force increase.

There is, however, another source of labor directly connected with the secondary results of the project, and that is the residents of the new households that will depend on the water. While it is not likely that the residents of the luxury units will add a substantial number to the labor force, it expected that the DHHL project - which comprise over 64 percent of the new units and will supply an even greater percentage of the population growth - will participate in the labor force. These new households have been added in to the natural growth of the labor force.

It should be noted that net effect of the As-Planned calculations is to add in the DHHL households to the potential labor force and then subtract them out of the "job-induced" population increase in order to avoid double-counting. This does not imply that all or even a substantial proportion of these residents will work at the resorts, but simply that they will become part of the overall labor supply in Kohala.

Surveys of hotel workers indicate that between 3 and 16 percent of workers may reside in Kona. This source has not been added in the labor/population equation for two reasons. One is that a number of Kohala residents presently (and perhaps will in the future as well) work in Kona. Also, when resort projects planned for North Kona are built they will provide an intervening source of jobs that may tend to detract from the proportion of Kona residents commuting to work in Kohala. It is possible that Hamakua, where the sugar plantation closings have drastically raised unemployment rates, could supply a modest supply of labor as well.

Other assumptions and methodology are made explicit in the notes accompanying the table.

Table 3.27
Job and Population Growth Generated as Result of Secondary Impacts

	YEAR 2010		YEAR 2020	
	HISTORICAL	AS-PLANNED	HISTORICAL	AS-PLANNED
Increase in Jobs	3,240	1,849	6,182	3,247
Increase in Workers	3,045	1,738	5,811	3,052
Predicted Natural Labor Force Growth	0	6,016	0	12,892
Worker In-Migration Needs	3,045	0	5,811	0
Increase in Population as Result of Labor In-Migration	4,750	0	9,065	0
Resulting Increase in Households	1,599	0	3,052	0

Notes: Number of workers is calculated by multiplying jobs times a persons-per-job conversion factor of 0.94, based on fact that average labor force member in Kohala holds 1.06 jobs (State Department of Labor and Industrial Relations data).

Natural growth in Kohala labor force is here defined as a base rate of 0 (because of existing full-employment) plus a proportion of new residents in DHHL-Kawaihae project based on 90 percent of households to be occupied by residents in-migrating to Kohala, with 1.91 workers per household (1990 U.S. Census data for Kohala). Household growth at DHHL is assumed to be 3,500 by the year 2010 and 7,500 by 2020.

Population increase is calculated by multiplying new workers times 1.56, a factor based on number of persons in households/number of workers for 1990 Census data for Kohala.

Number of households is derived by dividing total persons by 2.97, a factor based on the average number of persons/household in Kohala according to 1990 census data.

It is clear that impacts as a result of job creation will vary tremendously according to the type of development that proceeds. Labor needs can be totally absorbed by the Kohala population if the DHHL project is added to it. Indeed, additional job sources will be necessary for the residents.

In the **Historical Trends** scenario, which emphasizes hotel development, a great need for workers will emerge. As discussed in Section 3.2.2.2.2, which was concerned with impacts to State and County population in order to calculate the ratios between revenues and expenditures, a great island-wide shift in population might be

necessary to supply labor. However, even assuming a high unemployment rate of 10 percent in East Hawaii, a labor force population of over 100,000, and a 100 percent migration of Hawaii County unemployed to fill Kohala jobs, there would still be a labor force shortage by the year 2020 of up to 3,000 workers. Obviously, substantial in-migration from other islands, the Mainland and foreign countries would be necessary to satisfy this demand.

New Residents Who Relocate for Indirect Reasons

Although some people may choose to come to Kohala to be near (but not to live or work in) the resort area or the DHHL lands, the number is likely to be negligible in comparison to population increase from other sources and in any case is unquantifiable. Therefore, this component is discarded from further analysis.

Total Increase in Resident Population

The total increase is obtained from summing the calculations from above and is presented in Table 3.28 below.

Table 3.28
Potential Increase in Resident Population as Result of Project

SOURCE OF GROWTH	AS-PLANNED		HISTORICAL TRENDS	
	2010	2020	2010	2020
New Residents of Resort Area	1,150	2,712	938	1,875
New Residents of Kawaihae DHHL	11,025	23,625	0	0
New Residents Drawn by Employment	0	0	4,750	9,065
TOTAL INCREASE IN POPULATION	12,175	26,337	5,688	10,940

The reader is reminded that although figures for two scenarios are presented, any combination of the two scenarios is possible. For example, actual resort development may involve more hotels than currently planned, but less than historical trends would indicate. Current DHHL plans for Kawaihae may be seen in twenty years as overly ambitious. Therefore, impacts may also be "midway." It would be impossible to present the impacts for every possible combination, and for the most part it is unnecessary to do so, since the levels of impacts are generally contained within the extremes.

Distribution of Added Population

In the **As-Planned** scenario, the location of most population growth can be predicted and would be concentrated in the resort properties of South Kohala and the Kawaihae DHHL areas. In the **Historical Trends** scenario, in which population increase is largely due to resort jobs, the centers of population are more difficult to predict. The reader is referred to Section 3.3.2 for a discussion of housing impacts for further exploration of this topic.

In either scenario, a substantial component of job growth is due to indirect and induced jobs, which would be spread throughout the district, and indeed the County and State. Some of these jobs might lead to population increase and others might be filled by the unemployed or by the natural growth in the labor force in these areas. In any case, the population effects due to indirect and induced jobs would tend to be less concentrated and more diffuse.

Visitor Population Increase

As shown in Table 3.5 and discussed in Section 3.2.1.3.1, a total of between 450 and 3,000 new hotel units and between 3,000 and 4,300 resort condos or homes are expected to be constructed. The upper and lower limits of these ranges are determined by the **As-Planned** (more condos and homes) and **Historical Trends** (more hotels) scenarios. Table 3.29 below calculates visitor population based on these figures.

Table 3.29
Potential Visitor Population Increase
As Result of Project

SOURCE OF GROWTH	AS-PLANNED		HISTORICAL TRENDS	
	2010	2020	2010	2020
Hotels	275	450	1,500	3,000
Condo/Resort Residential	1,839	4,341	1,500	3,000
Additional Visitor Population	1,745	3,853	3,120	6,240

Notes: For hotels, an average occupancy rate of 70% and a figure of 1.9 occupants per room, industry norms in Hawaii, were assumed. For condo/resort residential a visitor occupancy rate of 25% and an average of 3.0 occupants per room is assumed. Note that an additional 25% of such units are expected to be occupied by residents.

Visitor population is much higher, particularly in relation to the resident population increase, in the **Historical Trends** scenario. It is in such situations, where visitors are contributing greatly to state excise taxes but also imposing a burden on public services such as roads and recreational facilities. In the **As-Planned** scenario such visitor population social impacts are relatively modest.

3.3.1.3 Impacts of Alternative Scenarios

As discussed in Section 2.2.1, population increase in Kohala over the last twenty years has paralleled growth in resort jobs. Nearly all population projections undertaken by the State and County agencies assume continued growth in West Hawaii resorts.

The proposed project would facilitate the unfolding of existing plans and in that sense would not be a source of population growth unanticipated by planners. Indeed, a total cessation of water supply growth in the project area would cause population projections to be undershot. Under any scenario this is unlikely. *Alternative Scenarios 2 and 3* would have essentially the same impact as the proposed project; even under the *No-Project Alternative* it is not at all clear whether private developers might undertake their own water projects (e.g., private desalinization plants) and t[illegible] enable projected growth anyway.

Exactly what [illegible]ld occur in the absence of this specific water supply project is difficult to determine. What can be examined is the relationship between the amount of population growth likely to ensue from the proposed project and the amount of total growth expected in the region. This frames the magnitude of the project in the context of cumulative impacts from other planned projects.

Several population projections have been developed to help the State and County prepare and plan for expected population growth. One that is often cited and relied upon is the so-called M-K Series (Hawaii State DBEDT 1988). The following table summarizes the findings:

Table 3.30
M-K Series Population Projections

POPULATION	HAWAII COUNTY	STATE OF HAWAII
1980 Resident	93,000	968,900
1980 De facto	99,500	1,055,800
1990 Resident	124,600	1,137,200
1990 De facto	134,400	1,269,100
2000 Resident	160,400	1,285,100
2000 De facto	183,000	1,468,600
2010 Resident	206,100	1,435,500
2010 De facto	243,000	1,674,200

Note: Actual 1990 census resident numbers were 1,108,229 for the State and 120,317 for the County.

These state projections do not include figures on a district-by-district basis. Several estimates are available for these projections: the Hawaii County General Plan (Hawaii County Planning Department 1989) and a recent draft report prepared as part of the Land Transportation Master-plan for the County of Hawaii.

The population projections to the year 2005 developed for the General Plan were derived from an econometric model designed to account for the relationship between employment and population. Three series were projected, A-C, based on ascending magnitude of economic activity. The following table summarizes the projections.

Table 3.31
Hawaii County General Plan Population Projections, Year 2005

AREA	SERIES A	SERIES B	SERIES C
Puna	39,790	49,190	59,340
South Hilo	44,115	55,335	65,790
North Hilo	1,211	1,519	1,806
Hamakua	5,363	6,721	7,998
North Kohala	5,363	6,721	7,998
South Kohala	19,203	24,087	28,638
North Kona	43,250	54,250	64,500
South Kona	10,899	13,671	16,254
Ka'u	3,806	4,774	5,676
Hawaii County	173,000	217,000	258,000

Note: Series A based on modest economic growth, Series C based on vigorous growth, Series B is midway.

The most recent district-by-district population projection effort was undertaken by consultants for the State of Hawaii Land Transportation Masterplan in summer of 1994. They are based on linear regression analysis of population growth, adjusted by a detailed review of planned and approved projects on a district by district basis. It should be emphasized that these estimates are in draft form and have not been adopted by the Department of Transportation. Nevertheless, their recent origin, unique methodology and the fact that they extend to the year 2020 make them relevant.

Table 3.32

Land Transportation Masterplan Population Projections, Year 2020

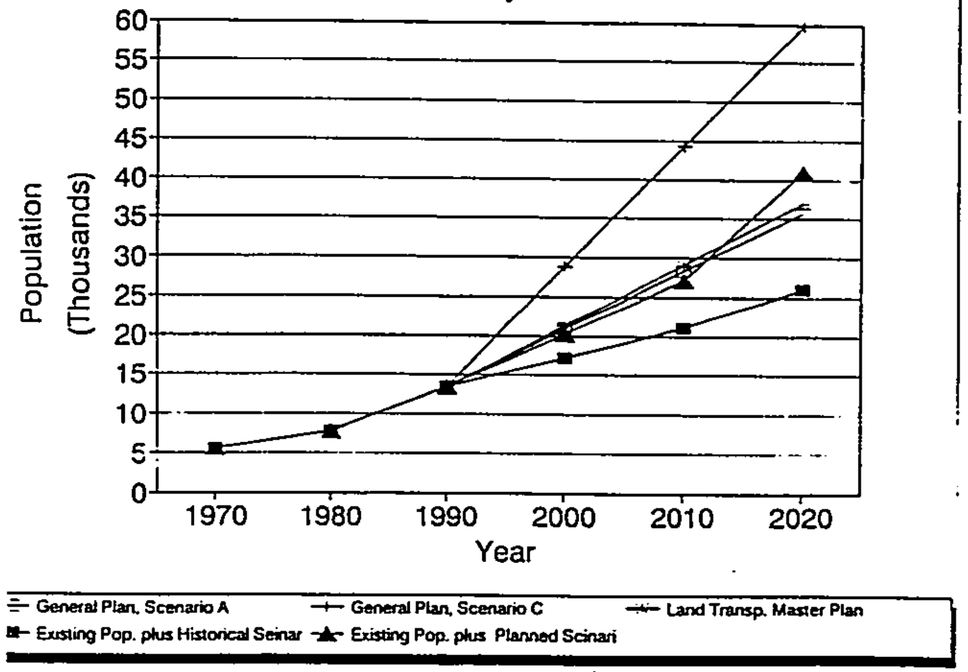
AREA	POPULATION 2020
Puna	37,400
South Hilo	55,800
North Hilo	1,700
Hamakua	9,700
North Kohala	11,800
South Kohala	25,200
North Kona	44,600
South Kona	15,300
Ka'u	8,000
Hawaii County	209,500

Source: Draft tables from State DOT.

Despite the difference in base years, it is immediately obvious that the projections diverge from one another. Figure 3.1 graphs figures from the General Plan and Land Transportation Masterplan for Kohala in order to illustrate the relative contribution of population increase expected to occur as a secondary result of the Kohala Water Transmission System. The extensions of the General Plan lines from 2005 to 2020 are based on straight-line continuation and are purely conjectural; nevertheless, Series A when extended matches very closely with the Land Transportation Masterplan numbers.

If the maximum level of build-out projected by developers and DHHL plans actually occurs within the next twenty-five years, a significant portion of the population increase expected by planners would be derived from the secondary effects of the DHHL project. The figures, of course, do not factor in additional development in Kohala, which would primarily be derived from Waikoloa resort expansion or from Chalon International plans for North Kohala. The magnitude of these potential expansions is not predictable at this time. If they substantially increase population, then all projections presented here with the exception of Series A would likely be significantly overshot by the year 2020 (see Section 3.4 for a discussion of cumulative impacts).

Figure 3.1: Kohala Region Population Projections



3.3.1.4 Potential Mitigation Measures

The adverse impacts of population growth are usually indirect rather than direct. Increased population may lead to pressure on scarce resources, undesirable changes in social conditions, and decreasing access to public facilities and services. More specific information regarding these impacts, their implications, and the mitigation planned for negative impacts are discussed in the sections which follow.

3.3.2 Housing Impacts

3.3.2.1 Temporary (Construction)

As discussed in Section 3.2.1, although construction of the pipeline is expected to generate numerous jobs, these are expected to be filled by workers already residing in the region and would thus have a negligible impact on population. Therefore, little or no impact on housing is to be expected either.

3.3.2.2 Secondary

As with labor and population, the impacts of housing are quite distinct between the **As-Planned** and **Historical Trends** scenarios.

In the former, housing is a "built-in" component of most projects, including both the resort units and the DHHL Kawaihae project. Although some growth in housing stock might be required for employees of jobs not filled by existing or project-related households, the magnitude is within the range to be expected as an extension of current trends (see Table 3.33), which has created over four thousand units in the twenty years.

Table 3.33
Housing Units in Kohala and Hawaii County, 1970 to 1990

AREA	1970	1980	1990
Hawaii County	18,972	31,215	48,253
North Kohala	941	1,540	1,540
South Kohala	798	1,966	4,235

Source: The U.S. Department of Commerce, U.S. Bureau of the Census, 1990 Census of Population and Housing.

Relatively high vacancy rates for rental units, reflective mainly of an over-supply of condominiums in Waikoloa, reveals a (probably temporary) large supply of housing (Table 3.34).

Table 3.34
Housing Vacancy Characteristics of Kohala and Hawaii County, 1990

	VACANT HOUSING UNITS		
AREA	TOTAL UNITS	HOMEOWNER VACANCY RATE (%)	RENTAL VACANCY RATE (%)
Hawaii County	6,792	1.5	10.3
North Kohala	189	1.1	12.5
South Kohala	1,140	3.1	21.7

Source: The U.S. Department of Commerce, U.S. Bureau of the Census, 1990 Census of Population and Housing.

If the **Historical Trends** continues, however, the jobs generated by resort hotels will lead to an increase in the number of households and a consequent demand for housing. As revealed in Table 3.27 previous, more than 3,000 new households could relocate to Kohala as a result of jobs generated by the secondary effects of the water project. This would create a demand for roughly 175 percent of the current inventory of housing (see Table 3.33).

A survey of workers at the Mauna Lani and Westin Mauna Kea resorts undertaken by CRI and Datametric (1987) revealed the housing and commute patterns of a very large sample of resort workers. While it is true that the conditions that led to such patterns may not be identical in the future, there is no reason to believe that the results would be substantially different.

Approximately 80 percent lived in single-family homes, with 20 percent in multi-family units, an arrangement somewhat more common with the younger, newcomer employees. Most employees lived in households with between three to six total inhabitants - usually the children of the employees.

The area of residence for these workers is listed in Table 3.35 below.

In the **Historical Trends** scenario, there would be a strong demand for housing composed largely of single-family homes situated reasonably near the resort complex. Affordable housing in the coastal region has not yet been produced, and given a lack of incentive or conditions, might continue to be lacking. In its absence, the result would be an increase in the number of commuters inside and outside Kohala.

Table 3.35
Actual and Preferred Area of Residence For Workers at Mauna Lani and Mauna Kea Beach

AREA OF RESIDENCE/PREFERRED AREA OF RESIDENCE					
PUAKO/ WAIKOLOA KAWAIHAE	WAIMEA	NORTH KOHALA	HAMAKUA	KONA	EAST HAWAII
11/22	24/29	26/26	19/11	16/10	2/2

Note: Figures represent percentages and are rounded. Source: CRI and Datametric 1987.

3.3.2.3 Impacts of Alternative Scenarios

The No-Project Alternative would probably represent a continuation of the current trends, i.e., a slow but steady increase in housing inventory commensurate with regional demands.

Because *Alternative Scenarios 2 and 3* entail virtually the same population impacts, and thus their housing impacts would also be similar.

3.3.2.4 Potential Mitigation Measures

The West Hawaii Regional Plan (Hawaii Office of State Planning 1989), which was designed to coordinate planning efforts among State agencies, laid out State policy for housing associated with the development of resorts. Included in policies pertaining to resort development were strategies to cluster resorts in "Resort Destination Nodes" of Mauna Kea and Mauna Lani/Waikoloa within Kohala. These nodes would serve as employment centers around which the State and County could focus efforts to provide economic incentives for private sector involvement in financing and enveloping social and physical infrastructure systems. This would include active designation and development of primary and secondary support communities to house employees working at Resort Destination Nodes.

The fulfillment of this objective will be enhanced but not enabled by the availability of water. Agreements between government and business concerns may be necessary to insure development of adequate affordable homes.

3.3.3 Impacts to Public Services and Infrastructure

Included in this discussion are impacts to roads, utilities, and public safety, health, education and social services.

3.3.3.1 Temporary (Construction)

Roads and Highways

Original project design called for the pipeline to be sited along the shoulder of Akoni Pule Highway from Makapala to Kawaihae. During the course of the scoping process for the EIS, it was discovered that one of the main concerns about the project was the potential for disruption to homes and businesses during construction in and near the villages of Hawi and Kapa'au. At the same time, DWS discussions with Chalon International Inc. led to the substitution of an all Akoni-Pule route to one that followed Pratt Road and thus avoided Akoni Pule from Makapala to an intersection approximately one-half mile west of Hawi (see figures in EIS).

Pratt Road is an unpaved private road owned by Chalon running almost parallel to the Hawi-Niuli'i Highway, from Makapala to Upolu. The road was formerly used by the sugar plantation for hauling cane and heavy equipment. Currently it is used to access the lands of Chalon and its lessees. A small number of farms and residences are located on or near Pratt Road, but only negligible disruptions to these would be expected as a result of pipeline construction.

Despite this substitution, there will be at least some disruption to vehicular traffic along the pipeline right-of-way. Most of the path is along the two-lane highway (composed of segments of Akoni Pule, Kawaihae Road and Queen Kaahumanu Highway) with a 120-foot right-of-way and a 55 MPH speed limit. Fortunately, the Average Daily Traffic along this route is very low compared to its capacity and the Level of Service is excellent (see Section 2.2.7). Therefore, considering the fact that construction will very seldom disrupt more than one lane and will often be confined to the shoulder, no excessive traffic problems would be expected as a result of construction.

Short segments where residences, businesses or major side roads or driveways would be inconvenienced are found in Kawaihae and sporadically elsewhere along the route.

The Hawaii County DWS has found that the average period during which a given 200-foot segment of shoulder is directly impacted by pipelines of this magnitude is typically 2 days. Impacts include the following:

- o Reduction of speed limit;
- o Inconvenience in accessing driveways and side streets (although some sort of access is required to be maintained);
- o Periodic closures of one or occasionally two lanes;
- o Delays to individual vehicles occasionally as long as 5 minutes.

Progress on the pipeline moves at an average rate of 1/8-mile per week, although unexpected events such as intense storms, archaeological finds or labor strikes can leave some areas affected for longer periods than such averages indicate (Okahara and Associates, pers. comm. 1994).

Approximately 22.1 miles of road frontage would be excavated. Less than one mile of this length occurs either in a business or residential district. Altogether, approximately 100 driveways or access roads directly fronting homes, businesses or other facilities would be briefly affected. Other residents and visitors would be affected as they travelled in the area of construction.

Because of the need to connect well and reservoir sites (which are located mauka of the highway) with the transmission main (which is makai), pipeline connections cross the highway in various locations (see EIS for description and maps). Minor disruption of traffic lasting up to several days will occur periodically throughout the two years of construction. Later, during the second phase of the project, very minor disruptions may also occur as a result of well and reservoir construction.

Other Services and Infrastructure

The level of electrical energy consumption required during construction will not necessitate any new electrical facilities or extra generating capacity. No impact to telephone, sewage, solid waste, public safety, education or other government services is expected during construction.

3.3.3.2 Operational and Secondary

Roads and Highways

Because the nature of the developments that will actually result from the proposed project cannot be ascertained, traffic impacts to specific roads and intersections are impossible to predict. General regional impacts, however, can be assessed by first estimating the increase in the de facto population, i.e., the number of people present in Kohala and presumably using the highways to access jobs, services, and recreational or tourist sites. Any increase in the de facto population can be assumed to cause traffic volumes to increase. The Level of Service (LOS) at highways may then decrease unless road improvements are made (e.g., lane expansion) or additional highways are built. The key to assessing general traffic impacts is thus the extent to which State and County highway planning (and presumably actual projects) will anticipate the level of growth.

By the year 2020, as discussed in Section 3.3.3.1, a project-related increase of between 3,800 and 6,200 in the visitor population can be expected as a secondary result of the project, depending upon the scenario of development. Coupled with a resident population of between 20,000 and 45,000, this means a total de facto population of between approximately 25,000 and 50,000. This equates roughly to a doubling or tripling of traffic on Kohala Roads, based on 1990 de facto population of near 18,000 (see Table 2.5). Although roads in most of Kohala are far from crowded today, this magnitude of increase could create traffic problems on certain highways, especially State Route 19 from Honokaa through Waimea and Kawaihae Junction to Kailua-Kona.

In the **As-Planned** scenario, the local roads needed to serve housing developments are integral parts of the Master Plans, thus reducing public impacts. The Master Plan for the Kawaihae DHHL project, for example, includes internal roadways and external connections. An Akoni Pule Bypass (120-foot right-of-way), which would route traffic away from Kawaihae Harbor and replace Kawaihae Road as the main linkage to Waimea and Queen Kaahumanu Highway, is an integral part of the circulation system. Another component is a mauka-makai "spine" road with an 80 foot right-of-way, designated to be the main roadway in the community and ultimately to provide a connection to the Kohala Mountain Road. Roads internal to resort communities would undoubtedly be privately planned and financed, with review by government agencies to assure proper standards and traffic control.

Utilities

The water wells for the proposed project require electricity. Current plans call for this to be supplied either by HELCO or through generators embedded in the well-site control rooms. If the public utility is used, peak demand would not exceed 2.0 megawatts (MW). Since pumping can be scheduled to coincide with off-peak demand times, the project would not adversely impact the ability of HELCO to supply power to its customers.

Secondary growth from the project will substantially increase demand for electrical, phone and cable services. Assuming a population growth of 12,000 to 25,000 residents, at least 12 to 25 MW of extra electrical generating capacity might be necessary.

HELCO projects a growth in capacity from 195 MW in 1994 to 319 MW by 2008. This is necessary to meet a corresponding growth in

projected demand from 163 to 283 MW (HELCO Forecast of Sales, Peak and SLF for 1991-2010. March 1991). Included in this forecast is growth in West Hawaii that would be induced by the proposed project. Extra capacity would be derived from a combination of new sources, including proposed upgrades to the Keahole Power Station, a diesel-oil facility at the former Haina sugar mill, a Kawaihae co-generation facility, and others.

It is beyond the scope of this document to discuss possible socio-economic impacts of future power generation plants. Nevertheless, periodic shortfalls in generating capacity experienced by HELCO make this an important public issue.

Sewage Treatment and Solid Waste

Secondary growth will induce a need for sewage treatment plants, particularly in the coastal areas of South Kohala but also along any portions of the North Kohala coastline that may experience increased development. The impacts from such systems are primarily physical and are covered in the EIS in a separate section on the marine environment.

Because of the landfill at Pu'u Anahulu is relatively recent, it is expected to accommodate solid waste needs for West Hawaii well into the future, particularly if East Hawaii is able to resolve its landfill capacity problems. Additional solid waste transfer stations will be required, particularly in large communities such as the DHHL Kawaihae project. Resort developments are normally required to contract for rubbish services and this can be expected to continue.

Schools and Libraries

The Kawaihae DHHL project, which accounts for most of the projected increase in demand for schools and libraries in the **As-Planned** scenario, has a Master Plan that includes siting for a full range of community facilities, including one intermediate and three elementary schools. In the **Historical Trends** scenario, schools and libraries would require more planning. Based on projected population increases of between approximately 10,000 and 18,000, at least one more high school and several intermediate schools, elementary schools and public libraries would be required. Siting would depend on the ultimate distribution of service communities.

Fire and Police Protection

The Kawaihae DHHL Master Plan includes a "Town Center" with provisions for a police and fire station. If the **Historical Trends** scenario is fulfilled, these public facilities would have to be expanded by the County of Hawaii. Although, as with schools, the ultimate distribution of service communities would determine the best location, Kawaihae is well situated to provide the hub for public safety services.

Government Agency Offices

The proposed "Town Center" planned for the Kawaihae DHHL project includes a community activity center, a post office and community support services, where certain social service and health agencies may be located. Under the **Historical Trends** scenario, expansion of services would probably follow the same pattern as for schools and public safety facilities. The Northwest Hawaii region, with a total projected population of perhaps 40,000 by the year 2020, would perhaps merit its own satellite County government central offices. Alternatively, decentralized small centers could offer the most needed government services in locations throughout Kohala. The North Hawaii Community Hospital, slated for opening in 1996, would contribute greatly to the anticipated medical needs of the region.

3.3.3.3 Impacts of Alternative Scenarios

Under the *No-Project Alternative*, the increase in traffic over the next two decades would probably be considerably less than anticipated by current DOT projections. Growth in demand for public services and facilities would also continue to increase at a modest rate. *Alternative Scenarios 2 and 3* would induce essentially the same level and location of demand for services and facilities as the proposed project.

3.3.3.4 Potential Mitigation Measures

It is essential for the maintenance of adequate public services and facilities in growing regions that State and County agencies carefully track potential growth. The proposed project has substantial potential to greatly increase demand for these. It is beyond the scope of this document to recommend individual projects for consideration. Subdivision and other permit conditions imposed by the County and State would determine the degree to which necessary infrastructure to support the developments would be provided by the individual landowners/developers.

In general, it is important to recognize and recommend to agencies such as the Hawaii County Council, the State Department of Transportation and others that planning for significant increases in demand be encouraged. Tracking of predicted versus actual magnitude and distribution of development using Geographic Information System (GIS) technology is also recommended.

3.3.4 Impacts to Outdoor Recreation

Impacts to scenery are discussed elsewhere in the EIS to which this report is an Appendix. As discussed in Section 2.1.1.2, a great concern exists, at least among some residents, for preservation of outdoor recreational opportunities and the rural and wilderness values of the region.

3.3.4.1 Temporary (Construction)

Negligible impact in the public use and enjoyment of lands will occur as a direct result of construction.

3.3.4.2 Secondary

The Division of State Park's master plan for Hapuna State Recreation Area calls for significant expansion in the next five to ten years. Although foreseeable potable water needs could probably be met through the existing water system, the proposed improvements would help firm up supply. Lapakahi State Park, which currently has no potable water supply, would gain a potential supply for drinking water, restrooms and possibly limited irrigation. The system would supply a key element for future, as-yet unplanned coastal parks between Mahukona and Kawaihae.

Substantial impact to the public use and enjoyment of land other than parks would also occur as a result of further development in Kohala. The resulting total or component impacts are difficult to classify as either beneficial or adverse, because such judgement is largely a matter of individual attitudes.

For example, one secondary result of construction might be the increased accessibility of a particular section of coastline. For some users, the addition of visitors to a formerly uncrowded fishing area along the coast would be a significant unwelcome intrusion. The effect might vary by the context of the interaction - e.g., the location, the time, the identity of the fisherman, and the nature and number of the visitors. For others, the improvement in access to a new coastal recreational area might constitute a significant benefit to one's recreational options.

Much public comment received through meetings, interviews and questionnaires focussed on this recreation in general and on the paradoxes of coastal access.

> "Actually it is easier now than was the case years ago for the public to reach the ocean for recreation. [However...] Kona Village Resort and a few others have made it more difficult for public use of ocean frontage: making the point that constant pressure must be applied to open up public access."

> "Positive impacts [of development on recreation] have been improved mauka-makai access to the coast, provision of certain day-use facilities, and good maintenance of what would otherwise quickly become a trash dump."

> "Those who were entitled to shoreline access prior to development may now think there is too much..."

> "Hapuna Prince is now developed and offensive to the beauty of Hapuna Beach."

Concerns were also raised about the role of the visitor industry, both positive and negative, to the preservation of historic sites. Some believed that the impact was mostly negative:

> "The cultural sites in Hawaii are not being preserved, it is either being put on display at hotels, or Hawaiians using the sacred sites are put on display for tourist. That last and most common is its being buried by dozers..."

Other saw a generally positive contribution from development:

> "Historic site location, access and knowledge was very limited prior to development. The developers examined and searched sites intensively and then saved the best examples. All this knowledge is now shared and accessible to the general public."

> "The preservation of these sites has allowed Hawaiians (those who knew about the sites, and those who did not) to come and enjoy/use them."

> "The newly opened access to historic sites invites people who can be curious and insensitive to the sites. They can also cause damage to the sites by moving stones or stealing them."

Concerning recreation in general, several respondents expressed appreciation for the diversity of opportunities:

> "...shoreline access for hiking, fishing, and picnicking [have] been dramatically expanded due to the development. Golf, tennis and swimming areas have been provided where once there was nothing. Developers had provided excellent rest rooms, showers, and picnicking spots, as well as, trails for interpretation."

There was concern, however, about how recreational resources were developed and made available to the average local resident:

> "I would, however, rather have seen such access and maintenance provided by public parks, so there would be more to enjoy when you got there. Better public camping and other facilities, possibly including low-key, moderately-priced

> lodges, would bring many tourists to the Big Island who can't now afford it, and would provide recreational opportunities that local families could participate in more on the level of equals with the tourists."

A lifelong Kohala resident and native Hawaiian was unqualified in his praise of the resort region:

> "Without this Garden of Eden type of development, this area would be an arid wasteland."

Another was bitter about the transformation:

> "No matter how much hotels say that access to the shorelines are open to the public, everyone knows the difficulty that we receive every time we want to go to our beaches and shorelines. Nature never benefits from hotels."

3.3.4.3 Impacts of Alternative Scenarios

The No-Project Alternative, because it assumes approximately half the growth expected in the with-project alternative, would entail considerably less impacts, both beneficial and adverse. *Alternative Scenarios 2 and 3* would have essentially the same impact as the proposed project.

3.3.4.4 Potential Mitigation Measures

The potential for outdoor recreation expansion and improvement in Kohala is very great. The following government actions are recommended.

- Accelerated expansion of Hapuna Beach State Recreation Area to anticipate demand.
- Creation of new coastal state parks, e.g., Pololu/Akoakoa State Park.
- Expansion of County coastal parks (such as Kapa'a Beach Park) to take pressure off other recreational areas.
- Encouragement of public park creation in all private sector projects of sufficiently large size.
- Vigorous action by the County and State to ensure access rights to and along the coastline consistent with State law. All private development projects should be evaluated for consistency with long-term access and trail programs at State and County levels.

- Actions to safeguard native Hawaiian gathering, fishing and hunting rights from direct or indirect encroachment as a result of continued development.

3.3.5 Impacts to the Socioeconomic/Ethnic Structure of Community

3.3.5.1 Temporary (Construction)

As discussed in Section 3.3.1, although construction of the water transmission system will generate a large number of jobs, no substantial population increase would result and thus no impact is anticipated to the social or ethnic structure of Kohala.

3.3.5.2 Secondary

Analyzing the "impact" of a transformed socioeconomic and ethnic structure in a community requires a great deal of caution. As a review of tourism impact studies pointed out, reports of racial or ethnic tensions often confound economic or class categories with ethnic ones (Turgut and Var 1984:7). Furthermore, planning to minimize ethnic and class conflicts (especially through avoidance of contact) is not necessarily harmonious with the melting pot ideology shared by most Americans, particularly Hawaii residents.

Nevertheless, the issue of ethnic and class identification of communities requires consideration. Hawaii residents tend to categorize certain communities as "more Hawaiian" or "more Japanese," etc. Our perception of these communities is often based, for good or for ill, on their ethnic makeup. Similarly, the phenomenon of gated communities, in which wealthy residents (mostly mainland Caucasian) barricade entire towns against the local population, is an issue that has generated much debate around the country. These are already appearing in Kohala (e.g., at Kohala Ranch) and have elicited mixed reactions. Also, even in a freely mixed setting, the juxtaposition of cosmopolitan, wealthy newcomers with rural, middle-class local residents has potential for conflict - as well as harmony.

Depending on how development actually unfolds, a number of trends - some with the net effect of canceling each other out - may occur.

With the **As-Planned** scenario, two quite distinct processes would unfold. For one, the growth of resort housing would bring to Kohala a social trend already seen in condominium-laden West Maui and Kona, where an essentially bi-modal population structure exists: well-off, older Caucasians from the mainland at one pole and a mostly middle-class, mixed-ethnic group at the other. There are now census areas in North Kona which are over 70 percent Caucasian and in which the "bell-shaped curve" typical of family income distributions is now bi-modal, with peaks at approximately

40 percent and 180 percent of the median value.

At the same time, however, the creation of 3,000-7,000 Hawaiian households at the DHHL development in Kawaihae would create the largest Hawaiian enclave in the County. If all units were built as planned and the average household size expected in similar settlements of these types were achieved, an addition of some 3,000 new resort residents (mostly Caucasian) and some 24,000 new DHHL residents (mostly Hawaiian) would result by 2020. To some extent, the outcome would create a Kohala in which the two most numerous ethnic groups currently - Hawaiians and Caucasians - would come to make up even larger proportions of the population.

The growth of DHHL housing and the resort industry in close proximity has the potential to match jobs with job-seekers. The hotel worker survey cited earlier (CRI and Datametric Research 1987) found that Hawaiians and part-Hawaiians constituted about one-third of the workforce at both the Westin Mauna Kea and the Mauna Lani Bay - the largest single ethnic group at either hotel.

There is no information available now detailing to what extent the resort housing communities will be gated and exclusive. We predict that the level of disharmony and conflict will be closely tied to the perceived exclusivity and wealth of the new resort communities.

Under the **Historical Trends** scenario, hotel construction would dominate and although there would be a great rise in the de facto population of mainland vacationers, many of them wealthy, there would be far fewer new residents in resort housing. The socio-economic polarization and reduction of ethnic diversity discussed for the first scenario would probably also occur, but in a less-pronounced manner, as an extension of the trends that have been dominant in Kohala for the last twenty years. Direct visitor industry jobs - as opposed to the more diverse indirect and induced jobs that would dominate under the first scenario - would increase the dependence of the economy on tourism and involve a larger proportion of the local population in the visitor industry lifestyle and culture.

Community members expressed diverse opinions about these processes. A common response was concern about polarization and the impact of hotel jobs on a rural population's identity and self-esteem.

Responses to questions about the value of new resort jobs are typified by the following:

> "Chambermaids, groundskeepers, security guards? And Hawaii County now has an unemployment rate almost twice the national average. So much for jobs."

> "No provision for upward job mobility at resorts; thus there is little job satisfaction."

Others admitted mixed feelings about hotel jobs but a recognition that more were needed:

"With the closing of Mauna Kea, a lot of people were laid off. Some promises were not kept. We need businesses that will hire local people."

"The positives in my opinion are that people are employed and are able to make an income (barely). Negatives are that the only types of jobs offered are those that require sucking up to tourists for a tip and lose pride.."

And some were enthusiastic supporters of the resorts and the jobs they offered:

"The people have prospered due to the work opportunities created to replace sugar..."

"Local people can now stay in this, their home community."

"[The positive impacts of resorts include the] sheer number of jobs, tax base increase, spawning of secondary business to support the resorts and its workers."

One individual involved in planning development apparently saw mixed benefits:

"[Resort development] has brought a higher standard of living to the area, requiring education that expounds upon communication skills. It has brought in a mix of transient type workers, who tend to blend in with those already living here. These transients bring bits of their own culture, heritage and values and share them with people in Hawaii and the visitors. [But, it also] caused a divergence in local versus newcomer populations, whereby, the newcomer, who is more aggressive and more educated, obtains jobs that could be for the locals."

Several people commented on the impact to the social structure of resort communities:

"Surrounding the resorts with high-priced condominiums only serves to further isolate them from the life of the island."

"[Resorts] are but enclaves that are never truly assimilated into the community, except for the jobs they provide, they exist apart and hence are not socially integrated. They may well be a necessary evil, but they conduct themselves as though they want no part of the community and this is a 'sore' that may, in time, become cancerous."

"Development has provided taxes for County, developed minimum wage jobs, provided little housing for workers, consequently creating "class" distinctions; job satisfaction is basically low - poor reliability because of the fluctuations of tourists and construction industries..."

Some people articulated an alternative vision for Kohala:

"We should be stressing ecotourism which emphasizes our natural, rather than our manmade, resources, and creates less of a socioeconomic gap between the visitors and those who serve them."

Interestingly enough, some of the strongest anti-resort comments came from those who were living in resort subdivisions or gated communities. Of those who commented negatively on the hotel jobs, very few worked in the visitor industry, although this may simply reflect the natural reticence to bite the hand that feeds you.

Impacts to the Hawaiian Community

An issue of increasing importance in State of Hawaii - one which all projects involving State funds or lands should consider, and one which has heretofore been neglected - is impacts to the Hawaiian community. The continuation of the "Hawaiian renaissance" that flowered in the 1970s and the movement to create some form of a sovereign Hawaiian nation indicate the strength and depth of this social phenomenon.

The issue is particularly apt in Kohala, the home to a large Hawaiian population both before and after Western contact, the birthplace of Kamehameha, and the setting for many of the critical events in Hawaiian history. As stated by a Hawaiian resident of Kawaihae in a questionnaire response:

"South Kohala is a unique area...It is the gateway of the Hawaiian past and the future of the State of Hawaii. South Kohala can brag that it embraces the lineage of Hawaiian people in Waimea and Kawaihae, at the same time welcoming all....be they tourist, ranchers, doctors, farmers, or developers..."

Today, a large population of Hawaiians flourishes. There is a growing sense that Kohala, with its large inventory of State ceded lands along with existing and planned Hawaiian Home Lands, will be one of the principal centers of the rebirth of the Hawaiian nation.

The benefits and adverse impacts to the Hawaiian community from development enabled by the water project clearly differ according to scenario and the aspect of culture and community considered.

In the **Historical Trends** scenario, in which hotel construction and employment dominate the economy and social change in the area, benefits might include more jobs as well as increased opportunity to "market" Hawaiian culture in the forms of performing arts and crafts, which builds skills and may act to reinforce cultural awareness. In the words of one local resident:

> "Jobs have been provided for our Hawaiian entertainers; thus giving them a chance for a livelihood while they hone their skills and culture."

The jobs that are such a valued component of resort development also bring with them an orientation towards life that may sometimes be in conflict with traditional values. A good deal of social research (summarized in the Lalamilo EIS by Belt, Collins & Assoc. 1980:IV-79) has examined so-called "under-achievement" by Hawaiians in both employment and education settings and has identified several crucial factors:

- An affiliation rather than achievement oriented motivations structure;
- Emphasis on accumulation of social rather than financial capital;
- Avoidance of personal confrontations;
- Continued effects of culture loss during the 19th century

Some Hawaiians fear that only by giving up the values at the core of their culture can the Hawaiian people as a whole "succeed" in modern society in the State of Hawaii - a sacrifice that may not be worth making.

One respondent stated that the result of relying on such jobs throughout recent history is that:

> "The social composition of these islands always were forced to change according to the haole beliefs..."

Nevertheless, development proposals promising jobs in Kohala have been responded to enthusiastically at public meetings by most members of the community, including native Hawaiians. Even if some accuse these demonstrations of being orchestrated by developers, it remains true that the principal source of jobs and income for Hawaiians in Kohala are resort hotels - where fully a third of employees are often Hawaiian (CRI and Datametric Research 1987).

As discussed earlier, however, even when local culture such as music, hula or crafts is promoted, some feel that such demonstrations may be a prostitution of culture. A questionnaire respondent noted:

> "Culture may become something that reflects the tastes of tourists, more than a varied, dynamic, and naturally evolving entity."

A Hawaiian from North Kohala expressed the thought that her culture was flexible enough to accommodate change:

> "As for the perpetuation of ongoing Hawaiian cultural practices I hope that we do not tend to do everything as our ancestors did. This is only my mana'o."

In the **As-Planned** scenario, the bulk of population growth could, theoretically, be accounted for in the Kawaihae Hawaiian Homes project. In this case, most would argue that a considerable benefit to Hawaiians would result through the provision of housing and the creation of a self-contained community in a beautiful and historic location on the Kohala coast, with access to coastal fishing, gathering and cultural sites as well as to jobs. In this scenario, also, the relative numbers of Hawaiians in Kohala would be largest. Although not everyone is content with the design of the community, there is evidence of strong support for settlement of the area. In meetings with the authors, current and prospective residents expressed support for County water supply to the area. In the words of one awardee:

> "I favor this pipeline. One reason. DHHL Planning."

Some felt, however, that fostering new resorts should not be a trade-off for supplying water to DHHL lands.

Whatever scenario envisioned, development would bring more people and more outsiders to the region. There would be an increase in the stress on natural resources and the visitation (and perhaps desecration) to historic sites. Many respondents focussed on this aspect:

> "No matter how much hotels say that access to the shorelines are open to the public, everyone knows the difficulty that we receive every time we want to go to our beaches and shorelines. Nature never benefits from hotels."

> "The cultural sites in Hawaii are not being preserved, it is either being put on display at hotels, or Hawaiians using the sacred sites are put on display for tourist. That last and most common is its being buried by dozers."

> "It seems that a lot of emphasis is made on shoreline access [as a condition imposed for the right to develop coastal parcels]. Sometimes that can be good and at times it can only damage some cultural sites that should be protected by limited or no visitation at all."

Some saw at least one benefit to developing near historic sites:

> "Historic site location, access and knowledge was very limited prior to development. The developers examined and searched sites intensively and then saved the best examples. All this knowledge is now shared and accessible to the general public."

> "The preservation of these sites has allowed Hawaiians (those who knew about the sites, and those who did not) to come and enjoy/use them."

There is also concern about the imposition of artificial landscapes and control in places that may have great meaning for some Hawaiians.

> "If thousands of homes go up on the Kohala coast, which is sacred to us, what happens to our mana?"

> "[W]e kanaka maoli's has been robbed from our lands to our culture and our language. Cause foreigner in our country wants to satisfy their needs what they want....If Akau or God wanted water then Akau or God would have allowed the resource. AOLE....The system is totally illegal."

By contrast, a lifelong Kohala resident and native Hawaiian was unqualified in his praise of the transformation wrought by the resorts:

> "Without this Garden of Eden type of development, this area would be an arid wasteland."

Overall, it can be stated that both benefits and adverse impacts to the Hawaiian community would be experienced, to a large extent depending on the orientation of individuals to the visitor industry, to urbanization, and to the land.

A North Kohala Hawaiian with experience in the visitor industry was cynical about the entire history of resort development in Kohala:

> "[Development in Kohala] has pushed us into minority status, destroyed subsistence, created lousy second-class jobs and pushed cost of living out of sight.."

Another Hawaiian from Kawaihae felt that despite development, the essence of Kohala had been and would continue to be preserved:

> "North and South Kohala have found a compromise secret to accommodate the local needs first, that tourism also benefit, and not the other way."

We wish to acknowledge that during the course of interviews, several persons commented that a true "cultural impact assessment" for such projects was just as necessary as one assessing the environment. They also said that such analysis should be undertaken not by Westerners according to Western methods but by Hawaiians in a way validated by their own culture.

3.3.5.3 Impacts of Alternative Scenarios

The No-Project Alternative would probably continue the trend that has been ongoing in Kohala for some twenty years as discussed under the **Historical Trends** scenario above, but at a slower rate. *Alternative Scenarios 2 and 3* would have the same impact as the proposed project.

3.3.5.4 Potential Mitigation Measures

Mitigation measures sometimes suggested for socioeconomic impacts are complex, controversial and often unrealistic. For the purposes of this document, it is simply suggested that whenever government agencies consider permitting conditions for the proposed developments in Kohala, that due consideration is given to the following:

- Policies that encourage the creation of jobs desired by Kohala residents, to be filled primarily by Kohala residents, in order to conserve to some degree the existing structure and generational continuity of Kohala.
- Support of affordable housing in order to retain housing opportunities for Kohala residents.
- The impacts of gated housing communities on the larger community.

- The involvement of all interest groups, and in particular the Hawaiian community, in planning decisions that will affect economic, social and land use patterns of Kohala.
- Continuing and expanded emphasis on Hawaiian culture in Kohala resorts.

3.3.6 Impacts to Social Well-Being and Lifestyle/Community Values

Because negligible direct effects would result, this section discusses only secondary impacts.

3.3.6.1 Secondary

Social Well Being

Pertinent to this discussion are impacts to indicators of social well-being or disruption include educational levels, family disorders, child and spouse abuse, divorce, alcohol and drug abuse, crime, juvenile crime, vandalism, mental illness, suicide, and similar problems.

The **Historical Trends** scenario assumes an augmentation of the resort hotel economy and lifestyle that is currently present in Kohala. There are those who assume that social disorders will increase as a result of a lifestyle more dependent on tourism. In the words of one questionnaire respondent,

> "Criminal populations are to a large extent uprooted, young, single males. The growth of the destination resorts along thee coast has stimulated the influx of just such a population. Once the initial construction is over, this group then becomes unemployed, needs affordable housing, burdens social services, and in large measure turns to criminal activities. In addition, the wealthy clients of these hotels attract criminal elements."

As discussed in Section 2.2.4, many indicators of social well-being have shown negative trends during the last twenty years in Hawaii, within the resort region and outside of it. Adult and juvenile crime, family break-ups and single-parent families in particular have become more prevalent. On the other hand, educational levels have been rising and the incidence of DUI has declined. Data for certain other problems such as drug abuse and child abuse are for various reasons somewhat difficult to compare over time.

There is no question that absolute incidence of crime and other disorders have increased when resorts are built and more people are present, but there is little evidence that crime rates have

increased as a result of the resort lifestyle. As discussed in Section 2.2.4, the crime rate is actually higher in Hilo than in either North or South Kohala. It has also been demonstrated that many social problems are associated with unemployment and underemployment. This in no way indicates that resorts prevent crime, but it does illustrate the complexity of the cause-effect relationship, if there is one.

In the **As-Planned** scenario, population growth is primarily a product of the Kawaihae DHHL project, the impacts of construction on the economy and to some extent resort homes. Whether the rates of social disorder will decline, increase or stay stable in relation to the trends in such rates for other areas of the State and County are virtually impossible to predict.

Community Values and Lifestyle

As part of the Lalamilo EIS (Belt, Collins & Assoc. 1980) the authors predicted the following sources of conflict with local mores, values and lifestyles as a result of resort expansion:

- Duties of employees in conflict with accepted community standards, family expectations or religious values.
- Necessity for employees to associate with people they would not normally associate with.
- Changes in the relationship between husbands, wives and children as a result of employment requirements or exposure to different standards.
- Changing community decision-making processes, often to the disadvantage of the local person.

In addition, a number of positive aspects derived from broadened education, employment and personal relationships were predicted.

In the experience of most residents of Kohala, as evidenced in surveys and the generally friendly reception given to visitors, the last fifteen years has shown that an economy largely based on the visitor industry can be compatible with the rural lifestyle and values of Kohala. Family, social group and community-wide values have indeed changed, but to what extent this is a function of the visitor industry is difficult to determine. Furthermore, some changes in values are welcomed.

Whether the expansion of the resident population, visitor numbers and settled area that will be brought about by the development enabled by the project (in addition to other pending developments in the area) will put a strain on harmony is difficult to foresee.

Community respondents to questionnaires were concerned about impacts to the existing community values and identity in Kohala, particularly as they concerned preservation of Hawaiian values, visitor industry jobs, and wilderness and coastal areas. These subjects are treated elsewhere in this assessment.

3.3.6.2 Impacts of Alternative Scenarios

The No-Project Alternative would represent a continuation of existing trends at a somewhat reduced level. Potential casualties of a failure to build the water project are such socially worthy projects as affordable housing, Hawaiian Homes Lands plans and public coastal parks, which might be precluded by a premium cost for water. This is not to say that such projects are guaranteed by the construction of the project, because other users who are quicker to pay the necessary facility charges and thus reserve water may consume all available water. Reservation of water for projects with perceived social benefit may require government intervention.

Alternative Scenarios 2 and 3 would have essentially the same impact as the proposed project.

3.3.6.3 Potential Mitigation Measures

The mitigation measures listed in 3.3.5.4 are also applicable here.

3.3.7 Added Development Opportunities/Pressures

Because negligible direct effects would result, this section discusses only secondary impacts.

3.3.7.1 Secondary Impacts

The Department of Water Supply has referred to the transmission system in public meetings as a "water highway" meant to carry ground water from North Kohala to South Kohala. Public comments received in scoping meetings, interviews and questionnaire responses included numerous concerns about the consequences of *unintended* development opportunities or pressures.

Several individuals stated that although the project might be intended as a "highway" to transfer water to South Kohala, it would also inadvertently open up large sections of the North Kohala coast, which are currently without any water service, for development. Some contended that in fact this might be the hidden agenda of the project.

In response to such comments, the Hawaii County Department of Water Supply (DWS) stated that the policy for allowing or recommending water hookups consisted of the following factors:

- If the requested use of water is legally permissible under existing zoning, then the hookup shall be permissible. If the zoning is not appropriate, then no hook-up will be allowed.

- The DWS does not recommend for or against rezoning applications. In response to written requests from the Planning Department in the course of rezoning applications, it is DWS policy to state whether or not the existing water system can be expected to accommodate the amount of water that will be required if the property is rezoned and water is requested.

Some community members in turn responded that any surplus of the system would tend to elicit rezoning applications (e.g., from Agriculture to Urban or higher density Agriculture) from property owners along the pipeline right-of-way seeking a windfall from property value increases. Some of this property might be in turn developed according to permissible zoning, resulting in development not now envisioned by zoning or the Hawaii County General Plan.

Research conducted for this document at the Hawaii County Planning Department indicated that approximately 50 parcels with shoreline or near shoreline frontage are present between the Upolu Point area and the Kawaihae Hawaiian Homes boundary (the southern limit of major concerns). At least seven of these belong to the State of Hawaii, including several parcels with large acreage and substantial shoreline frontage. Parker Ranch and Chalon International (which already has development entitlement for a resort at Mahukona) are owners of another large fraction of acreage/frontage. The remaining parcels vary between less than one and several hundred acres. Because of the proximity of the Akoni Pule Highway to the ocean along most of this section, access conditions are generally excellent. The provision of water would provide one of the last physical elements to make development feasible (the reader is referred for illustration to the figures in Chapters 5 and 6 of the EIS which depict land ownership, State Land Use Classification, General Plan Designation and Special Management Area status of potentially affected lands in North and South Kohala).

A number of land use regulations currently limit the extent of development options available for most of the parcels. Current zoning for these parcels is mostly Unplanned. The General Plan designation for most of these areas is Extensive Agriculture or Conservation near the coastline. The State Land Use Classification is mostly Conservation within a buffer zone of varying width near the coastline and Agriculture behind this line. Many of the parcels are included wholly or partially within the Special Management Area. Therefore, most developments would require at least two and often more levels of review, involving environmental studies, public hearings, and administrative or legislative approval. These include Change of Zone, General Plan Amendments, State Land Use District Boundary Amendments, Special Management Area Permits, and other permits.

Because of the multiplicity of factors involved, it is impossible to predict which if any landowners may choose to undertake the process necessary to develop a parcel.

It is important to note that for any given parcel, other water supply options are theoretically available, including wells, water transfer from private systems (such as is currently occurring on Kohala Ranch), and even desalination. Furthermore, the simple availability of water does not enable rezoning. The Planning Department, Planning Commission and County Council of Hawaii County consider a complex of factors when considering rezoning. Several public hearings and a vote of the Council is required for rezoning. Therefore, it is by no means a certainty that even if surplus water is available, rezoning will follow.

One respondent expressed the concern that building a water system without sufficient up-front funding would mean that:

> "...the project will be driving the County Council to make future land use decisions. This occurs because the funding by county bonds will require that county legislators both seek and approve land uses which will be able to use the water, and thereby recover the up-front costs of the project."

This argument has elicited the response from DWS that if sufficient guarantees for user-derived funding are not obtained, the project will not be built.

It should also be pointed out that substantial benefits (as well as adverse impacts) may result from "unintended" development. Jobs are created and tax revenues rise, in addition to profits achieved by individual landowners and developers.

3.3.7.2 Impacts of Alternative Scenarios

The No-Project Alternative would effectively tend to limit "unintended" development of North Kohala coastal parcels by forcing developers to build their own water recovery systems or in some other way arrange for water, which would in most cases not be cost-effective. However, some larger parcels may still experience development pressure.

Alternative Scenarios 2 and 3 would have a similar impact to the *No-Project Alternative* and in fact might even decrease development pressure even further because much demand for coastal resort units in Kohala would be filled at alternative locations.

3.3.7.3 Potential Mitigation Measures

The extensive process of State and County public hearings, Commission and County Council votes, and other forums for public involvement offer a means for community members with concerns about unwanted development to voice them and exert pressure towards their goals.

3.4 Cumulative Impacts of the Project

Throughout the text, note has been taken of the fact that the Kohala Water Transmission Line is only one stimulus for development in Kohala. Innumerable smaller projects and several larger projects are likely to add population, jobs and housing, and may also transform the economic and social composition of the area in ways that augment or cancel out trends that would result from the proposed project.

The quantification, or even description, of projects that may occur over the next 25 years is problematic. Smaller projects are not liable to a great deal of advance planning or public review. General conceptual plans for larger projects may be available, but the scope and nature of such projects are notoriously subject to substantial modification according to financial or social factors.

For this reason, we have attempted to estimate the net impact of the project in its various aspects - employment, fiscal, demographic, housing - and to frame this impact where possible in the context of larger trends.

Concerning population, where a number of projections exist, some clear comparisons are possible. As discussed in Section 3.3.1.3, depending on the scenario and the particular projection used, the proposed project may account for as little as 50 percent or as much as 140 percent of predicted population growth. Other types of impacts are more difficult to predict without specific information such as firm and reliable projections of job-counts or housing units, which are lacking.

In the absence of viable, large-scale agriculture or industry prospects for Kohala, the most significant influence in the economy and population over the next two decades in this region will probably be the growth of resort hotels and housing. Several major development schemes and a number of smaller projects are expected to have significant economic and social impacts in Kohala over the next two decades. The following list is a general description of the most prominent proposed projects, using information provided in the *Draft Northwest Hawaii Open Space and Development Plan* (Townscape, Inc. 1992). It must be cautioned that although many projects have estimated figures for housing or hotel units, these figures are often speculative and subject to change.

Chalon International, Inc.

Mahukona Lodge. 240 hotel rooms and as many as 150 one-acre ag. lots, with golf course.
Kohala Plantation West. 40 single-family lots, with golf course.
Ainakea Village. 70 single-family lots.
Hawi Makai. 500 lots.
Kukuipahu Mauka and Makai. 100 single-family lots, with golf course.

Kohala Ranch

Resort Community. 962 single-family lots and 528 multi-family units.

Waikoloa Development Corporation

Waikoloa Village. 12,000 single-family lots; 1,000 multi-family units; 1,100 larger lots.
Waikoloa Beach Resort. 1,200 hotel rooms; 1,000 single-family lots; 1,600 multi-family units.

Other

Parker 2020. 626 single-family lots; 418 multi-family units; 37 larger lots.
Kohala Makai. 416 multi-family units.
Kahua Shores. 300 single and multi-family units.

A number of smaller projects are also planned. According to calculations by Townscape, Inc. (1992:114), projects with the necessary approvals for development account for approximately 31,000 units in northern North Kona and Kohala. Of this number in Kohala, possibly as many as 20,000 housing units and 1,500 hotels units are essentially unrelated to the proposed water project.[6]

6 It should be noted that a number of hotel and resort housing projects in North Kona may have a spillover effect into South Kohala in terms of jobs and population, although this may be canceled out by the fact that Kona residents often take Kohala jobs as well.

Furthermore, additional conceptual projects with little if any development entitlements might swell these numbers even further. If a significant proportion of such planned and conceptual projects were implemented, the consequences would dwarf the secondary impacts of the Kohala Water Transmission System. Tens of thousands of jobs and perhaps billions in government revenue might result. Population in Kohala could conceivably exceed 50,000 as a result of all plans unfolding. However, it is far from clear to what extent these plans will be fulfilled and according to what timetable. Many lack zoning and other entitlements, and some also lack financing or markets. It is too early to know the context of the impacts of the proposed project in terms of cumulative future growth. It will be the duty of State and County government to monitor this context and adjust goals and policy, plan for infrastructure, and impose development conditions as necessary.

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ATTACHMENT A: Key Informants

The following persons kindly cooperated with researchers on the Socioeconomic Impact Assessment Team by sharing their views on the project and on Kohala in general through personal interviews and/or questionnaire surveys.

Josephine Tanimoto	- Hawaiian Homes awardee, Kawaihae
John Broussard	- Resident and activist, Kohala
Kelly Pomeroy	- Resident and activist, Kohala
Bill Graham	- Resident and activist, Kohala
Judith Graham	- Resident and activist, Kohala
Jim Dupont	- Dept. of Hawaiian Homes Official
Henry Ross	- Resident and activist, Kohala
Matt Grady	- Chalon Planner
Mike Gomes	- Chalon Land Management
Bill Shontell	- Chalon Land Management
Ana Nawahine	- Kohala Resident, member of Ohana Council
Kate Nawahine	- Kohala Resident
Kaleo Pilago	- Kohala Resident and Marine Issues Activist
Albert Kahoopii	- Kohala Resident
Tom Quinlan	- Kohala Resident
George Russell	- Kohala Resident/Energy Researcher
Alexa Russell	- Kohala Resident
Mike Moriarty	- Kohala Resident/Coastal Issues Activist
Toni Withington	- Kohala Resident/Coastal Issues Activist
Charles Kunz	- Kona Employment Services Office, DLIR
Leoni Fukui	- Society of Human Resources Mgmt
Noelani Whittington	- Kohala Coast Resort Association
Naves Santiago	- Kohala Resident, Active in Seniors
Janet Coit	- Kohala Resident, Active with Youth Groups
John Gray	- Former Kohala Resident/Hotel Owner
Phil Hooton	- Long-time Kohala Resident
Sunny & Marie Solomon	- Hui Makaala
Leon Thevenin	- Puako Resident, Chair, South Kohala Resort Advisory Committee
Ed Austin	- Pres. Puako Comm. Assoc.
Lesley Patton	- Business Owner, Makapala
Angela Rosa	- Business Owner, Hawi
Don Rich	- Business Owner, Kapaau

ATTACHMENT B: SOCIAL IMPACT QUESTIONNAIRE

KOHALA PIPELINE SOCIAL IMPACT QUESTIONNAIRE

Ron Terry, Ph.D., is conducting a Social Impact Assessment as part of the background research for the upcoming Kohala Pipeline Environmental Impact Statement (EIS). This document is being prepared by Meg Kon, P.E., Inc., under contract to the Hawaii County Department of Water Supply in compliance with State law.

This questionnaire has been designed to discover what various community members feel about the indirect results of the Kohala pipeline - resort development, population growth, job creation and social change.

We would appreciate your replies to this questionnaire. You may include your name and telephone number if you wish, or you may answer anonymously.

Please mail responses to HCR 1, Box 9575, Kea'au Hawai'i 96749, or fax them to 982-5831. If you have any questions or have further information to pass along, please contact Dr. Terry at 982-5831. Thank you.

1. Concerning the development that has occurred during the last two decades on the South Kohala coast:

   a) What do you believe have been the positive and negative effects in terms of the economy (taxes, services, diversity of jobs, job satisfaction, etc.)?

   b) What do you believe have been the positive and negative effects in terms of the preservation of Hawaiian cultural sites and the perpetuation of ongoing Hawaiian cultural practices and activities?

   c) In what ways do you believe recreation (e.g., fishing, hunting, camping, sports, shoreline access, hiking, boating) been affected, either positively or negatively?

   d) What do you believe have been the positive and negative effects in terms of the social composition of the island (e.g., ethnic makeup, socioeconomic groups, visitor vs. resident, mental health)?

2. Do you see the existing South Kohala resort region as a net positive or net negative for Hawaii County?

3. Do you believe that the provision of this additional water for South Kohala is basically a positive or a negative action? What aspects are particularly positive (or negative)?

4. Please circle all of the following potential users that you would tend to favor getting water:

Hawaiian Homes Lands	Hapuna State Park Expansion
South Kohala Resort Hotels	South Kohala Resort Homes
North Kohala Resort Hotels	North Kohala Resort Homes
South Kohala Affordable Homes	North Kohala Affordable Homes
Upgrade of North Kohala Water System	

5. In general, would you say that you favor, oppose, or are neutral about the development of the Kohala pipeline? What are the most important reasons for your opinion?

NAME ______________________ TELEPHONE # ____________
(optional)

Please provide any additional comments about the project that you feel are important to express.

APPENDIX B

FEASIBILITY STUDY FOR A KOHALA COAST WATER SYSTEM

USGS REPORT
GROUND WATER AVAILABILITY FROM THE HAWI AQUIFER IN THE NORTH KOHALA AREA, HAWAII

A PRELIMINARY REPORT

FEASIBILITY STUDY FOR
A KOHALA COASTAL WATER SYSTEM

North & South Kohala, Island of Hawaii
State of Hawaii

DEPARTMENT OF WATER SUPPLY
County of Hawaii

25 Aupuni Street
Hilo, Hawaii 96720

June 1988

W. Y. Thompson, Consultant
98-1051 Kahapili Street, Aiea, HI 96701

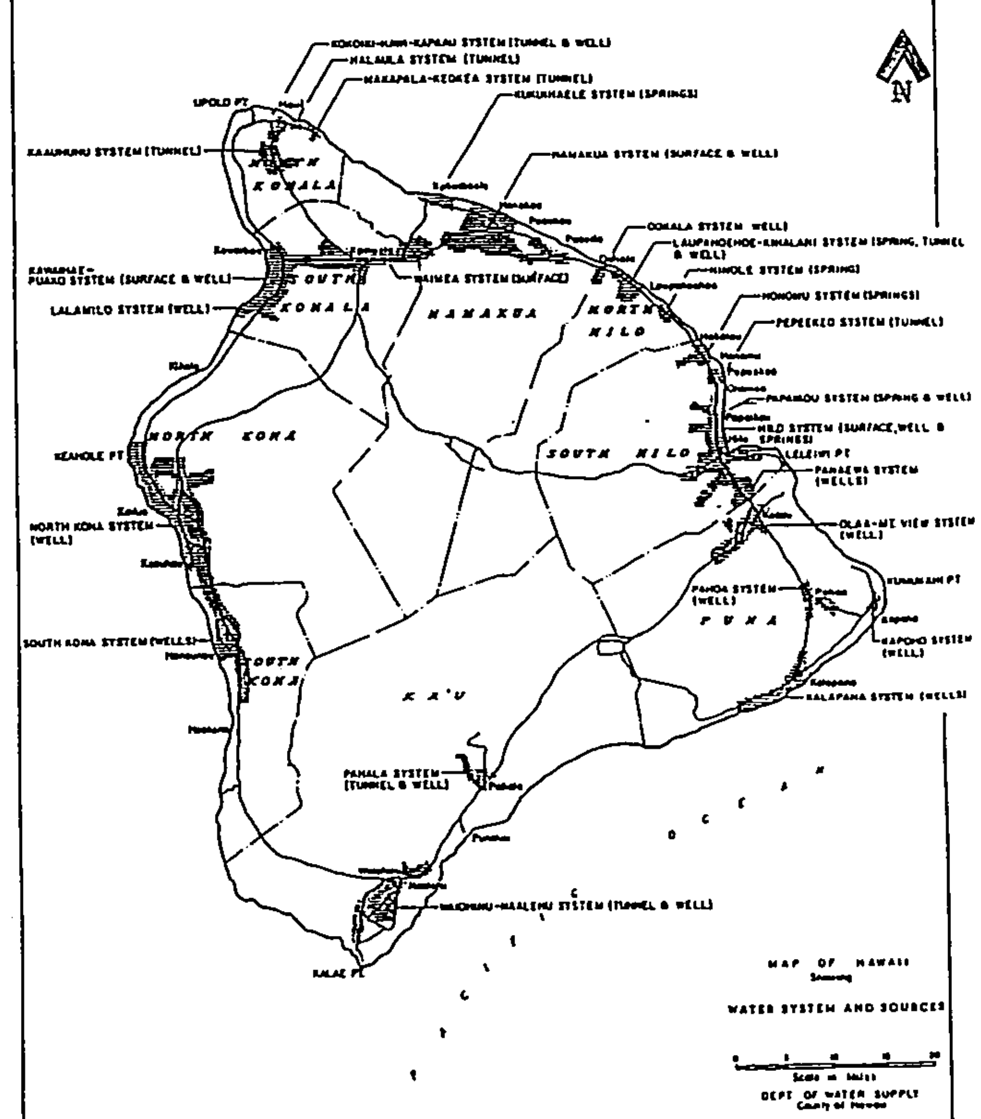


FIGURE I

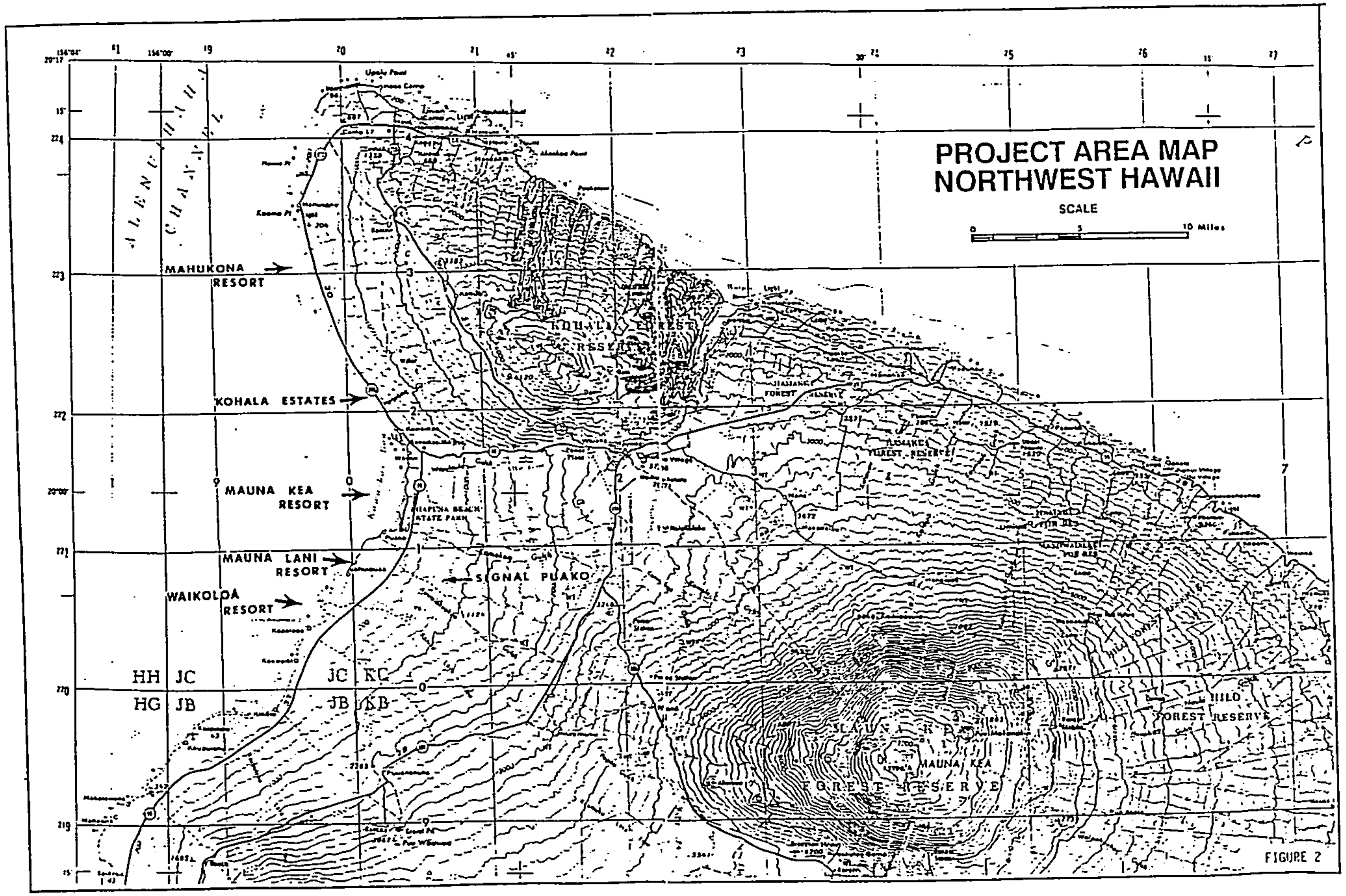

PROJECT AREA MAP
NORTHWEST HAWAII
SCALE
0
5
10 Miles
MAHUKONA RESORT
KOHALA ESTATES
MAUNA KEA RESORT
MAUNA LANI RESORT
SIGNAL PUAKO
WAIKOLOA RESORT
HH
JC
HG
JB
JC
KC
JB
KB
KOHALA FOREST RESERVE
MAUNA KEA
FOREST RESERVE
HILO FOREST RESERVE

FIGURE 2

THE BACKGROUND

The growth of West Hawaii as a resort destination area is the fulfillment of State and County planning efforts which started taking root with the advent of Statehood. The construction of the Keahole Airport in North Kona and the completion of the Queen Kaahumanu Highway linking the coastal areas of South Kohala and North Kona opened the door, literally, to this magnificient untouched area. The large land holdings, sunny climate, spectacular vistas of the mountains and ocean, the white sand beaches, relatively calm ocean waters - these were the ingredients that lured development funds to this northwestern coastal region of the Island of Hawaii.

The construction of the world class Mauna Kea Beach Hotel signalled the start of what is becoming a premier resort destination area. Followed by the Waikoloa Resort and the Mauna Lani Resort developments, the economy of the County of Hawaii has shot upward. Figure 2 shows the location of these resorts.

Present population projections predict a doubling of the northwest Hawaii region from 42,000 to 84,000 persons by the year 2005. This includes the districts of North and South Kona, North and South Kohala and Hamakua. For the Kohala region, the population expansion could reach 28,000 persons by the year 2005.

The population growth is, of course, a direct result of the resort development. As in the past, an adequate water supply continues to be an elusive goal. The water for the resort region first came from the limited supply of Waimea Village through the pipeline serving Kawaihae. The attempt to develop ground water

in the lower coastal area resulted in limited success. Water will high chloride content (300+ ppm) was developed and mixed with the surface supply from Waimea before use.

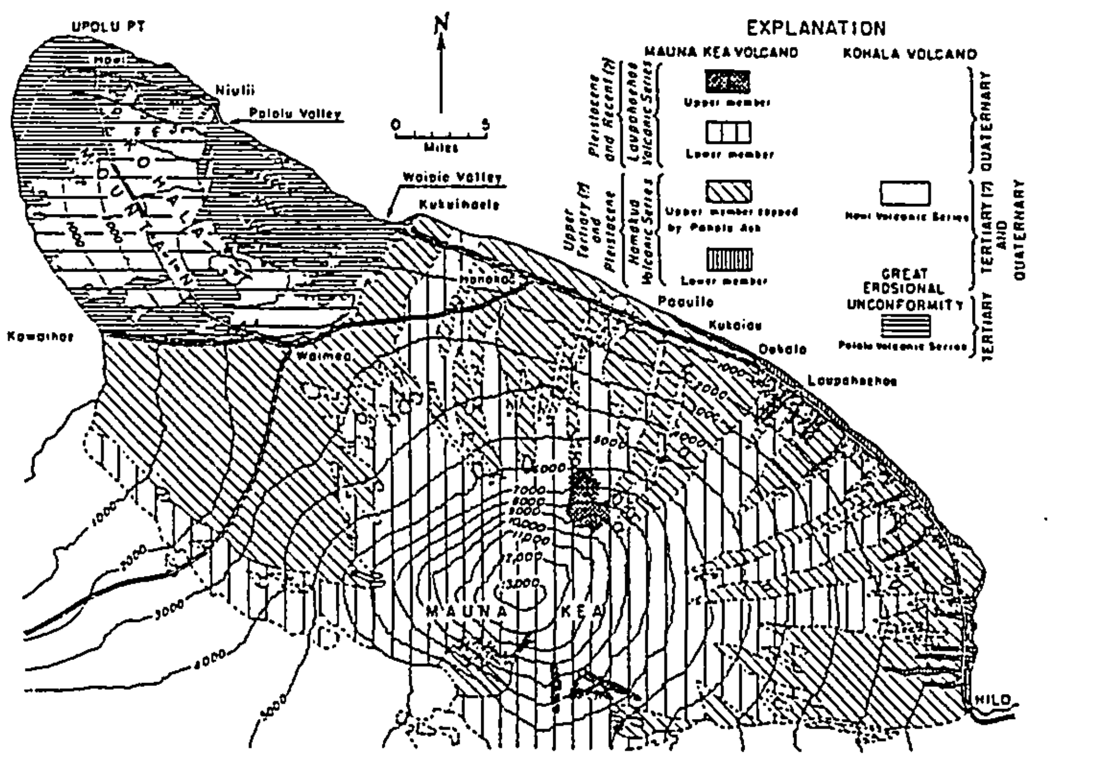
Then in 1977, the first of the Lalamilo wells was drilled. Water of excellent quality pumped at over 1000 gpm was produced. Other wells were subsequently drilled. This is the main supply for the resort and coastal developments today. However, the supply is limited, probably 4- or 5-mgd will be the maximum safe yield for from the Lalamilo well field area. The Lalamilo well development is attributed to the successful well drilled by Waikoloa Resort on the neighboring lands of Waikoloa. Previously, it was thought that deep wells could not reach any fair measure of success based on the earlier wells drilled in the lower (less than 500-foot) elevations.

However, the ground water supply is not inexhaustible. It has been estimated that as much as a 6 million gallons per day per mile of shoreline recharges the general area. Of this amount, possibly 3-mgd per mile could be withdrawn. Several factors must be taken into consideration such as the location or distance of the well from the shoreline, the particular geology of the well site, the capacity of the well, the annual rainfall over the recharge area, and the spacing of the individual wells.

FUTURE WATER DEMAND

The Department of Water Supply made an assessment of the projected water demand based on the number of hotel/dwelling units approved or proposed by various landowners/developers. The following is a summary of the estimated future water pro-

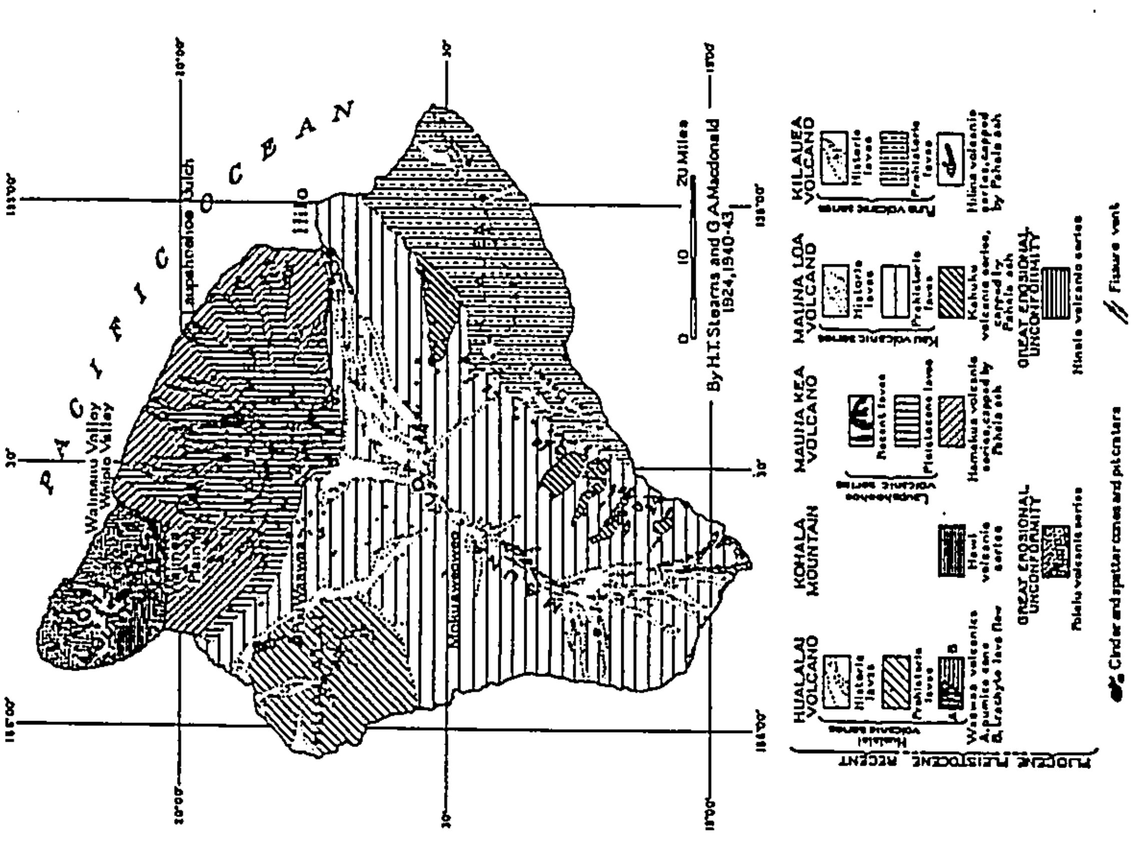
GENERALIZED GEOLOGIC MAP OF KOHALA MOUNTAIN AND MAUNA KEA



Source: Circular C14
USGS/DOWALD - 1963

FIGURE 4

GEOLOGIC MAP OF THE ISLAND OF HAWAII



Source: Bulletin 9
USGS - 1946

FIGURE 3

jections based on a per unit usage of 600 gallons per day (gpd).

Mauna Kea Resort complex	5.7 mgd
Mauna Lani Resort complex	6.0
Signal Properties	4.0
Hawaiian Homes Lands	0.28
Puako development	0.16
Mahukona Properties	2.20
North Kohala: misc. lands	1.00
South Kohala: misc. lands	2.00
TOTAL:	21.34 mgd

Since the Lalamilo wells produce 3.26 mgd, the additional future water demand is estimated to be 18.08 mgd (21.34 mgd less 3.26 mgd). However, the Lalamilo wells will be kept on a standby basis to be activated in any emergency since the proposed well sources in North Kohala will be about 25 miles away. Therefore, the North Kohala well field production should be at least 20 mgd.

It should be noted that the Waikoloa Resort has its own private water company and will continue to develop its own water supply without assistance from the County Water Department.

The following sections examine different hydrologic areas which could develop the 20+ mgd required by the resorts and the accompanying residential population growth.

A BRIEF GEOLOGY OF KOHALA MOUNTAIN

Kohala Mountain is one of the five volcanic mountains that make up the Island of Hawaii. It is said to be the oldest. It is an oval shield volcano with its highest peak at 5,480 feet elevation. The rocks of Kohala Mountain are composed of two volcanic series: the older Pololu flows and the younger Hawi flows.

The Pololu series consists largely of basaltic flows, generally 5 to 20 feet thick. Successive layers of these lava flows 2000 feet thick can be seen in the exposed deep canyon walls. The series is composed of thin-bedded primitive olivine, basalts with porphyries at the top in most places. The younger Hawi series mostly caps the top of the mountain in flows generally 10 to 150 feet thick averaging about 40 feet. The flows are chiefly andesites.

The Pololu volcanic flows are highly permeable and freely yield water to wells and high level tunnels in the rift zones. In contrast, the younger Hawi volcanic flows are mostly dense flows of poor permeability. The Mauna Kea lavas bank against the southern slope of Kohala Mountain. A few feet of Pahala ash also overlie the Hawi flows on the the southern slope. Figure 3 is a geologic map of the Island of Hawaii, while Figure 4 is an enlargement detailing the geology of the northern part of the island.

A graben 1 to 3 miles wide and up to 6 miles long crosses the summit of Kohala Mountain. It is bordered by faults which cut both volcanic series. This graben is thought to have directed flows that issued in it either to the southeast or the northwest as the northeast fault scarps were higher and no flows passed over the scarps between Honokane Nui and Kawainui Streams. The result was that erosion on the western and northern slopes of the mountain were constantly interrupted and the eroded areas were re-built by the Hawi flows while erosion continued unabated on the northeastern slopes and created deep canyons there.

The Kohala Volcano was built over a northwest rift (N 35° W), a southeast rift (S 65° E) and a poorly developed southwest rift (S 50° W). Lavas have issued along all the rifts but the northwest rift has been the most productive. The volcano is presumed to have begun its eruptive period 450,000 years ago and activity probably ceased 60,000 years ago. The volcano is considered to be extinct. The late activity of Kohala Volcano was contemporaneous with the later part of the mountain-building stage of Mauna Kea. Mauna Kea remained active long after activity in the Kohala Volcano ceased.

Of interest from a hydrological viewpoint are the presence of numerous dikes in the mountains that are exposed in the deep canyons. These dikes account for the presence of high level water supplies. It is estimated that the dike complex confine large amounts of water and the dry weather discharge from high-level springs emanating from the dike complex is about 100 million gallons per day. The following tables list the dikes, number and sizes, exposed in the canyons:

TABLE 1

DIKES IN CANYONS IN KOHALA MOUNTAINS

Canyon	Number
Waipio	
Hiilawe Branch	4
Waima Branch *	36
Koiawe Branch	78
Alakahi Branch	62
Kawainui Branch	16
Waimanu	7
Waihilau Branch & Tributaries	9
Honokane Nui	
East Branch	35
West Branch **	3
Pololu	1
	251

* Includes 20 dikes exposed in the high ditch tunnel in the east wall of Waima Canyon.

** A landslide at an altitude of 1,500 feet prevented examination above it.

TABLE 2

SIZE OF DIKES IN KOHALA MOUNTAINS

Width (in feet)	Number*
1/2 - 1	40
1 - 1 1/2	48
1 1/2 - 2	38
2 - 3	25
3 - 6	46
6 - 12	14
12 - 24	4
More than 24	2
	217

* Some of the dikes cut across the country and are measured in more than one canyon. Thick dikes are more apt to be measured at more than one place than thin dikes as they tend to crop out in spite of heavy vegetation.

Note: Tables from U.S.G.S. Bulletin 9: Stearns & MacDonald

HYDROLOGIC AREAS

In determining the area most suitable for the development of water resources to serve the target area, six areas were examined and the likely water resources assessed based on available records. These areas are shown on Map No. 5. An assessment of each area follows.

Hydrologic Area No. 1

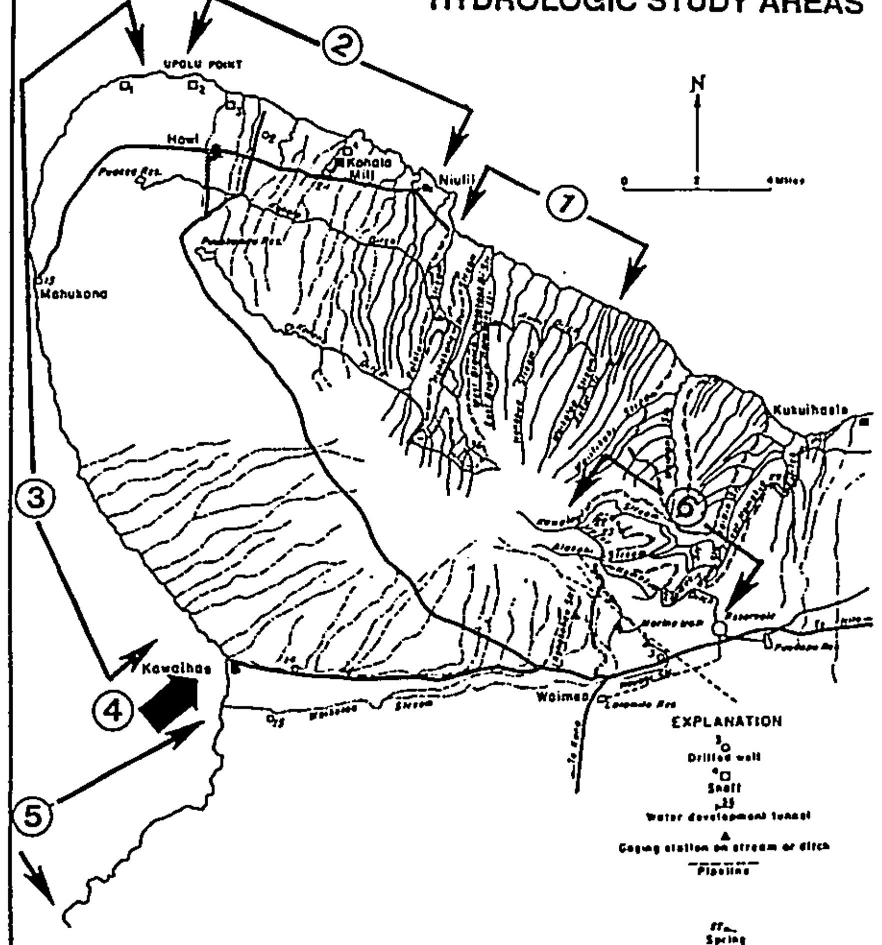
This area is located in North Kohala and generally includes the mountainous sector between Waikaloa Stream and Polulu Valley. The Kohala Ditch derives its supply from this sector. The ditch system south of Honokane Nui Canyon is called the Awini Ditch which collects water from Waikaloa Streams, other streams it crosses and 30 water development tunnels before discharging the supply into Honokane Nui Canyon where it is picked up by the Kohala Ditch and thence transported out to the former Kohala Sugar Company canefields. The ditch system at one time had a capacity of 76 mgd with a mean flow of 23.2 mgd.

Since the closure of Kohala Sugar Company in 1974, no maintenance of any consequence has been carried out on the Awini Ditch section. The Kohala Ditch is maintained minimally today and serves several customers utilizing former sugar cane lands at one time or another for other agricultural pursuits: flower and foliage, forage crops, aquaculture, livestock watering and orchards. The potential for water supply is great in this area.

Hydrologic Area No. 2

This area covers the sector between Pololu Valley and Upolu. There are no perennial streams in this sector. There are some

HYDROLOGIC STUDY AREAS



LEGEND

(2) HYDROLOGIC AREA

Map Source: Circular C14
USGS/DOWALD - 1963

FIGURE 5

springs and tunnels which are currently in use by the County Department of Water Supply and private land owners. The springs and other high level water supplies are generally of small capacity and run low or stop flowing during prolonged dry weather. Some of these discharges are:

Hapahapai Tunnel: 0.045 mgd

Watt Tunnel: 0.175 mgd

Bond Tunnel: 0.2 mgd

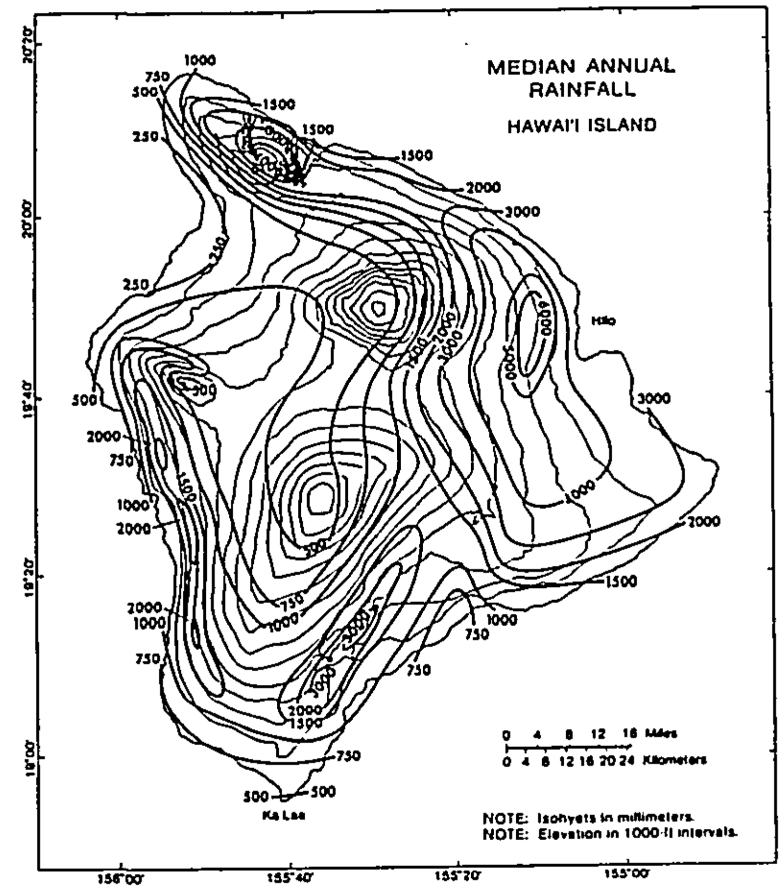
Lindsay Tunnel: 0.093 mgd

The basal or ground water in this area has good potential for development. It is estimated that the head runs from 10 feet above sea level at Pololu Valley to 2 feet or less beyond Kokoiki at Mahukona. The heads are highest where the annual rainfall is abundant at over 100 inches and lowest where the rainfall is about 10 inches or so, as can be seen from the rainfall map, Figure 6. The recorded data of the following deep wells in North Kohala are:

SELECTED DEEP WELLS IN NORTH KOHALA

Well	Ground Elev.	Capacity	Static Head	Chloride
Union Mill #1	311 ft.	1850 gpm	6.2 ft.	48-73 ppm
Union Mill #2	420 ft.	1850 gpm	7.1 ft.	52-129 ppm
Hawi Well	541 ft.	400 gpm	5.15 ft.	18 ppm

A preliminary to the Hawaii Water Resources Regional Study indicated the following ground or basal water potential of this area according to the following computations prior to the closing of Kohala Sugar Company.



Source: Rainfall Atlas - R76
DOWALD - 1986

FIGURE 6

GROUND WATER POTENTIAL
Pololu to Upolu

	MGD	Percentage
Input		
Rainfall	140	80
Imported Water	35	20
Output		
Runoff	25	14
Irrigation and Evapotranspiration	140	80
Surplus to basal ground water	10	6

Unpublished Report: Circa 1977

Since the sugar company has shut down its operations, the large quantity attributed to evapotranspiration is no longer valid. Further, the imported water is estimated to be 8 to 15 mgd more or less, currently, serving a handful of agricultural tenants on Kohala Corporation lands. In this respect, the surplus to basal ground water would be about 50 mgd for this sector.

Obviously, the best area for tapping the basal supply would be in the region between Niulii and Hawi and back of the shoreline where the water table is greater than 6 feet above sea level. Based on the Ghyben-Herzberg principle, the depth of the fresh water lens would be over 240 feet.

Hydrologic Area No. 3

This area covers the western coast of North Kohala and includes the area from Upolu Point to Kawaihae. This shoreline

area is part of the driest section of the Island of Hawaii. The area is fairly steep as can be seen from the U.S.G.S. topographic map.

The wet summit area of Kohala Mountain contributes considerable recharge to the basal water lens; however, the rocks are so permeable that mixing of the fresh water with the ocean water occurs near the coast. It is not likely that potable water with acceptable chloride limits can be developed less than 2 miles from the shoreline.

Deep wells drilled at elevation 1200+ feet near the North and South Kohala boundary north of Kawaihae have successfully produced potable water. The wells are 2.5 miles from the shoreline and the water table stands at 9 feet above sea level. The chloride content is approximately 25 ppm.

In this general area, the following estimate of the ground water discharge has been computed.

GROUND WATER DISCHARGE
Upolu Point to Kawaihae

	MGD		Percentage of Input	
	Range	Average	Range	Average
Input				
Rainfall		200		100
Output				
Runoff	70-100	85	35-50	42
Evapotranspiration	70-100	85	35-50	42
Surplus to basal ground water	60-0	30	30-0	15

Unpublished Report: Circa 1977

The percentage of runoff is higher than for the Niulii-Kokoiki region since much of the slopes is comprised of the less permeable Hawi Volcanic Series. Much of the discharge of the basal flow is probably to the south and into the Mauna Kea lavas and is discharged to sea in the area south of Kawaihae. The average ground water flow probably approaches 2 mgd per mile of shoreline. Discharge of basal water along the western shores of the Kohala Mountains is apparently significantly less judging by the generally high salinity of the water underlying this coast.

Owing to the generally sporadic and low rainfall input and the small ground water storage in thin basal water lens, much of the discharge of the fresh basal water is not recoverable in the lower shoreline area.

Hydrologic Area No. 4

This area covers the underground potential north of Kawaihae. As noted earlier, the ground is permeable and mixing of sea water with the basal water table extends far inland. The test wells drilled 1.5 miles and 2.5 miles from the coastline along the Kawaihae Road yielded water with high chloride content. The well 1.5 miles from the coastline at elevation 580 had an initial water table of 3 feet. After a pump test of about 2 days, the chloride content tested at 300 ppm. The second well 2.5 miles from the coastline at elevation 982 feet yielded slightly better results. The chloride content was found to be 229-269 ppm. This well water is mixed with water from Waimea to reduce the chloride content for domestic use. This well is used intermittently. A surprising find was made, both wells had

water with high temperature; water from the first well was 81° F. while the second well was 93° to 96° F.

Another test well was drilled at elevation 3613 feet on the south southwest slope of Kohala Mountain to explore for high level or dike-impounded water supplies. The well was unsuccessful.

According to geophysicists, there is a geothermal anamoly in this Kawaihae region. The test wells along Kawaihae Road mentioned above which contained ground water with temperatures of 90° F, more or less, attests to this geothermal anamoly. The existence of the poorly developed third rift zone emanating from the Kohala Mountain summit in a S 50° W direction points to this general area north of Kawaihae.

Hydrologic Area No. 5

This area includes the lands below Waimea Village and primarily includes the State lands of Lalamilo and the privately-owned Waikoloa lands. The groundwater recharge (or the amount escaping into the ocean) for this area is estimated to be about 38 billion gallons per year based on a mean annual rainfall of 260 billion gallons. This amounts to 6.38 mgd per mile of coastline. The safe yield by pumping from deep wells or tunnels will, of course, be lower than this figure.

Several wells have been drilled in this area in recent years. Figure 7 shows the location of these wells as well as those mentioned in Hydroglogic Area #3 and #4. Data from the wells are as follows:

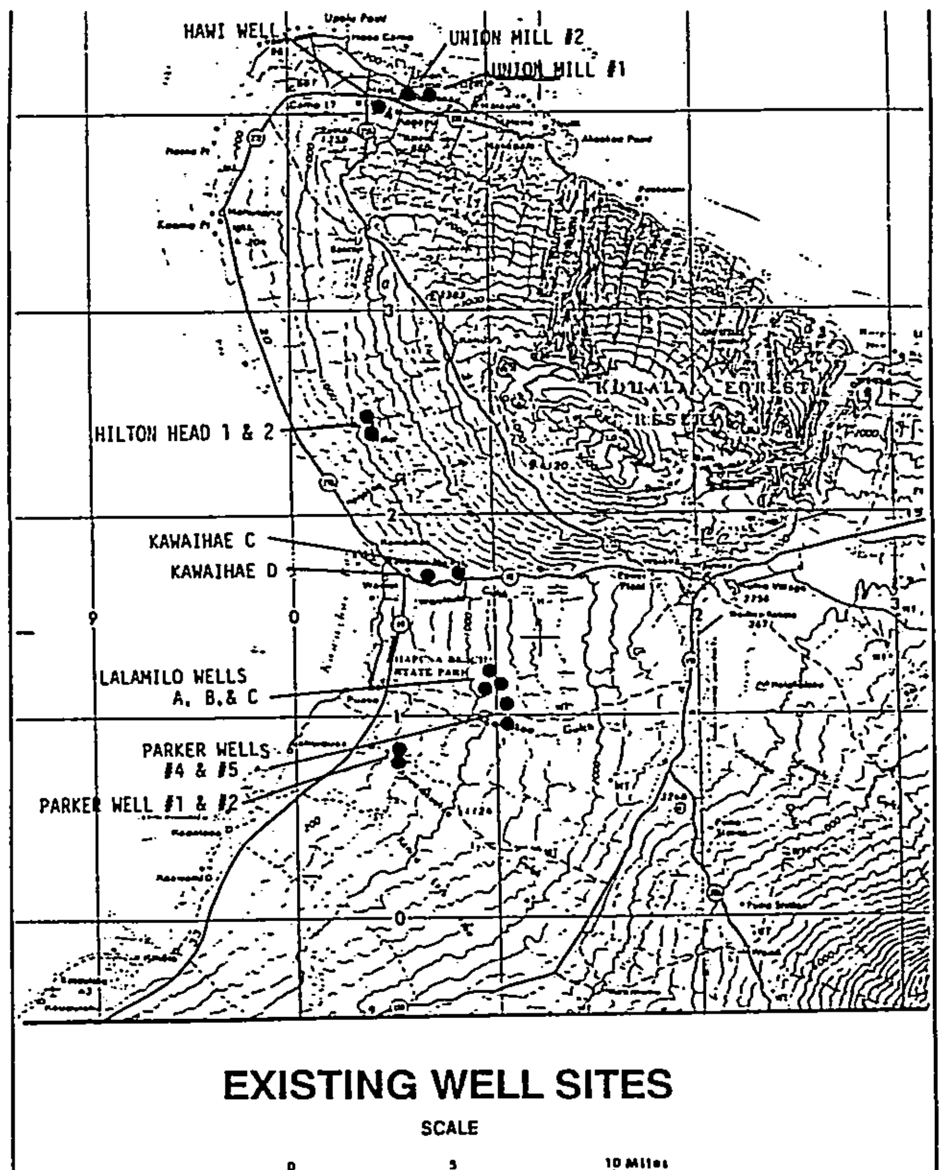


FIGURE 7

SELECTED WELL DATA

Well	Ground Elev.	Static Level	Chloride Content	Pump Capacity
Kawaihae Well #D	580 ft.	3.27 ft.	250 ppm	
Kawaihae Well #C	982 ft.	4.62 ft.	270 ppm	
Parker Well #1	800 ft.		500 ppm	
Parker Well #2	621 ft.		350 ppm	
Parker Well #4	1203 ft.	16 ft.	32 ppm	700 gpm
Parker Well #5	1213 ft.	16 ft.	33 ppm	666 gpm
Lalamilo Well #A	1172 ft.	8.2 ft.	78 ppm	1000 gpm
Lalamilo Well #B	1088 ft.	6.6 ft.	31 ppm	1000 gpm
Lalamilo Well #C	1087 ft.	7.6 ft.	59 ppm	1000 gpm

The static water level gradient is about 2 feet rise per mile. However, the static level of Parker Well #4 and #5 seems to indicate a barrier of undetermined origin resulting in the higher (16 ft.) static water level.

Hydrologic Area No. 6

This area generally covers the southern portion of Kohala Mountain and lies immediately above Waimea Village. This is the principal source for the domestic and irrigation needs of Waimea Village and its surrounding agricultural lands.

The County Department of Water Supply derives its water supplies from Waikoloa Stream at the Marine Dam intake and from the diversion pipeline from Kohakohau Stream. To ensure dependable service, 108 million gallons of storage capacity is presently in use with an additional 50-million gallon reservoir to be placed into service shortly.

The State Waimea Irrigation System depends on the old Upper Hamakua Ditch System for its supply. The ditch system, over 80 years old, is in the process of being renovated to restore the ditch system to its designed capacity. This system serves the farmers at Puukapu, Hawaiian Homes farm lots and the Lalamilo farm lots. Storage to cope with the dry months include a 60-million gallon and a 4-million gallon reservoir. This storage will be increased considerably when improvements to the old Puu Pulehu Reservoir is completed; over 100 million gallons of storage will be gained.

Parker Ranch operates is own water system to take care of its ranching needs. The main source is from Alakahi Stream.

A test well at elevation 3023 feet has been drilled in search of high level dike-impounded water. Tests of this well located above the 60-million gallon Waimea Reservoir are being evaluated. Preliminary results indicate that the well has some potential for development. The depth to the water was 1284 feet from the surface; pumping will be required to use this high level supply stored in the Kohala Mountain dike system.

EVALUATION OF THE HYDROLOGIC AREAS FOR WATER DEVELOPMENT

Hydrologic Area No. 1 is primarily the irrigation system developed to serve the sugar companies (five at one time) and includes the area from Waikaloa Stream to Pololu Valley. The irrigation system is made up of Awini Ditch which discharges the supply diverted from Waikaloa Stream (and other stream sources) into Honokane Nui Stream and Kohala Ditch which adds the Awini

Ditch flow to the Honokane and Pololu diversions.

Since the agricultural needs of North Kohala are uncertain during this transition period following the demise of the sugar industry in North Kohala, this hydrologic area was not selected for development (or restoration of the ditch systems to its former capacity). With good agricultural lands lying below the Kohala Ditch, it is felt that the future agricultural potential of these former sugar lands should be evaluated; until such time, the Kohala Ditch system should not be considered for urban development type of use.

Hydrologic Area No. 3 was not selected for water development as the permeability of the rocks reduces the prospects of developing water at at proposed nominal pumping lift of about 600 feet. The wells in this area will have to be located above the 1000-foot elevation contour to obtain water of acceptable chloride content and of sufficient well capacity. Such wells will most likely have to be 3 to 4 miles from the coastline to be successful.

Hydrologic Area No. 4 was not selected for water development due to the uncertainty of potable water in sufficent quantities based on the geologic features of the area such as the southwest rift zone and the absence of high level water supplies in the area above the prospect area. The existence of a nearby geothermal anamoly adds another uncertainty to this selection.

Hydrologic Area No. 5 appears to have some attraction for water development. However, deep wells would be inefficient for the quantity to be developed, i.e., 20+ mgd. Tunneling would be an alternative. However, the tunnel would have to be confined to the Lalamilo lands which is only 2 miles wide restricting the lateral interception of the ground water moving towards the sea at a rate of 6 mgd per mile of coastline. Further, intercepting the water by tunneling inland would undoubtedly adversely affect the output from the Lalamilo wells. The nearby Waikoloa lands are privately owned and being developed as part of the huge Waikoloa resort project; water rights would be a problem.

Hydrologic Area No. 6 is the source for the domestic and agricultural needs for Waimea. A limited amount, less than half a million gallons per day, is transported from Waimea along the Kawaihae Road to serve the lower coastal areas. The bulk of the water is kept for the mauka areas. Since the high level sources are only now reaching the state of being able to accommodate the present and predicted demands of Waimea Village and its surrounding urban development and agriculutural facilities, export of water from this area is unlikely. The growth of Waimea Village and its surrounding community will require all the water that can be developed in this hydrologic area; no plans to divert the water to other regions are foreseen.

The choice then falls upon Hydrologic Area No. 2 for the water development needs of the South Kohala resort region. The advantages of this selection include:

1) There is excellent ground water availability and good recharge from the heavy rainfall in the upper areas.
2) With the closing of the sugar industry in this area, competition for ground water is lacking.

3) The proposed pipeline from North Kohala to South Kohala will also furnish water to the drier regions of North Kohala where some development projects have been proposed.
4) Ground water can be developed by deep wells at a reasonable elevation, not exceeding 600 feet, with a significant reduction in pumping costs as compared to the present Lalamilo wells in operation, 600 ft. vs. 1200 ft.
5) The wells can be developed on an incremental basis; that is, as the demand arises, additional wells will be drilled to meet such demand.
6) Much of the area that the pipeline will traverse is undeveloped at present; pipeline rights-of-way should not be an insurmountable problem.

THE PROJECT

To meet the water demands of the South Kohala resort region, it is proposed that ground water be developed in the North Kohala region between Niuli and Hawi. Test wells should be drilled to provide information which can be correlated to the data of the existing deep wells to guide the location, size and capacity of each deep well. For example, 12 wells (including 2 standby) producing 2-mgd per well would meet the design consumption demand of 20+ mgd.

Each deep well should be as far inland as practical to supply the holding reservoir with an overflow height at the 600-foot elevation. The spacing of the deep wells will depend on the analysis compiled from the test wells and the availability of well sites.

The holding reservoir would be incrementally constructed; however, the units should be of 5 million gallon capacity if the topography permits. Other units should be of 5 million gallon capacity also, including the reservoirs floating on the pipeline and the final distribution reservoir.

The pipeline would be located along established highways or roads to minimize local disruption of existing community buildings from the well development area to Honoipu where the holding reservoir(s) would be constructed. The pipeline gradient appears favorable.

Serious consideration should be given to locating the transmission pipeline, which will run from Honoipu to the South Kohala region, above the existing Akone Pule State Highway to eliminate excessive presssure in the transmission pipeline. Since this area is sparsely developed, negotiations for a pipeline right-of-way could be worked out.

The final distribution tank would be located on the State lands of Lalamilo which appears to be the center of the resort development and its ancilliary projects. The proposed water system is designed to serve the coastal development below the 500-foot contour. The main distribution storage would be set at elevation 300 feet to service the coastal resorts. Developments above the State Kaahumanu Highway would be served by the next pressure zone and limited to the 500-foot contour. While plans for urban development in this secondary zone above Kaahumanu Highway and between the Kawaihae Road and the northern boundary of Waikoloa have been proposed, there are no development at the

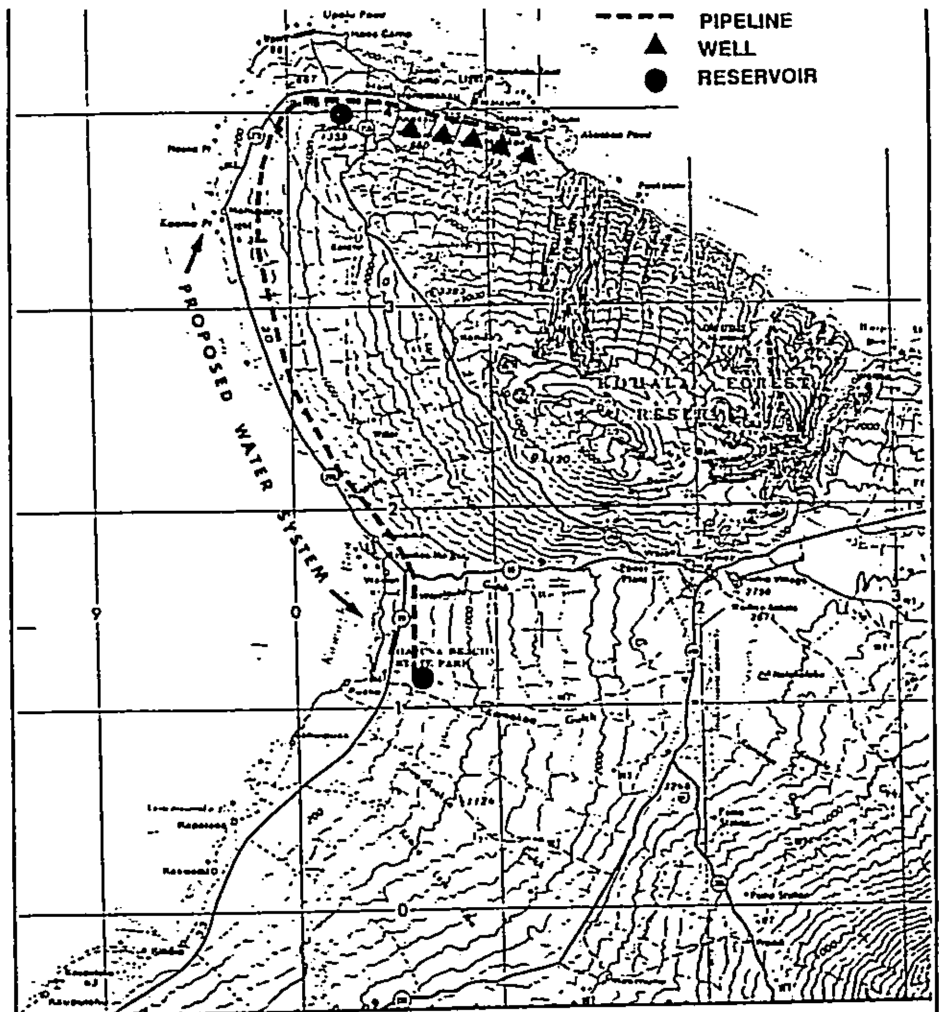
present time.

The proposed system as shown on Figure 8, is expected to cost approximately $50,000,000 including engineering and related design costs.

FINANCING

The cost of this project is beyond the financial capability of the County Department of Water Supply inasmuch as it represents 50% of the total assets of the Department. While a revenue bond could be issued to finance the proposed project, it is doubtful that the Department's financial advisers would find it acceptable. Since much of the target area is undeveloped and unzoned for urban use, there is some speculative risk involved as to whether or not the full development of the region as advanced by various developers will occur. More importantly, the Department has no control over the granting of Urban classification, a State Land Use Commission function, and the zoning for urban development, a County Planning Department responsibility.

In this respect, assistance from the State in issuing bonds for the construction of the proposed project would be essential. The bonds will be retired from the facilities service charge to be collected from prospective consumers. The facilities service charge is presently $1600 per connection and expected to rise to $2000 or more during the bond retirement period.



PROPOSED KOHALA COASTAL WATER SYSTEM

FIGURE 8

COMPLETION TIME

It is estimated that design and processing of the plans including environmental reports for approval will require about two years. The construction period is expected to take at least two to three years. To expedite the project, the work could be divided and let out under several contracts, to wit, drilling of wells and furnishing of pump equipment, installing pipeline for well water collection, constructing reservoirs, and installing the transmission pipeline in two increments.

Another method may involve a turn key project; that is, a prime contractor will take over the design and construction of the project. At completion, the contractor would be reimbursed at an agreed upon price.

NOTE:

The data for wells, tunnels, springs, etc. are from records taken at a specific time. Figures may have changed, such as chloride content and static water level due to pumping over a period of time or long term changes in climatic conditions.

The Hawaii County Department of Water Supply has contracted with the U. S. Geological Survey for a hydrological study of the North Kohala areas referred to as Hydrological Area No. 2 in this report including the drilling of deep well test holes. The results of this study will be available in 1989.

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GROUND-WATER AVAILABILITY FROM THE HAWI AQUIFER IN THE KOHALA AREA, HAWAII

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 95-4113

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1995

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
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FIGURES

FIGURES--Continued

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Conversion Factors

Multiply	By	To obtain
acre	4,047	square meter
foot (ft)	0.3048	meter
foot per mile (ft/mi)	0.1894	meter per kilometer
foot per day (ft/d)	0.3048	meter per day
foot per day per foot (ft/d)/ft	1	meter per day per meter
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
gallon per minute (gal/min)	0.06308	liter per second
million gallons per day (Mgal/d)	0.04381	cubic meter per second
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
inch (in.)	25.4	millimeter
inch per year (in/yr)	25.4	millimeter per year

Temperature is given in degrees Celsius (°*C*), which can be converted to degrees Fahrenheit (°*F*) by using the equation:

$$°F = (1.8 \times °C) + 32$$

Abbreviations used in water quality descriptions:

µg/L, micrograms per liter
mg/L, milligrams per liter
µS/cm, microsiemens per centimeter at 25° Celsius
ppm, parts per million
gm/cm^3, grams per cubic centimeter

GROUND-WATER AVAILABILITY FROM THE HAWI AQUIFER IN THE KOHALA AREA, HAWAII

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Mark R. Underwood, William Meyer, and William R. Souza

ABSTRACT

A ground-water study consisting of test-well drilling, aquifer tests, and numerical simulation was done to investigate ground-water availability in the basal part of the Hawi aquifer between the western drainage divide of Pololu Valley and Upolu Point in Kohala, Hawaii. The test-well drilling provided information on geology, water levels, water quality, vertical extent of the freshwater, and the thickness of the freshwater-saltwater transition zone in that aquifer. A total of 12 test wells were drilled at eight locations. Aquifer tests were done at five locations to estimate the hydraulic conductivity of the aquifer. Using information on the distribution of recharge, vertical extent of freshwater, hydraulic conductivity, and geometry of the basal aquifer, a numerical model was used to simulate the movement of water into, through, and out of the basal aquifer, and the effect of additional pumping on the water levels in the aquifer.

Results of the modeling indicate that ground-water withdrawal of 20 million gallons per day above the existing withdrawal of 0.6 million gallons per day from the basal aquifer is hydrologically feasible, but that spacing, depth, and pumping rates of individual wells are important. If pumping is concentrated, the likelihood of saltwater intrusion is increased. The additional withdrawal of 20 million gallons per day would result in a reduction of ground-water discharge to the ocean by an amount equal to pumpage. Although model-calculated declines in water-level outside the area of pumping are small, pumping could cause some reduction of streamflow near the mouth of Pololu Stream.

INTRODUCTION

The Kohala area of the island of Hawaii is the northwest peninsula of the island (fig. 1). The area is dominated by the asymmetrical, elongated Kohala Mountain. Kohala Mountain is an extinct volcanic dome reaching an altitude of 5,605 ft and is the oldest of the five volcanoes forming the island. The Hawaii Water Resources Protection Plan (George A.L. Yuen and Associates, Inc., 1992) delineated three aquifer systems in the Kohala area: Hawi, Waimanu, and Mahukona (fig. 1). Ground water in these systems is found as basal ground water along the flanks of the volcanic dome, and as high-level water in the rift zones (Stearns and Macdonald, 1946) (fig. 2). The basal ground water extends from the outer edges of the rift zones to a discharge area seaward of the shoreline, and is a roughly lens-shaped body of freshwater floating on seawater. The maximum altitude of the water table of the basal water is unknown.

The windward (northern) side of Kohala Mountain is relatively cool and wet, receiving more than 160 in/yr of rainfall near the summit (fig. 3). The leeward (southern) side of the mountain is in the rain shadow of Kohala Mountain. Average rainfall is less than 10 in/yr along the coast near Kawaihae. Tourism on the leeward side of the Kohala area is expected to grow considerably because of the dry, warm climate. One of the primary limitations for growth and development in this area is the availability of water. The Hawaii County Department of Water Supply (DWS) estimates that water demand in the year 2005 will increase by about 20 Mgal/d more than the present use of 0.6 Mgal/d (Thompson, 1988). Ground water is the preferred source to supply the projected demand, because of its quality, reliability, and lack of required treatment as compared with surface water.

To address an increased demand for water, the DWS and the U.S. Geological Survey (USGS) began a cooperative study to investigate ground-water availability from the basal part of the Hawi aquifer. This area was selected because of its high rainfall and because of the known existence of an extensive basal aquifer. This report describes the results of the study and includes a summary of exploratory well drilling and aquifer tests, and numerical simulation of the changes in the aquifer resulting from increased pumpage of 20 Mgal/d.

Scope

The primary study area for the field investigations was the basal part of the Hawi aquifer between the western drainage divide of Pololu Stream and Upolu Point (fig. 1). This basal aquifer extends to the southeast beyond the Pololu drainage divide and is contiguous with the basal part of the Waimanu aquifer. The Waimanu aquifer was not considered for ground-water development because of its rugged terrain; however, the Pololu drainage basin, which is within the Waimanu aquifer (fig. 1), was included in the numerical ground-water flow model constructed for this study. Because the basal aquifers are part of a larger ground-water system within the Kohala area, it was necessary to quantify rates of ground-water movement into the basal aquifers from areas adjacent

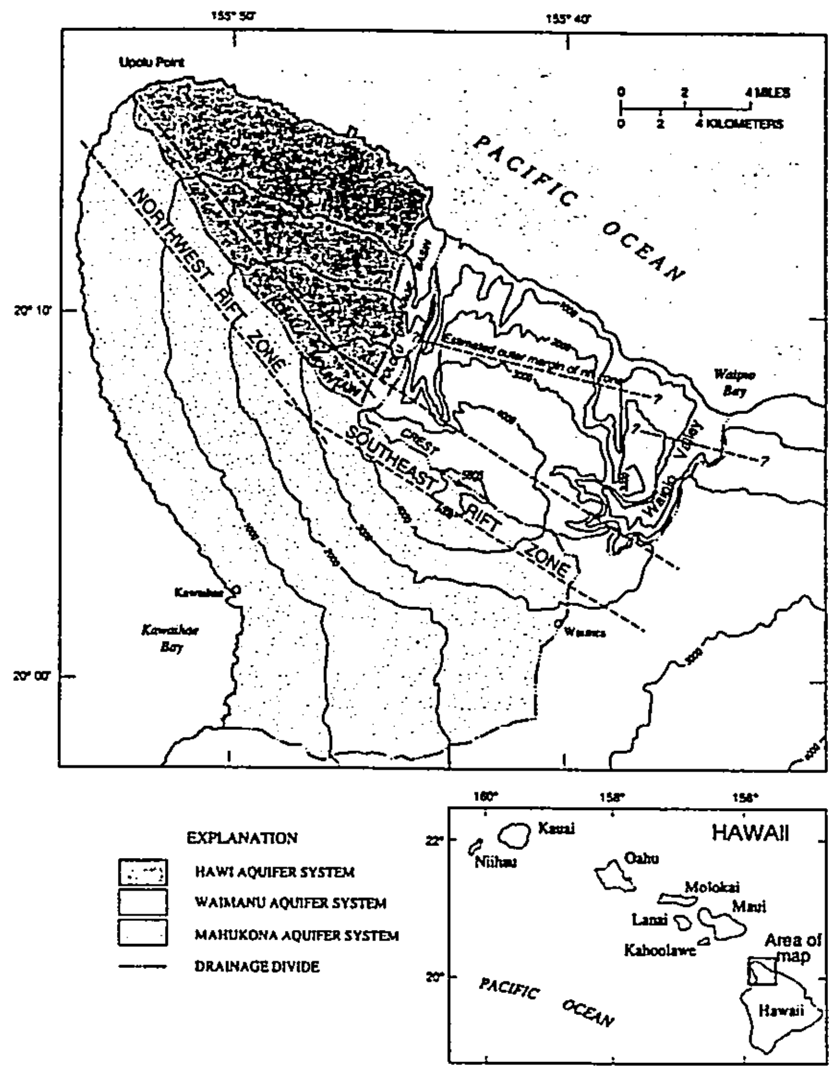


Figure 1. Hawaiian Islands and aquifer systems in the Kohala area, island of Hawaii (aquifer systems are from George A. L. Yuen and Associates, Inc., 1992).

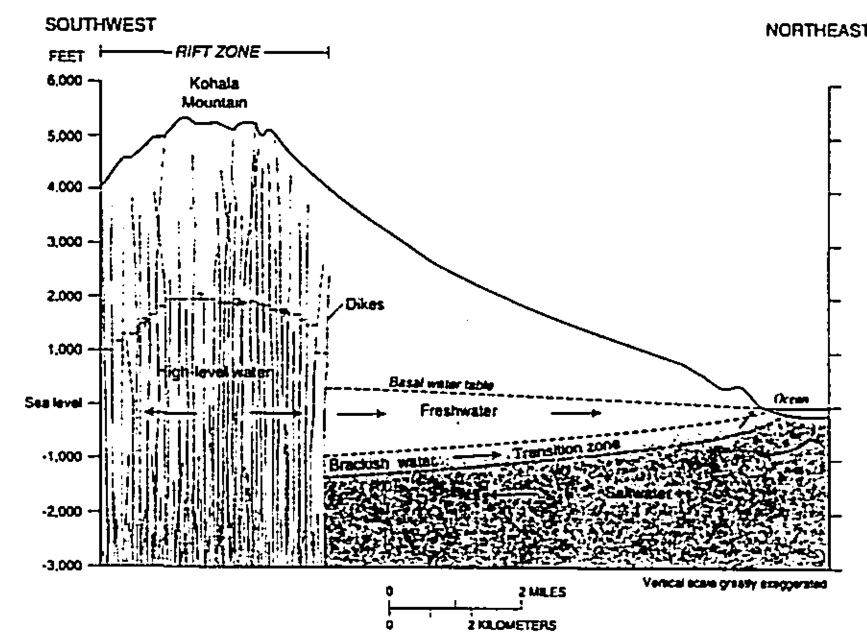


Figure 2. Generalized section of Kohala Mountain showing basal aquifer and direction of ground-water movement.

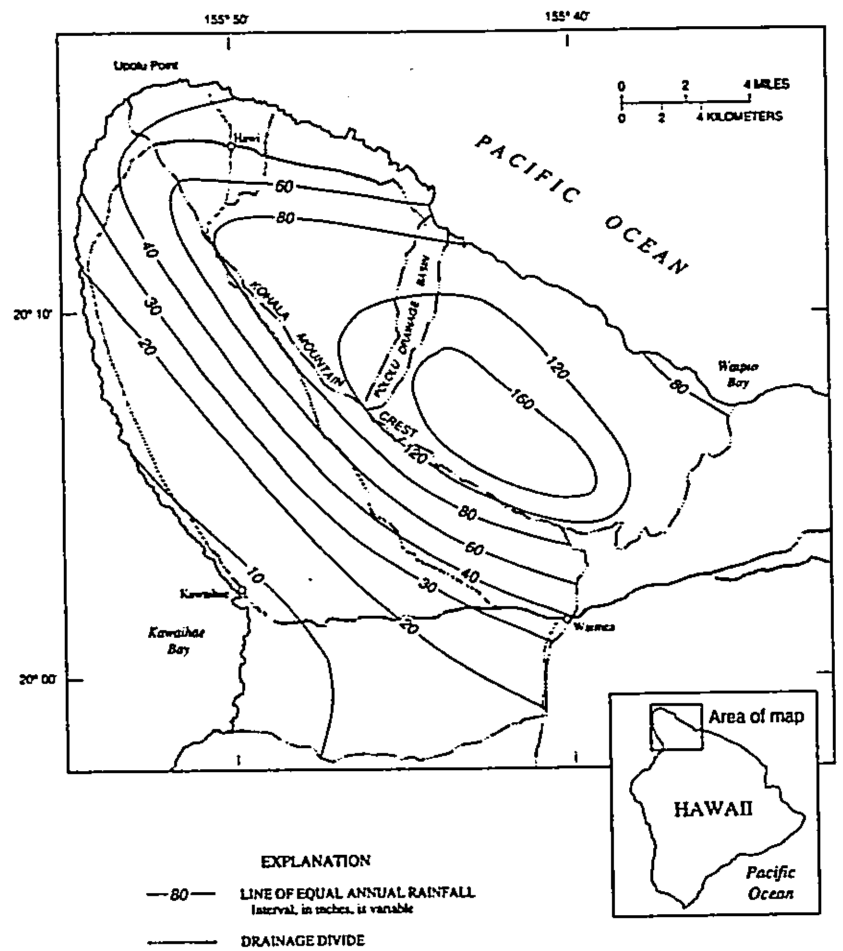


Figure 3. Mean annual rainfall, Kohala area, island of Hawaii (from Giambelluca and others, 1986).

to the basal aquifers. This information was provided in a study of ground-water recharge for the entire Kohala area by Shade (in press).

A program of test-well drilling was instituted in the Hawi basal aquifer to obtain information on geology, water levels, water quality, and vertical extent of freshwater and the transition zone. A total of 12 test wells were drilled at eight locations at altitudes ranging from about 108 to 630 ft above sea level (see fig. 7). Aquifer tests were done at five locations to estimate the horizontal hydraulic conductivity of the aquifer. Using information on the distribution of recharge, vertical extent of freshwater, horizontal hydraulic conductivity, and geometry of the basal aquifer, a numerical model was constructed to simulate the movement of water into, through, and out of the basal aquifer.The model was then used to estimate the hydrologic feasibility of developing 20 Mgal/d of fresh ground water in addition to the existing use of 0.6 Mgal/d.

Previous Investigations

Early studies in the Kohala area focused on streamflow in the area southeast of Pololu Stream. During a 10-month period in 1890, Lydgate measured streamflow in Waipio Valley (Davis and Yamanaga, 1963). During a 5-month period in 1889 and 1890, Brunner (Davis and Yamanaga, 1963) measured flow in the 17 streams that are tributary to Honokane Nui Stream (fig. 4). In 1901 and 1902, Tuttle (Martin and Pierce, 1913) investigated water resources in the Honokane Nui and Waipio Valleys as well as regions southeast of Waipio Valley by collecting information on streamflow, springs, and wells. Systematic streamflow measurement in the Kohala area was begun in 1907. Since 1912, stream and irrigation discharge ditch data have been published annually by the USGS. Many of the stream and ditch measurements were discontinued when sugarcane production was halted in the early 1970's.

The geology and ground-water resources of the island of Hawaii were described by Stearns and Macdonald (1946) who also provided a conceptual model of the hydrologic system of the Kohala area. Hydrologic information provided by Stearns and Macdonald (1946) was updated by Davis and Yamanaga (1963). A thorough inventory of basic water resources and historical records was compiled by the State of Hawaii (1970).

A project by the Kohala Sugar Company in 1964 drilled five successful observation holes into the Hawi basal aquifer between Upolu Point and Pololu Stream (Bowles and others, 1974). A water-level map was drawn from the data obtained from these holes and from existing data from wells in the area. Bowles and others (1974) evaluated surface-water and ground-water resources in the Kohala area with a focus on the flow in the Kohala ditch (fig. 4). Using a simplified water budget and Darcy's law they estimated that 40 to 45 Mgal/d flowed through the Hawi aquifer; of that quantity, 30 to 35 Mgal/d (75 percent of flow through the system) was available for development.

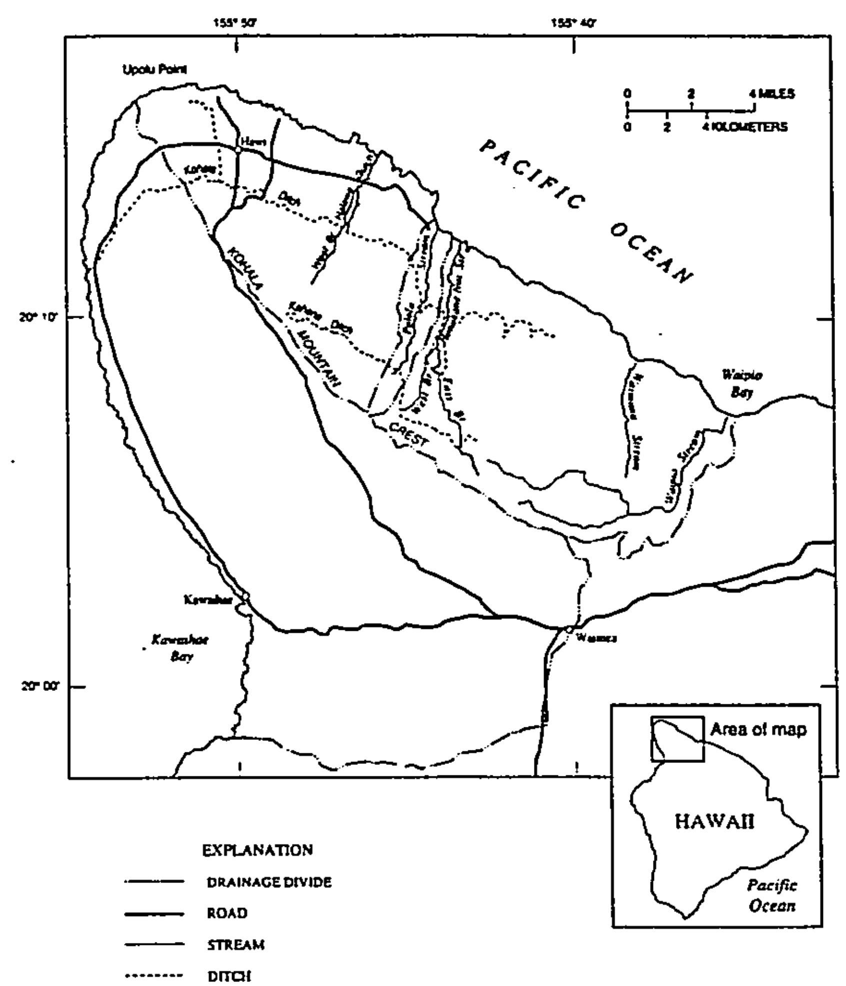


Figure 4. Streams, ditches, and tunnels in the Kohala area, island of Hawaii.

DESCRIPTION OF STUDY AREA

The Hawi basal aquifer is bounded along the southeast by the Pololu drainage divide and along the north and northwest by the Pacific Ocean. The southern and southwestern boundary is the rift zone along the crest of Kohala Mountain that extends from the summit toward the coast near Upolu Point (fig. 1). A slightly extended study area for modeling purposes included the continuation of the basal aquifer into the drainage area of Pololu Stream (fig. 4).

Altitude of the land surface on the Kohala Mountain increases gradually from sea level at the shoreline to 5,605 ft above sea level at the mountain summit (fig. 1). In general, the surface relief of the study area is moderately dissected. It is covered dominantly by pastures and orchards, with forests covering upland areas. Sugarcane was produced over much of this area from the early 1900's until the early 1970's. Two major irrigation ditches, Kohala and Kehena (fig. 4), were constructed in the early 1900's to transport water from the area east of Pololu Stream into the study area to support agriculture.

The Kohala ditch, constructed in 1901–02 by the Kohala Sugar Company, presently diverts water from the east branch of Honokane Nui Stream at an altitude of 2,000 ft. The ditch carries the water for 18 mi northwest, mostly as tunnel, toward Hawi where it delivers most of its water to the intake of a hydroelectric plant near Hawi (fig. 4). The ditch also captures minor flows from springs and streams west of Pololu Stream.

During 1928–60, median monthly flow rates in the Kohala ditch out of Honokane Nui Stream ranged from 21.9 to 31.9 Mgal/d (Bowles and others, 1974). Present flow rates are about 10 to 15 Mgal/d. Much of the decline in flow in recent years can be attributed to the loss of water previously derived from streams east of Honokane Nui Stream. At the hydroelectric plant at Hawi, the water released by the plant is injected into the basal aquifer through a holding pond into a row of five shallow injection wells located about 1.7 mi inland at about 520 ft altitude. Depths of these injection wells range from 160 to 240 ft altitude and lateral spacing between them is about 35 ft. The average rate of injection is about 8 Mgal/d.

The Kehena ditch diverts water from an intake at Honokane Nui Stream above the canyon rim at an altitude of about 4,200 ft (fig. 3) and carries the water westward for about 8 mi. Discharge measurements were made in the ditch from 1917 through 1919 and from 1928 through 1966. Average discharge in the ditch for these periods was 7.38 Mgal/d. In recent years the ditch has fallen into disrepair and does not flow continuously.

The extended study area, included for purposes of ground-water modeling, contains the Pololu Stream drainage area. As discussed by Stearns and Macdonald (1946, p. 228), the source of water in Pololu Stream is from springs in its canyon walls below the dike zone and Stearns and Macdonald have described these springs as perched. Pololu Stream is sufficiently entrenched near the ocean to presumably intersect the basal aquifer. If this occurs, the area near the mouth of the stream would be expected to gain water from the Waimanu basal aquifer.

The geohydrologic setting of that part of the Waimanu aquifer beyond Pololu Valley is highly complex and to some extent poorly understood. The work of Stearns and Macdonald (1946) remains the definitive report for the area, but even so, the extent of the high-level and basal aquifers and the relation between surface water and ground water is unclear. Stearns mapped numerous dikes and dike-associated springs and described an area of high-level water about 6 mi wide underlying the higher part of Kohala Mountain (Stearns and Macdonald, 1946, p. 228). This width would extend the high-level aquifer considerably into the Waimanu aquifer. Stearns' description, however, does not allow the extent of the high-level aquifer to be closely delineated. Ground water discharging from behind dikes causes streams to gain along their entire course to the ocean, indicating that most of the area may consist of high-level water. However, Stearns and Macdonald mapped much of the area as basal aquifer. Three streams, Pololu, Waimanu, and Waipio may intersect the basal aquifer near the ocean, but the other streams are hundreds to thousands of feet above sea level along their entire courses and discharge to the ocean from high cliffs.

GEOLOGY

Kohala Mountain was formed by volcanic rocks derived from the now-extinct Kohala Volcano. The mountain is composed mainly of basaltic and andesitic (Pololu Basalt and Hawi Volcanics, respectively) lavas that erupted from two main rift zones that trend N 35° W and S 65° E from Kohala summit. These rift zones are referred to as the northwest and southeast rift zones, respectively. The estimated location and orientation of the central part of the rift zones are shown in figure 5. The estimated outer margin of the rift zone in the Waimanu aquifer, on the basis of mapped dikes (Stearns and Macdonald, 1946, plate 1), is also shown (figs. 1 and 5). The southern flanks of Kohala Mountain merge with Mauna Kea Volcano and form a saddle that slopes toward the eastern and western coasts of the island of Hawaii.

Pololu Basalt.--The Pololu Basalt contains a thick sequence of basalt lava flows composed of hundreds of individual pahoehoe and aa lava flows that range from a few to 50 ft in thickness and dip from 3 to 10 degrees away from the rift area (Stearns and Macdonald, 1946, p. 174). The basal aquifer is contained within lava flows of the Pololu Basalt. Lavas of the Pololu Basalt make up most of Kohala Mountain above sea level, and, because of subsidence of the island, extend an unknown distance below sea level.

Most of the eruptive areas of the Pololu Basalt have been buried by later lava flows of the Hawi Volcanics. Typically the upper 50 to 200 ft of the Pololu Basalt is decomposed from weathering processes (Stearns and Macdonald, 1946, p. 174). Greater weathering occurred in the wet areas and where the rocks were not covered by the later flows. Intercalated soils greater than a few inches thick are rare below the upper part of the Pololu Basalt, indicating that periods of time between flows were short. Thin vitric ash beds can be found throughout the basalts but rarely on the windward slopes of Kohala Mountain (Stearns and Macdonald, 1946).

In general, the Pololu Basalt resembles the Koolau Basalt on Oahu, which forms aquifers with high transmissivities. The clinker areas on either side of aa flows have high horizontal hydraulic conductivities as do the interflow faces between pahoehoe flows, fractures, and cooling joints in the rock. Because these lavas are layered and nearly horizontal, horizontal hydraulic conductivity is likely to be greater than the vertical hydraulic conductivity. Aquifer tests and numerical studies in the Pearl Harbor aquifer of Oahu indicate that the greatest-to-least (horizontal-to-vertical) hydraulic conductivity ratios, or anisotropy ratios, are from 10:1 to 1,000:1. In an analysis of the Pearl Harbor aquifer, Souza and Voss (1989) estimated a ratio of horizontal to vertical hydraulic conductivity of 200:1.

Intrusive dikes cut the Pololu Basalt flows in the deep canyons on the northeast slope. Dikes trend N 50° to 80° W and dip about 75° northeast (Stearns and Macdonald, 1946, p. 175). Widths of Pololu dikes range from a few inches to 10 ft and average about 2 ft. Dike concentrations become greater with depth and closeness to the rift areas. Their dense composition, late-stage intrusion, and

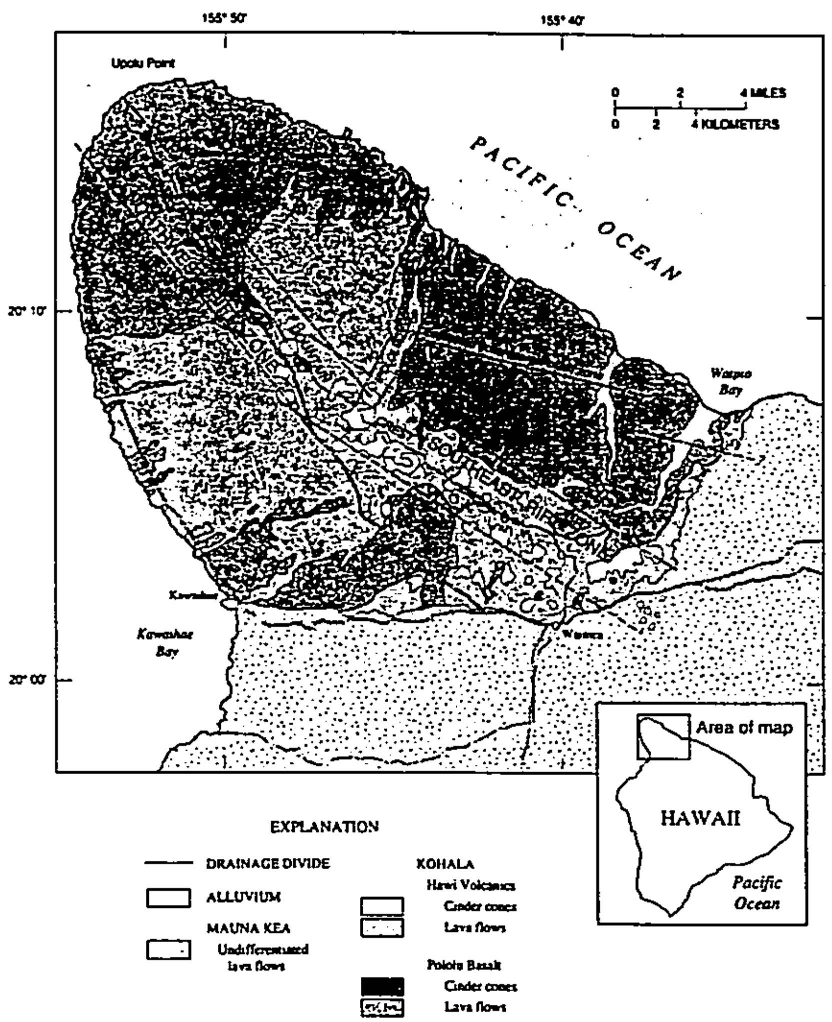


Figure 5. Surficial geology of the Kohala area, island of Hawaii (modified from Langenheim and Clague, 1987; and Stearns and Macdonald, 1946).

near-vertical emplacement give dikes relatively low horizontal hydraulic conductivity that impedes ground-water flow. On the basis of a description of the area between Pololu Stream and Waipio Stream (fig. 4) by Stearns and Macdonald (1946), the northern margin of the southeast rift zone, and the associated high-level water, may extend more than 4 mi from the summit area towards the ocean (fig. 5). As discussed, Stearns and Macdonald (1946) indicate a total width of about 6 mi for high-level water in the area of the Waimanu aquifer.

Hawi Volcanics.--The Hawi Volcanics form a cap over most of the rift zone and cover about a third of the northeast slope and about half of the southwest slope below the rift zone (fig. 5). Lava flows of the Hawi Volcanics were composed almost entirely of highly viscous aa that flowed onto the existing Pololu Basalt surface. An unconformity, that in places is marked by a red soil, exists between the Pololu Basalt and the overlying Hawi Volcanics. The red soil prevails on the southeastern slopes and indicates that most of the original topographic slopes were not eroded before being covered by lava flows of the Hawi Volcanics.

Only a few lava flows of the Hawi Volcanics extend to the coast. Thickness of individual lava flows range from 10 to 150 ft and average about 40 ft. In up-slope areas, flows overlap to reach a composite thickness as great as 500 ft near the summit. Many of the Hawi flows followed existing topography and filled the shallow canyons. Thin, ashy soils and gravel can be found between individual Hawi flows indicating longer periods of time between flows than in the Pololu Basalt. Soils that form on Hawi rocks are gray and can exceed 3 ft in thickness. These soils support agriculture when adequate moisture is present.

Alluvium.-- Alluvial deposits are found in the floors of the larger canyons on the windward side of Kohala Mountain (Stearns and Macdonald, 1946). These deposits consist of unconsolidated deposits of poorly sorted silts, sands, and boulders; landslide deposits characterized by blocks of volcanic rock in an earthy mix; and consolidated alluvium consisting of poorly sorted boulder conglomerates that form terraces in the lower stretches of the larger canyons and gulches. Stearns and Macdonald (1946, p. 172) indicate a thickness for the consolidated alluvium on the order of 500 ft and thickness of the unconsolidated deposits of about 25 ft. Both deposits are thought to be poorly permeable.

GROUND-WATER OCCURRENCE

The general movement of water in the Kohala area is from the mountainous areas toward the ocean. A schematic representation of this movement is shown in figure 2. In the mountainous areas, the movement of water is impeded by the presence of dikes within the rift zones. This impedance results in relatively high water levels in the rift zone that can be more than 2,000 ft above sea level (Stearns and Macdonald, 1946). Orientation of dikes is subparallel to the main orientation of the rift zone so that intersecting dikes are common and ground water is compartmentalized between the dikes. In Hawaii, this water is referred to as high-level water.

The water budget for the study area was estimated by Shade (in press). The major source of water to the basal part of the Hawi aquifer is from direct infiltration of precipitation. Recharge derived from this source is 53.1 Mgal/d on a mean annual basis. The movement of water into the basal aquifer from the adjacent rift zone constitutes another source of water that equals 6.9 Mgal/d on a mean annual basis. Mean annual recharge from infiltration of precipitation falling on the basal aquifer in the Pololu Stream drainage area is 7.2 Mgal/d and mean annual recharge to this aquifer from the rift zone above it is 1.2 Mgal/d. The actual rate of recharge at any point is dependent on the rate of precipitation minus water lost to evapotranspiration, direct runoff, and soil-moisture storage. Each of these factors varies from location to location. The areal distribution of ground-water recharge for the entire area is shown in figure 6.

A small amount of ground-water recharge is derived from water that infiltrates from the Kohala ditch. Discharge measurements made in the ditch during this study indicate a seepage loss ranging from 0.16 to 0.33 Mgal/d per mile with a total loss of about 2.0 Mgal/d in the study area. An additional source of recharge to the aquifer is derived from the injection of an estimated 8 Mgal/d at the Hawi hydroelectric plant.

Ground water moves out of the rift zone into the basal aquifer where the direction of ground-water motion is mainly horizontal. The altitudes of water levels in the basal aquifer measured on March 22, 1990 in the test wells drilled for this study ranged from a high of 11.3 ft above sea level to a low of 2.5 ft (fig. 7). Water levels higher than those shown in figure 7 would be expected inland toward the rift zone. As indicated by the water levels, there is a general northerly movement of water in the basal aquifer. Existing hydrologic conditions in the basal aquifer in terms of recharge to and discharge from the aquifer have not changed significantly for many years, indicating that water levels shown in figure 7 would represent equilibrium or near equilibrium conditions, although seasonal variations in water levels would be expected. Extensive agriculture and irrigation of crops ceased in the mid-1970's and water previously used for irrigation has been injected at the Hawi hydroelectric plant since about 1979. The only regularly pumped well in the basal aquifer is the DWS well. Production at this well (7449-02; see fig. 9) averages about 0.6 Mgal/d. Water levels were regularly measured in shaft 7652-01 from 1972 to 1995 and periodically measured in well 7347-02 (see fig. 9) from 1986 to February 1991 (fig. 8). This data supports the concept that equilibrium conditions exist in the aquifer.

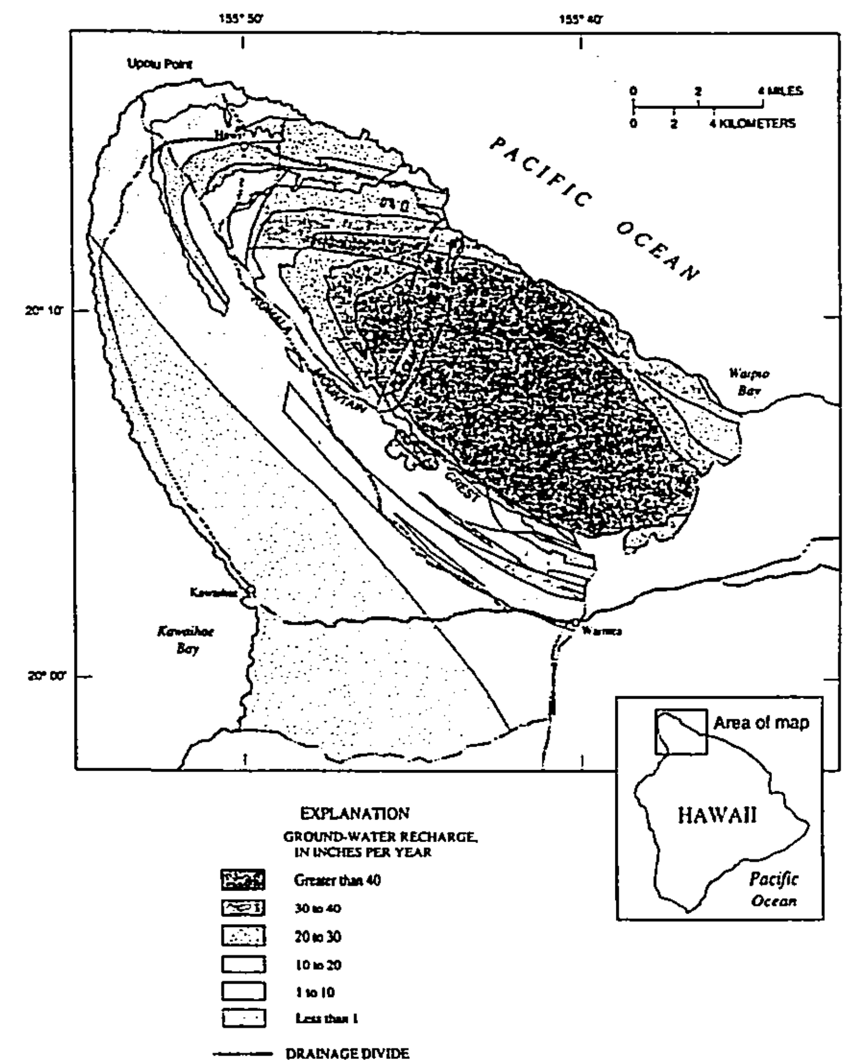


Figure 6. Ground-water recharge, Kohala area, Island of Hawaii (Shade, in press).

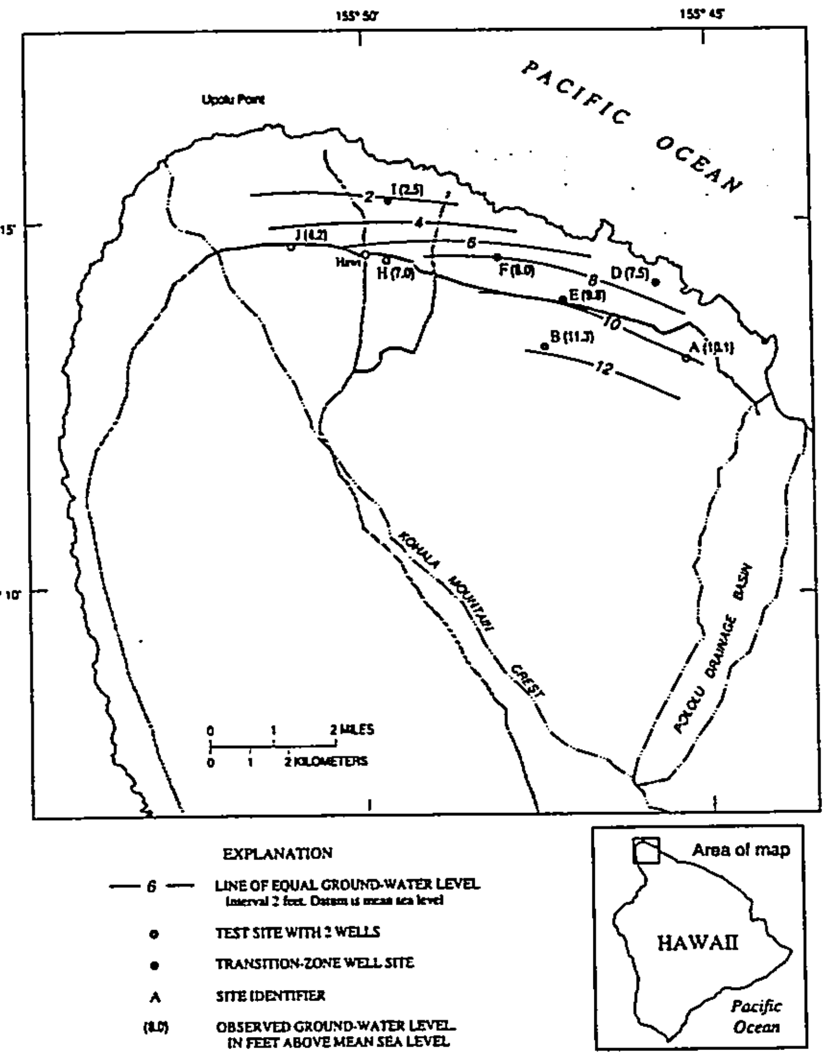


Figure 7. Observed ground-water levels in the Hawi basal aquifer and test-well sites, Kohala area, island of Hawaii.

Ground water discharges from the basal aquifer into the ocean and, near the shoreline, there is an upward component of ground-water flow. The upper 50 to 250 ft of the basaltic basal aquifer is largely decomposed by weathering, but it is not known if the weathered layer extends under the ocean. Waves along the coast may have eroded all or part of this layer. If a weathered layer exists, it would help impede the movement of ground water from the basal aquifer into the ocean because the hydraulic conductivity of weathered basalt is generally much lower than that of fresh basalt. Sedimentary deposits similar to those found along the shoreline of other islands in Hawaii are not present along the Kohala shoreline because of the relatively young age of the basalts in the area.

Springflow in the study area occurs primarily between 600 and 1,800 ft altitude and has been described by Stearns and Macdonald (1942) as perched water that, for the most part, issues from a clinker zone at the bottom of the Hawi Volcanics and above the red soil at the top of the Pololu Basalt.

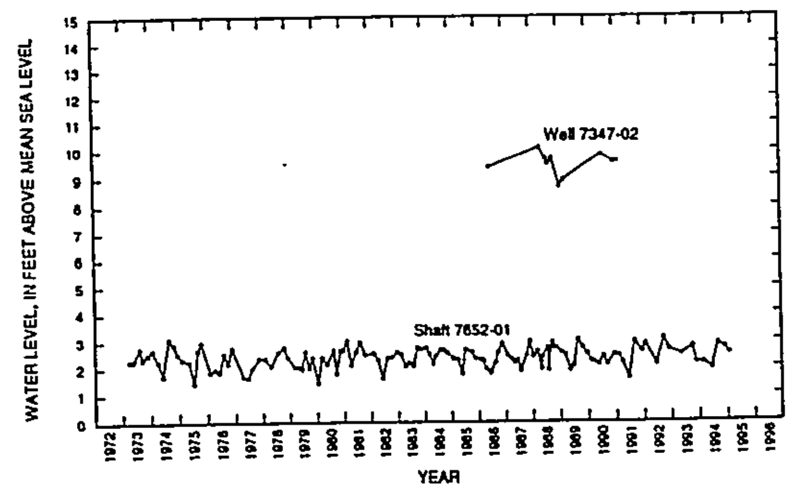


Figure 8. Water levels measured in well 7347-02 and shaft 7652-01, Kohala area, island of Hawaii.

Ground-Water Development

The locations of wells, shafts, and test holes constructed in the Hawi basal aquifer prior to this study are shown in figure 9. Altogether there are four wells, four shafts, and five test holes. With the exception of the DWS well (well 7449-02) near Hawi, all of the other wells, shafts, and test holes were drilled by sugar plantations. The first well (7448-01) was drilled in 1898 by the Kohala Sugar Company (State of Hawaii, 1970). Water from the well was used for sugar mill supply in 1901, but the well was ultimately abandoned (Davis and Yamanaga, 1963). Between 1899 and 1901 three shafts (Kohala, Alaalae, and Hoea) were sunk to sea level for water for sugarcane irrigation; a fourth shaft (Waikane) was constructed in 1920. Well 7347-02 was drilled in 1948 for domestic use and the Union Mill #1 well was drilled in 1965 with the intent of using the water for irrigating sugarcane. The wells were drilled at altitudes ranging from 310 to 540 ft. Finally, the five test holes described by Bowles and others (1974) were drilled in 1964. These holes were drilled at altitudes ranging from 170 to 362 ft. The shafts were constructed at low altitudes near the coast.

The present source of domestic water in the Kohala area comes primarily from the DWS well (0.6 Mgal/d) and three tunnel systems that have been dug to tap spring discharge: the Bond 1 tunnel, discharging at altitudes of about 1,000 ft and 1,400 ft; the Watt 1 tunnel, discharging at 1,700 and 1,800 ft; and the Murphy tunnel, discharging at about 1,250 ft. The greatest flows are from the Bond and Watt tunnel systems, which have discharges as large as 1.25 Mgal/d each. The Murphy tunnel discharges about 0.25 Mgal/d. The greatest untapped springflow is about 0.15 Mgal/d from the west branch of Halawa Gulch (fig. 4) (State of Hawaii, 1970). The total average flow for all tunnels and springs is 4 to 5 Mgal/d with a maximum total flow of 17 to 18 Mgal/d and a minimum total flow of about 1 Mgal/d (Stearns and Macdonald, 1946).

Sufficient data are not available to recreate the historical distribution and rates of ground-water development, although the general pattern of this development from 1940 to 1961 is discussed by Davis and Yamanaga (1963), and the pattern from 1962 through 1967 is available in State of Hawaii (1970). The following summarizes information in those two reports.

From 1940 through 1961 the average pumpage of ground-water from the aquifer was about 7.5 Mgal/d and most of the water was used to irrigate sugarcane (Davis and Yamanaga, 1963). The range in use during this time was 2.2 to 14.2 Mgal/d. Shaft pumpage from 1962 to 1967 was about 3.2 Mgal/d (State of Hawaii, 1970), about half of that from 1940 through 1961. Davis and Yamanaga (1963) indicated that chloride concentrations in one of the shafts averaged about 400 ppm and at another averaged about 1,500 ppm. Given that the shafts were constructed at low altitudes near the coast, and given their rate of pumpage, the relatively high chloride concentrations are to be expected. At the time of this study (1989-90) and as of 1995, the DWS well is the only well regularly pumped in the basal aquifer.

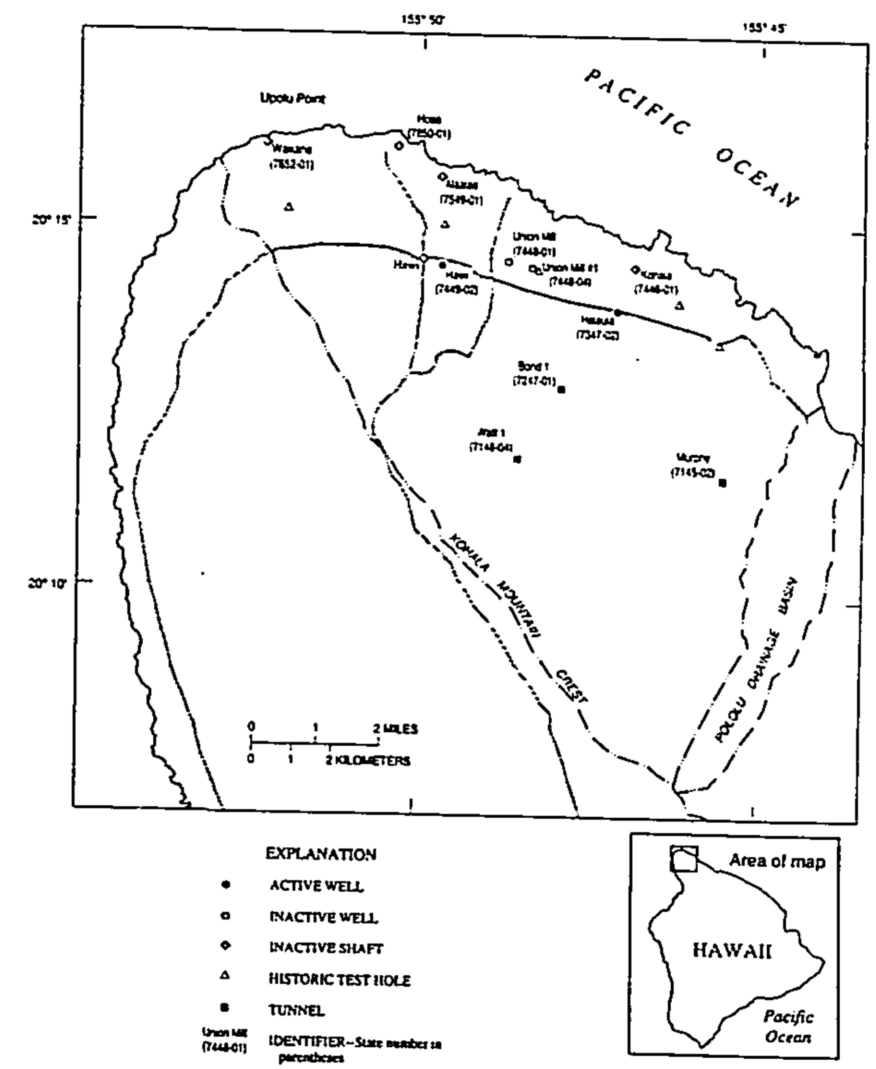


Figure 9. Locations of existing and historic wells, existing tunnels, and historic test holes in the Kohala area, Island of Hawaii.

Ground-Water Quality

The quality of water in the basal aquifer was investigated by analyzing water samples from five of the eight test-well sites (A, B, E, F, and H in fig. 7) for concentrations of common ions. Samples were analyzed at the U.S. Geological Survey Central Laboratory according to standard methods (Fishman and Friedman, 1989, Wershaw, and others, 1987). Results show that the ground water in Kohala is typical of water from Hawaiian basalt aquifers (Swain, 1973). Dissolved ion concentrations were low, with specific conductance values ranging from 165 to 245 µS/cm and chloride concentrations ranging from 19 to 36 mg/L (table 1).

At three sites (A, B, and F), water samples were also collected for analysis for 18 dissolved metals and as many as 79 organic compounds, including agricultural chemicals, volatile constituents of fuel, and solvents (table 2). No dissolved metals or organic compounds were found at concentrations exceeding maximum contaminant levels (U.S. Environmental Protection Agency, 1991).

Iron and aluminum were the metals found in highest concentrations, as might be expected given their abundance in basalt. Iron and aluminum may also have been released into the water samples from the iron well casing, metal pump, and aluminum discharge line. The other metals were either not detected or detected at low (10 µg/L or less, except for barium) concentrations that are typical of ground water from basalt aquifers (Halbig and others, 1986; Eyre, 1994).

Samples were free of significant anthropogenic organic compounds. The only organic compounds reported were from well A, where toluene and xylene were found at or near the level of detection (0.2 µg/L). This concentration is far below the USEPA limit of 1,000 µg/L (U.S. Environmental Protection Agency, 1991). Given these low levels, it is possible that the presence of these compounds was the result of sample contamination during collection, false detection in the laboratory, or possible local contamination of the water during well drilling. Further sampling at this location would be necessary to verify the existence of the compounds.

Table 1. Concentrations of common ions and other water-quality characteristics of water samples from the Hawi basal aquifer, Kohala area, island of Hawaii

[mg/L, milligrams per liter; µg/L, micrograms per liter; <, value shown is less than actual value; µS/cm, microsiemens per centimeter at 25 °C]

State well number	7345-04	7449-02	7347-02	7448-07	7347-05
USGS test well (fig. 7)	A	H	E	F	B
Latitude	20°13'07"N	20°14'28"N	20°13'52"N	20°14'28"N	20°13'19"N
Longitude	155°45'20"W	155°49'42"W	155°47'06"W	155°48'02"W	155°47'23"W
Date	7/7/89	8/4/89	8/15/89	8/31/89	10/20/89
Time (24 hour)	1530	800	1510	1300	1400
Altitude of land surface (feet)	396	541	342	415	628
Depth of well, total (feet)	480	591	510	429	720
Flow rate, instantaneous (gallons per minute)	900	475	1000	185	900
Specific conductance (µs/cm)	175	190	165	245	180
pH (standard units)	7	7.7	8	7.8	7.9
Temperature (°C)	21.5	22	22	24.5	22
Hardness, total (mg/L as $CaCO_3$)	56	44	45	58	47
Hardness noncarb. (mg/L as $CaCO_3$)	<1	<1	6	5	4
Calcium, dissolved (mg/L as Ca)	11	7.8	8.1	10	7.9
Magnesium, dissolved (mg/L as Mg)	6.9	5.9	6	7.9	6.5
Sodium, dissolved (mg/L as Na)	19	21	18	27	16
Potassium, dissolved (mg/L as K)	1.3	1.9	1.7	2.2	1.5
Alkalinity (mg/L as $CaCO_3$)	59	50	39	53	43
Sulfate, dissolved (mg/L as SO_4)	6	7	5	10	7
Chloride, dissolved (mg/L as Cl)	20	21	21	36	19
Fluoride, dissolved (mg/L as F)	0.1	<0.1	0.1	0.1	0.1
Silica, dissolved (mg/L as SiO_2)	37	51	41	44	44
Solids, sum of constituents, dissolved (mg/L)	138	148	18	174	133
Iron, dissolved (µg/L as Fe)	55	6	27	41	16
Manganese (µg/L as Mn)	<1	<1	1	6	<1

Table. 2. Concentrations of trace metal and organic compounds in water samples from the Hawi basal aquifer, Kohala area, island of Hawaii
[All values in micrograms per liter; <, actual value is less than value shown]

State well number	7345-04	7448-07	7347-05
USGS test site (fig. 7)	A	F	B
Date	7/7/89	8/31/89	10/20/89
Time	1530	1300	1400
Turbidity (NTU)	--	0.1	0.1
Dissolved metals			
Aluminum	130	10	<10
Arsenic	<1	<1	<1
Barium	100	<100	<100
Berylium	<10	<10	10
Cadmuim	<1	<1	<1
Chromium	2	1	1
Cobalt	1	1	1
Copper	4	4	2
Iron	180	50	40
Lead	2	4	1
Lithium	<10	<10	<10
Manganese	<10	<10	<10
Mercury	<0.1	0.1	<0.1
Molybdenum	<1	<1	<1
Nickel	6	<1	1
Selenium	<1	<1	<1
Silver	1	<1	<1
Zinc	<10	<10	<10
Organic compounds			
Alachlor	<0.1	<0.1	--
Aldrin	<0.01	<0.01	<0.01
Ametryne	<0.1	<0.1	--
Atrazine	<0.1	<0.1	--
Benzene	<0.2	<0.2	<0.2
Bromoform	<0.2	<0.2	<0.2
Carbontetrachloride	<0.2	<0.2	<0.2
Chlordane	<0.1	<0.1	<0.1
Chlorobenzene	<0.2	<0.2	<0.2
Chlorodibromomethane	<0.2	<0.2	<0.2
Chloroethane	<0.2	<0.2	<0.2
2-Chloroethylvinylether	<0.2	<0.2	<0.2
Chloroform	<0.2	<0.2	<0.2
Cyanazine	<0.1	<0.1	--
DDD	<0.01	<0.01	<0.01
DDE	<0.01	<0.01	<0.01
DDT	<0.01	<0.01	<0.01
DEF	--	<0.01	<0.01
Diazinon	<0.01	<0.01	<0.01
1,2-Dibromoethane	<0.2	<0.2	<0.2
Dichlorobromomethane	<0.2	<0.2	<0.2
1,2-Dichlorobenzene	<0.2	<0.2	<0.2
1,3-Dichlorobenzene	<0.2	<0.2	<0.2
1,4-Dichlorobenzene	<0.2	<0.2	<0.2
Dichlorodifluoromethane	<0.2	<0.2	<0.2
1, 2-Dichloroethane	<0.2	<0.2	<0.2
1,1-Dichloroethane	<0.2	<0.2	<0.2

Table. 2. Concentrations of trace metal and organic compounds in water samples from the Hawi basal aquifer, Kohala area, Island of Hawaii--Continued
[All values in micrograms per liter; <, actual value is less than value shown]

Organic compounds--continued			
1,2-Transdichloroethene	<0.2	<0.2	<0.2
1,1-Dichloroethylene	<0.2	<0.2	<0.2
1,2-Dichloropropane	<0.2	<0.2	<0.2
1,3-Dichloropropene	<0.2	<0.2	<0.2
cis-1,3-Dichloropropene	<0.2	<0.2	<0.2
trans-1,3-Dichloropropene	<0.2	<0.2	<0.2
Dieldrin	<0.01	<0.01	<0.01
DiSyston	--	<0.01	<0.01
Endosulfan	<0.01	<0.01	<0.01
Endrin	<0.01	<0.01	<0.01
Ethion	<0.01	<0.01	<0.01
Ethylbenzene	<0.2	<0.2	<0.2
Heptachlor	<0.01	<0.01	<0.01
Heptachlorepoxide	<0.01	<0.01	<0.01
Lindane	<0.01	<0.01	<0.01
Malathion	<0.01	<0.01	<0.01
Methoxychlor	<0.01	<0.01	<0.01
Methylbromide	<0.20	<0.2	<0.2
Methylchloride	<0.20	<0.2	<0.2
Methylenechloride	<0.20	<0.2	<0.2
Methylparathion	<0.01	<0.01	<0.01
Methyltrithion	<0.01	<0.01	<0.01
Metolachlor	<0.1	<0.1	--
Metribuzin	<0.1	<0.1	--
Mirex	<0.01	<0.01	<0.01
Naphthalenes, polychlorinated	<0.1	<0.1	--
Parathion	<0.01	<0.01	<0.01
PCB	<0.1	<0.1	<0.1
Perthane	<0.1	<0.1	<0.1
Phorate	--	<0.01	<0.01
Prometon	<0.1	<0.1	--
Prometryne	<0.1	<0.1	--
Propazine	<0.1	<0.1	--
Silvex	<0.01	<0.01	--
Simazine	<0.1	<0.1	--
Simetryne	<0.1	<0.1	--
Styrene	<0.2	<0.2	<0.2
1,1,2,2-Tetrachloroethane	<0.2	<0.2	<0.2
Trichloroethylene	<0.2	<0.2	<0.2
Toluene	0.3	<0.2	<0.2
Trithion	<0.01	<0.01	--
Toxaphene	<1	<1	<1
1,1,1-Trichloroethane	<0.2	<0.2	<0.2
1,1,2-Trichloroethane	<0.2	<0.2	<0.2
Tetrachloroethylene	<0.2	<0.2	<0.2
Trichlorofluoromethane	<0.2	<0.2	<0.2
Trifluralin	<0.1	<0.1	--
Vinylchloride	<0.2	<0.2	<0.2
Xylene	0.2	<0.2	<0.2
2,4-D	<0.01	<0.01	--
2,4-DP	<0.01	<0.01	--
2,4,5-T	<0.01	<0.01	--

Vertical Extent of Freshwater

Saltwater underlies freshwater in the basal aquifer. When water is pumped from the basal aquifer, the lowering of ground-water levels associated with pumping will result in an upward movement of the saltwater. Ultimately, the amount of water that can be developed from the basal aquifer is constrained by the salinity of the water. To address the constraint on ground-water availability imposed by salinity, two wells (D and I, fig. 7) were designed to measure the vertical extent of freshwater and the upper part of the transition zone. Observation well D, located about 0.4 mi from the coast at an altitude of 108.5 ft, was completed at a depth of 351 ft below sea level. Observation well I, located about 0.7 mi from the coast at an altitude of 299.5 ft, was completed at a depth of 137 ft below sea level. The wells were open to the aquifer below the water table.

To estimate the thickness of freshwater and the upper transition zone, water samples were collected in March 1990 from several depths in each well and analyzed for chloride concentration (an indicator of salinity) (fig. 10). For this report, freshwater is defined as ground water containing water with a chloride concentration less than 250 mg/L (U.S. Environmental Protection Agency, 1991). Seawater collected around the Hawaiian islands has a chloride concentration of about 19,600 mg/L (Wentworth, 1939). The change in salinity between freshwater and seawater at depth is not abrupt, rather, freshwater and seawater mix and the change is somewhat gradual through a transition zone. The entire transition zone from freshwater to seawater includes all water with a chloride concentration between 250 mg/L and about 19,600 mg/L.

Through the transition zone, the density of the mixed water also varies from that of freshwater (about 1.000 gm/cm^3) to that of seawater (about 1.025 gm/cm^3). On the basis of this density difference, freshwater may be assumed to extend below sea level to a depth 40 times the water level above sea level. This is referred to as the Ghyben-Herzberg relation (Bear, 1979, p. 560). In practice, the depth defined by the Ghyben-Herzberg relation approximates the mid-point of the transition zone (Lau, 1962). The mid-point of the transition zone is at a chloride concentration of about 9,800 mg/L. Thus, the upper transition zone includes water with a chloride concentration between 250 and 9,800 mg/L.

In well D, the depth to a chloride concentration of 250 mg/L and thus the estimated thickness of freshwater is about 265 ft. The depth of the mid-point of the transition zone was about 345 ft below the water table, making the upper transition zone about 80 ft thick (fig. 10). In well I, the depth to a chloride concentration of 250 mg/L and thus the estimated thickness of freshwater is about 83 ft. No water samples were obtained at or below the mid-point of the transition zone in well I. On the basis of an extrapolation of the existing data, the depth of the mid-point of the transition zone was about 145 ft below the water table, making the thickness of the upper transition zone about 62 ft (fig. 10).

The preceding analysis is based on the assumption that the salinity profiles logged in the wells are representative of the salinity of water in the surrounding aquifer. However, each well is

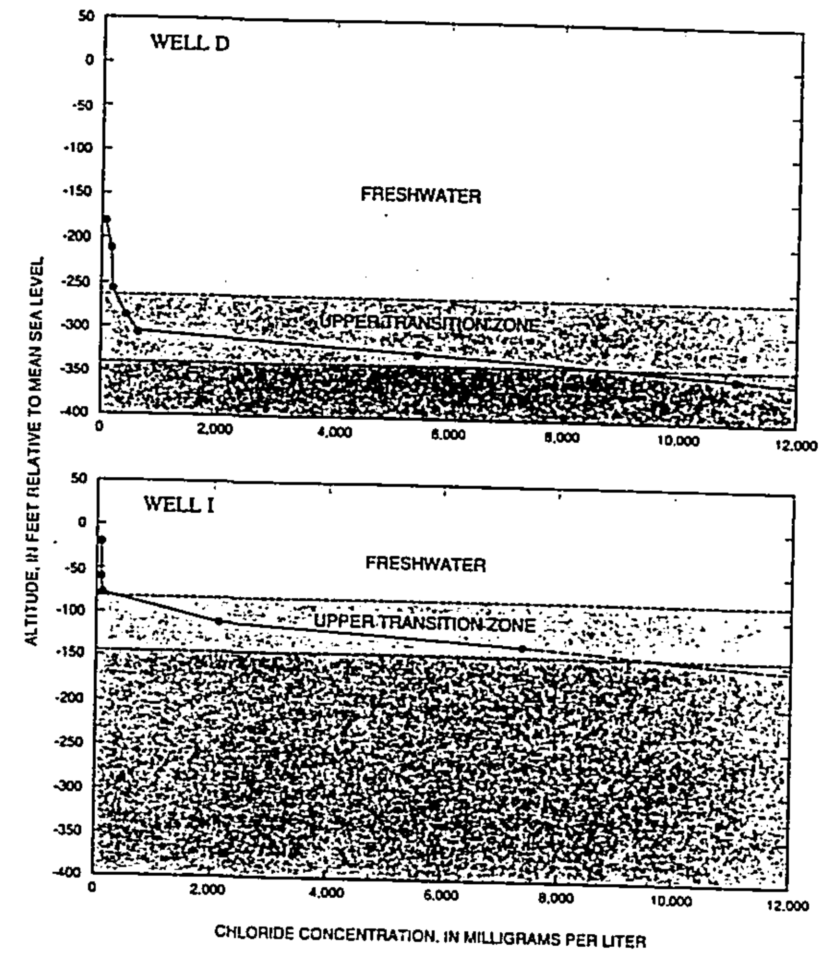


Figure 10. Chloride concentrations and depth for test wells D and I, Kona area, island of Hawaii.

open to the aquifer for the entire depth below the water table, providing an open conduit through the pre-existing aquifer layers. If vertical hydraulic gradients exist in the aquifer, water will flow vertically within the well bore, entering from aquifer zones with greater hydraulic head and exiting to zones with lesser head. If ground-water flow in the aquifer is predominantly horizontal and vertical flow in the well bore is inconsequential, the salinity profile in the well can be expected to correspond closely to the salinity profile in the aquifer. However, vertical flow in the well could be of sufficient magnitude to distort the salinity profile and thickness of the transition zone in the well bore from that in the aquifer.

Test wells D and I are located between 0.4 and 0.7 mi from the shore, and here the dominant direction of ground-water movement is expected to be horizontal. As a result, vertical flow in the aquifer, and thus in the test wells would not be significant. If vertical flow does occur, it would most likely be upward because of the wells proximity to the shoreline where freshwater begins to discharge upward into the ocean. Upward flow within the well bore would tend to bring saltwater to higher altitudes in the well bore than exist in the aquifer. Accordingly, the salinity profile as logged in the well bore would be displaced upward by some unknown amount. Thus the well bore salinity profile would indicate that the top of the transition zone is shallower than it actually is in the aquifer.

HYDRAULIC CONDUCTIVITY OF THE BASAL AQUIFER

Estimates of the horizontal hydraulic conductivity of the basal aquifer were obtained from aquifer tests at five wells: A, E, F, H, and Union Mill #1 (fig. 11). Aquifer tests were done in wells drilled during the present study, and also in several wells drilled prior to this study. Similarly, aquifer-test data were mostly from tests done during the present study but also from data from several earlier tests (not done by USGS) that were reanalyzed as part of this study. A summary of well characteristics is shown in table 3.

Each test site consisted of a pumped well and an observation well. Each observation well was installed so that the depth of penetration into the aquifer was about the same as that of the corresponding pumped well. None of the wells fully penetrated the aquifer, the thickness of which is unknown. For an aquifer test, it is desirable to have the deepest possible well penetration that allows sufficient withdrawal without inducing an unacceptable saltwater upconing. As a result, the penetration of each pumped well drilled for this study is about one third of the estimated freshwater thickness, as approximated from the Ghyben-Herzberg relation. By avoiding the withdrawal of salty or brackish water, the complicating effects of variable-density fluid flow on hydraulic analysis were avoided.

Two types of aquifer tests were done at each site: a step-drawdown test and a 12-hour continuous pumping-rate test. The step-drawdown test involved measuring the drawdown induced in the pumped well at each of three to five successively higher pumping rates. Each step lasted about 1 hour. The sustained 12-hour test involved pumping the well at a steady rate for 12 hours and measuring the drawdown induced in both the pumped and the observation well over this time. Tests done during this study included step-drawdown tests at sites A, E, and F, and sustained pumping tests at site A, E, F, and H. Earlier tests included a step-drawdown test done in 1975 at site H by the County of Hawaii Department of Water Supply (unpub. data in files of U.S. Geological Survey, Honolulu), and a step-drawdown test and a sustained pumping test at Union Mill #1 in 1964 (Akinaka and others, 1975).

The step-drawdown data were analyzed to estimate the two components of drawdown in the pumped well: (1) the hydraulic head loss in the aquifer, (2) the hydraulic head loss from friction and turbulence within and near the well column, and (3) well entrance losses at the screen. An empirical relation between drawdown and pumping rate developed by Jacob (1947) allows a well efficiency at a desired pumping rate to be calculated. The measured drawdown in the well is then adjusted on the basis of the efficiency, and the resulting value represents the drawdown due only to hydraulic head loss in the aquifer. This adjusted value of drawdown is then used in subsequent equations of aquifer analysis.

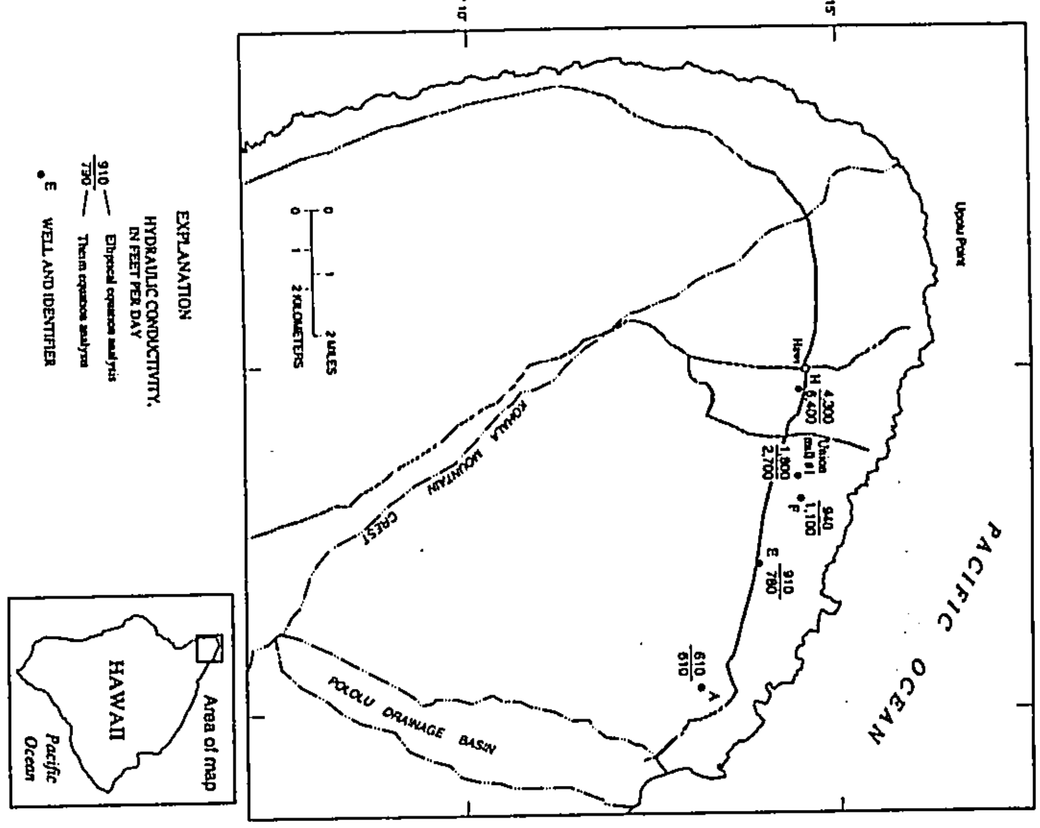


Figure 11. Aquifer-test values for horizontal hydraulic conductivity, Kohala area, island of Hawaii.

Table 3. Summary of characteristics of wells used for exploration and aquifer testing of the Hawi basal aquifer, Kohala area, island of Hawaii

[Includes exploratory wells drilled for this study and pre-existing wells used in the aquifer tests. Well number refers to the State of Hawaii numbering system. "Test pumping" wells were pumped during aquifer tests only and are not permanent withdrawal wells; --, no data]

Test site or well (figs. 7 and 11)	State well number	Well use	Land surface altitude (feet)	Depth drilled (feet)	Water-table altitude (feet)	Altitude of open interval (feet)	Type of open interval
A	7345-03	observation (water level)	395.3	440	10.2	175 to -45	open hole
A	7345-04	test pumping	395.9	495	10.3	-44 to -99	open hole
B	7347-04	observation (water level)	630.4	730	11.4	530 to -100	open hole
B	7347-05	test pumping	628.2	720	11.4	18 to -102	perforated steel/open hole
D	7445-01	observation (salinity profile)	108.5	460	7.5	74 to -352	open hole
E	7847-02	withdrawal	344	505	--	-8 to -161	open hole
E	7347-03	observation (water level)	340.5	405	9.8	261 to -64	open hole
F	7448-06	observation (water level)	411.6	440	8.0	289 to -28	open hole
F	7448-07	test pumping	414.8	429	8.1	8 to -22	steel perforated
H	7449-02	withdrawal	541.4	591	--	7 to -50	perforated steel/open hole
H	7449-03	observation (water level)	541.2	585	7.0	451 to -44	open hole
I	7549-03	observation (salinity profile)	299.5	436	2.3	169 to -137	open hole
J	7451-01	observation (water level)	566.6	632	4.2	467 to -65	open hole
J	7451-02	test pumping	566.8	632	4.8	7 to -65	perforated steel/open hole
Union Mill #1	7448-03	observation (water level)	306.3	402	4.9	306 to -96	open hole
Union Mill #1	7448-04	withdrawal	312	412	--	0 to -100	perforated steel/open hole

The adjusted drawdown data from the step-drawdown test were then analyzed using equation 1 (Harr, 1962; Polubarinova-Kochina, 1962):

$$K = \frac{Q \ln\left(1.6\frac{L}{r_w}\right)}{2\pi L s_w} \quad (1)$$

where: K is horizontal hydraulic conductivity, in feet per day;
Q is pumping rate, in cubic feet per day;
ln is natural logarithm (base e = 2.718);
L is length of the open interval of the well, in feet;
π is the number pi, equal to 3.1415;
r_w is radius of the well, in feet; and
s_w is drawdown in the pumped well, in feet, adjusted for well loss.

Equation 1 describes steady-state flow to a pumped well that partially penetrates an aquifer that is much thicker than the depth of the well, a condition met by the wells in this study. The geometry of flow is such that lines of equal drawdown in the aquifer take the shape of ellipses; thus the equation is referred to herein as the elliptical equation. This equation was solved for values of K using drawdown data from the step-drawdown tests, adjusted for well loss as described above.

Drawdown data from the 12-hour sustained pumping-rate tests were analyzed by the Thiem equation, which assumes steady, radial flow and requires measurements of drawdown in two observation wells. Differences in well construction required use of both the confined and unconfined forms of the Thiem equation (Todd, 1980):

$$K = \frac{Q \ln\left(\frac{r_2}{r_1}\right)}{2\pi b (s_1 - s_2)} \text{ (confined);} \quad (2)$$

and:

$$K = \frac{Q \ln\left(\frac{r_2}{r_1}\right)}{\pi (h_2^2 - h_1^2)} \text{ (unconfined),} \quad (3)$$

where: K is horizontal hydraulic conductivity, in feet per day;
Q is pumping rate, in cubic feet per day;
ln is natural logarithm (base e = 2.718);
r_1 is radial distance to observation well 1 (closer to the pumped well), in feet;
r_2 is radial distance to observation well 2, in feet;
π is the number pi, equal to 3.1415;
b is aquifer thickness, in feet;

s_1 is drawdown in observation well 1, in feet;
s_2 is drawdown in observation well 2, in feet;
h_1 is thickness of flow at observation well 1, in feet; and
h_2 is thickness of flow at observation well 2, in feet.

Several qualifications regarding application of the Thiem equation are pertinent. First, the pumped well was considered to be observation well 1, and the radius of the pumped well and the adjusted drawdown (computed from the step-drawdown analysis) were used. Next, because the thickness of the aquifer in the Kohala area is unknown, the submerged open length of the pumped well was substituted for aquifer thickness, b (flow is presumed to be horizontal and radial within the depth interval corresponding to the open length of the pumped well). The confined form of the Thiem equation was used for sites E, H, and Union Mill #1, sites where there was no drawdown-induced dewatering of the pumped interval because solid casings in the pumped wells extend below the level of drawdown. The unconfined form of the Thiem equation was used for sites A and F, sites where the pumped wells are open at the water table and drawdown caused dewatering of the pumped interval. Here, drawdown was subtracted from the pre-pumping submerged open length of the well to obtain the thickness of flow, h. Lastly, the Thiem equation assumes that steady-state, or equilibrium, flow has been attained. Typically, this constraint is closely approximated within a few hours in the permeable lavas of Hawaii at the short radial distances of these tests. Also relevant is the work of Bennett and others (1967), who conducted pumping tests in the Punjab region of West Pakistan. Using drawdown measurements in observation wells both within and outside the pumping interval, they demonstrated that the slope of the cone of depression within a few hundred feet of the pumped well stabilized after a few hours of pumping even though the cone of depression continued to expand. It was concluded that the flow to the pumped well was dominantly horizontal within the depth range of the open interval of the pumped well at radial distances of a few open-interval lengths, once the hydraulic gradient stabilized within this region. Consequently, the Thiem equation could be used to analyze this data.

Values of hydraulic conductivity(K) obtained from the aquifer tests ranged from 610 to 6,400 ft/day (table 4, fig. 11). Differences between values obtained by the two analytical methods at a given site ranged from 0 to 44 percent of the mean of the two values. Within the area of the tests (fig. 11), hydraulic conductivity seems to increase progressively in the northwest direction.

Table 4. Summary of aquifer-test data and results, Kohala area, Island of Hawaii

[ft/d, feet per day; r, radius from center of pumped well; K, horizontal hydraulic conductivity of aquifer]

Test well site or well (fig. 11)	Pumped well	Length of pumping interval (feet)	Distance at observation well from pumped well (feet)	Step drawdown test: Number of steps	Step drawdown test: K, calculated using elliptical equation (ft/d)	Sustained pumping test: Pumping rate, Q (gal/min)	Sustained pumping test: Duration of pumping (hours)	Drawdown (feet): Observed in pumped well	Drawdown (feet): Adjusted in pumped well	Drawdown (feet): Observed in observation well	K, calculated using Theis equation, (ft/d)
A	7345-04	55	50	6	610	900	71	14.5	4.5	0.29	610
B	7347-02	153	40	5	910	1,240	14	7.5	1.6	0.31	780
F	7448-07	22	50	4	940	400	16	--	2.6	0.13	1,100
H	7449-02	57	55	4[a]	4,300	495	72	3.1	0.32	0.13	6,400
Union Mill #1[b]	7448-04	100	73	3	1,800	2,000	365	8.7	1.9	0.8	2,700
				$K_{average}$	1,700				$K_{average}$		2,300
				K_{median}	940				K_{median}		1,100

[a] Step-drawdown test was done at time of completion of well construction in 1975; data reported by Hawaii County Department of Water Supply (1975).
[b] Union mill #1 aquifer tests were done in 1965-66; data used in analysis reported in Akinaka and others (1975).

NUMERICAL SIMULATION OF THE BASAL AQUIFER

Ground-water flow in the basal aquifer was simulated using the two-dimensional areal ground-water model AQUIFEM-SALT (Voss, 1984), which is a finite-element numerical model that simulates an aquifer containing freshwater that floats on saltwater of greater density. The model simulates water-levels and movement of the freshwater only. The saltwater is assumed not to flow and to have a hydrostatic pressure distribution. It is assumed that the boundary between the freshwater and saltwater is a sharp interface and that the two waters do not mix. It is further assumed that the location of the interface in the model represents the mid-point of the transition zone of the aquifer. The position of the interface in the model is determined so that the hydrostatic pressure in both freshwater and saltwater are equal on both sides of the interface.

Description of the Model

Boundary conditions.--The inland extent of the basal aquifer terminates at the rift zones of Kohala Mountain. Although water moves through the rift zone into the basal aquifer, hydraulic conductivity of the dikes in the rift zone is orders of magnitude less than that of the basal aquifer. As a result, the rift zone was not included as part of the modeled area, but the discharge of water from it into the basal aquifer was accounted for in the model by specifying additional recharge to the model elements adjacent to the rift zone (fig. 12).

Discharge of ground water along the shoreline of the modeled area is simulated using a head-dependent flux boundary. Ground-water discharge into the ocean through the ocean floor occurs in model elements along of the shoreline (fig. 12). Such discharge occurs because there is a hydraulic connection between the basal aquifer and the ocean, and the freshwater head in the aquifer is higher than the head at the ocean floor. The rate at which water discharges is controlled by the difference between the freshwater head in the aquifer, the equivalent freshwater head at the ocean floor, and the thickness and vertical hydraulic conductivity of the basalt and the weathered zones in the basalt, if the latter exist on the ocean floor.

The model was extended beyond the primary study area to include the entire Pololu drainage area, because simulated pumpage in the Hawi basal aquifer was close to this area and drawdowns induced by pumping would be expected to extend into it and possibly beyond it. Because the geohydrologic setting of the area east of Pololu Stream is highly complex and not completely understood, the model was not extended into this area. Given the lack of detailed knowledge concerning the relation between the Waimanu basal aquifer and Pololu Stream, the stream was not simulated on the model. Model-simulated drawdowns at the mouth of Pololu Stream resulting from pumping 20 Mgal/d in the Hawi basal aquifer are discussed, however, in order to qualitatively evaluate the possible effect of pumping on this stream.

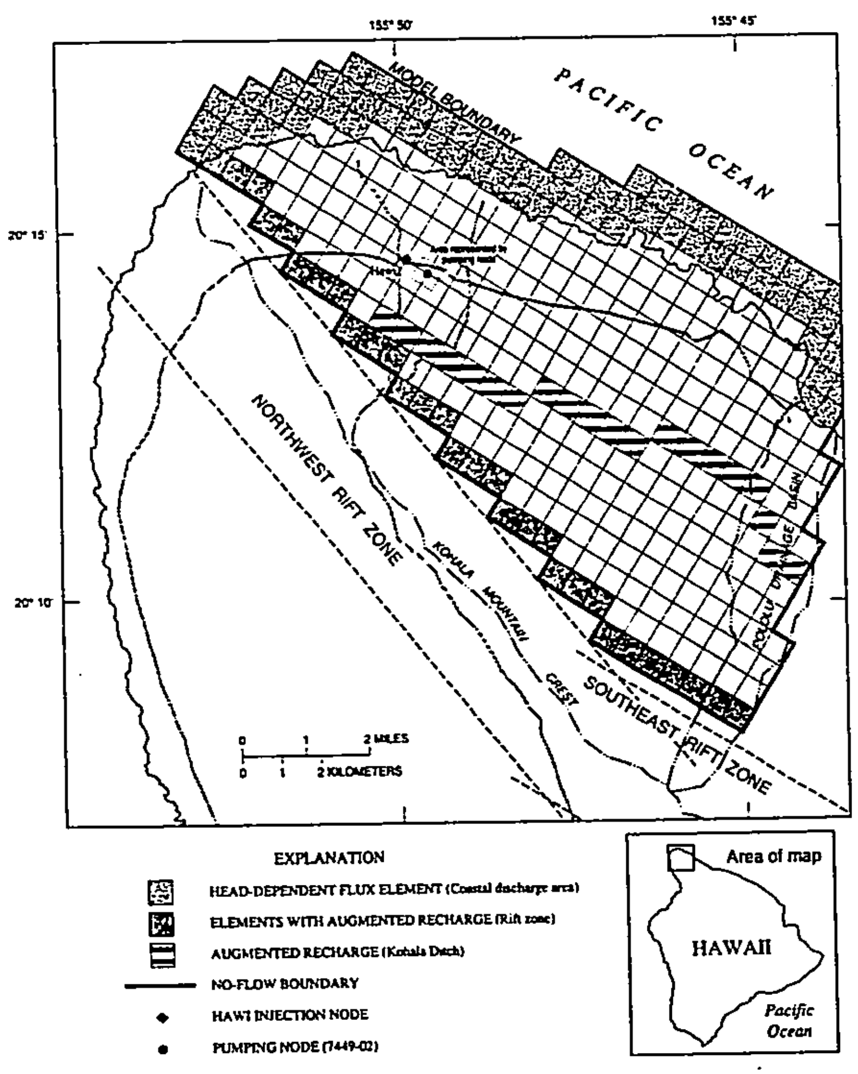


Figure 12. Model grid and boundaries used in the numerical simulation, Kohala area, island of Hawaii.

The basal aquifer is made up of hundreds of thin permeable lava flows that, because of subsidence of the island, now extend from the land surface to well below sea level. The depth of the bottom of the aquifer is not known. However, it is likely that the permeable lava flows extend several thousand feet below sea level because most Hawaiian volcanoes have subsided 6,000 to 12,000 ft (Moore, 1987). As a result, the model uses a single layer with a total thickness of 3,000 ft. This is not to indicate that freshwater extends to this depth. This depth represents only the estimated depth of permeable rock and conceptually, the total aquifer thickness includes both freshwater and saltwater. In the model, however, freshwater flows only in the interval between the water table and the freshwater-saltwater interface. The freshwater-saltwater interface as calculated by the model defines the bottom of the aquifer and is a no-flow boundary at a depth that is a function only of the local head in the aquifer.

Recharge.--Water is input into the model as ground-water recharge distributed areally over the modeled area using the distribution of mean annual recharge rates estimated by Shade (in press). Total recharge to the model is 78.4 Mgal/d. Recharge to the model from direct infiltration of rainfall on the basal aquifer, 60.3 Mgal/d, was distributed on the basis of values shown in figure 6. Recharge to the basal aquifer derived from that part of the rift zone between the topographic divide at the crest of Kohala Mountain and the boundary of the modeled area (8.1 Mgal/d) is accounted for by augmenting the recharge in the elements along the model boundary adjacent to the rift zone (fig. 12). Recharge to the basal aquifer from the Hawi hydroelectric plant injection wells (8 Mgal/d) was simulated as a constant flux to the model node where the injection wells are located. The estimated seepage loss from Kohala ditch (2 Mgal/d) was modeled as augmented recharge in elements along the ditch (fig. 12).

Ground-water pumpage.--The withdrawal of ground water at the DWS well (7449-02) was simulated as a constant rate of withdrawal equal to 0.6 Mgal/d. The location of the pumping node is shown in figure 12.

Hydraulic conductivity.--Values of hydraulic conductivity of the basal aquifer calculated during this study provided a range from 610 to 6,400 ft/d (table 4). The average value of hydraulic conductivity calculated from the aquifer test using the Thiem method is 2,300 ft/d; the median value is 1,100 ft/d. However, among the aquifer-test sites, higher values of hydraulic conductivity were obtained in the northwestern part of the basal aquifer than in the southeastern part (fig. 11). This variability was investigated and is discussed in the calibration section of the report. The hydraulic properties of the basal aquifer in Pololu Valley are not known, so that the hydraulic properties of the basal aquifer in this area were assumed to be the same as the southeastern part of the Hawi basal aquifer. In addition it is possible that the regular, tabular structure of basalt lava flows may cause the hydraulic conductivity to be greater along the lava flow direction than across it, making the aquifer areally anisotropic.

Shoreline discharge.—One of the most important considerations in boundary conditions is the nature of the discharge of freshwater from the basalt aquifer through the ocean floor. This discharge is impeded because, near the shoreline, ground-water movement is predominantly vertically upward and across the layering of the basalt flows. There is resistance to vertical movement because the freshwater must flow through the dense, less permeable interior part of individual lava flows. There would be additional resistance to vertical movement if the basalt layers are weathered or there are ocean bottom sediments overlying the basalt. Also, freshwater must discharge against the saltwater head at the ocean floor. In the model, the saltwater head would be expressed as an equivalent freshwater head, $h_f = (1.025z - z)$ for z equal to the depth below sea level to the ocean floor. Because AQUIFEM-SALT does not distinguish between freshwater and saltwater, the model will use the ocean as a source of freshwater to the aquifer if the calculated freshwater equivalent head at the ocean floor in the discharge area of the model (fig. 12) exceeds the head in the underlying basalt aquifer. To avoid this, the freshwater equivalent head of the ocean was set to zero in the discharge area. Thus, in any simulation, the aquifer head would be greater than the head at the modeled discharge area. The effect on the simulation is a small error in the simulated hydraulic connection between the ocean and the basal aquifer. This error would tend to make the model overestimate water-level declines associated with pumpage and thus make the model more conservative when estimating ground-water availability.

Near the shoreline, ground water moves upward from the basal aquifer to discharge into the ocean. This movement is resisted by the vertical hydraulic conductivity (K') of the basalts and by the weathered zone at the top of the basalt if it exists. Discharge is proportional to the effective vertical hydraulic conductivity of the basalt and weathered zone (assuming it exists) divided by the thickness of the zone of discharge (m'). As discussed previously, the vertical hydraulic conductivity of basalts in Hawaii is assumed to fall within a range of about one tenth to one thousandth of the horizontal hydraulic conductivity. On the basis of results of the aquifer tests for the Hawi basal aquifer, this would result in a range of values for the vertical hydraulic conductivity of the basalt between 0.6 to 640 ft/d. The thickness of the zone of discharge can be approximated by estimating the freshwater thickness at the shoreline. Water levels near the shoreline are about 5 ft, indicating a freshwater thickness of about 200 ft. For modeling purposes, it can be assumed the vertical distance over which discharge occurs is one-half this distance, or 100 ft. Assuming that the weathered zone does not exist, the value for K'/m' would fall between 0.006 and 6.4 ft/d/d (d^{-1}). The ratio K'/m' is referred to as the hydraulic connection between the basal aquifer and the ocean.

The model was calibrated by comparison of model-calculated water levels with water levels measured in the basal aquifer at the test wells (fig. 7) on March 22, 1990. Two parameters were varied during the calibration procedure: the horizontal hydraulic conductivity, K, of the basal aquifer, and the hydraulic connection of the basal aquifer with the ocean (K'/m'). Despite being varied, the simulated values for the horizontal hydraulic conductivity of the aquifer were kept within the general range of values obtained from the aquifer tests and ultimately varied spatially in the same manner as indicated by the test results. Thus, the major uncertainty in modeled parameters was the hydraulic connection of the aquifer with the ocean.

The first step in the calibration analysis was to make a series of simulations where the simulated K was held constant while the simulated value of K'/m' was varied over a range from 0.0005 to 10.0 ft/d/ft. The model was run to steady state for each value of K'/m', and the values of model-calculated water levels at the test wells were recorded. Three sets of simulations were made using simulated values for K of 500; 1,000; and 5,000 ft/d. Results of this series of simulations are shown in figure 13.

The relation between the model-calculated water levels and water levels observed at the test wells varied spatially, falling into two groups (fig. 13). The plot of model-calculated water levels compared with the simulated value of K'/m' shown for test well E (fig. 13) is representative for wells E, A B, D, and F, all of which are located in the eastern part of the basal aquifer. A similar plot for test well H (fig. 13) is representative for wells H, I, and J, all of which are in the western part of the basal aquifer.

As shown in figure 13, it was possible to match water levels observed at test wells E, A, B, D, and F for all simulated values of K, although the value for K'/m' ranged from about 0.004 to 0.1 ft/d/ft. On the other hand, as shown in figure 13, values of K greater than 1,000 ft/d are necessary in order to match water levels observed in test holes H, I, and J regardless of the simulated value for K'/m'. At test well H, a match between model-calculated and observed water levels was obtained for K equal to 5,000 ft/d and the K'/m' equal to about 0.006 ft/d/ft.

Several conclusions are possible from the above information. First, larger values for K are required in the model for the western part of the basal aquifer compared with the eastern part. This corresponds to the distribution of hydraulic conductivity indicated by the aquifer tests. Second, the range in values of K'/m' that resulted in model-calculated water levels matching observed (0.004 to 0.1 ft/d/ft) are within the general range of values previously calculated for this parameter (0.006 to 6.4 ft/d/ft) assuming vertical movement of ground water is resisted only by the vertical hydraulic conductivity (K') of the basalt flows.

The spatial variability of K of the basal aquifer necessary to allow a closer match between model-calculated and observed water levels was investigated further, initially by using the results

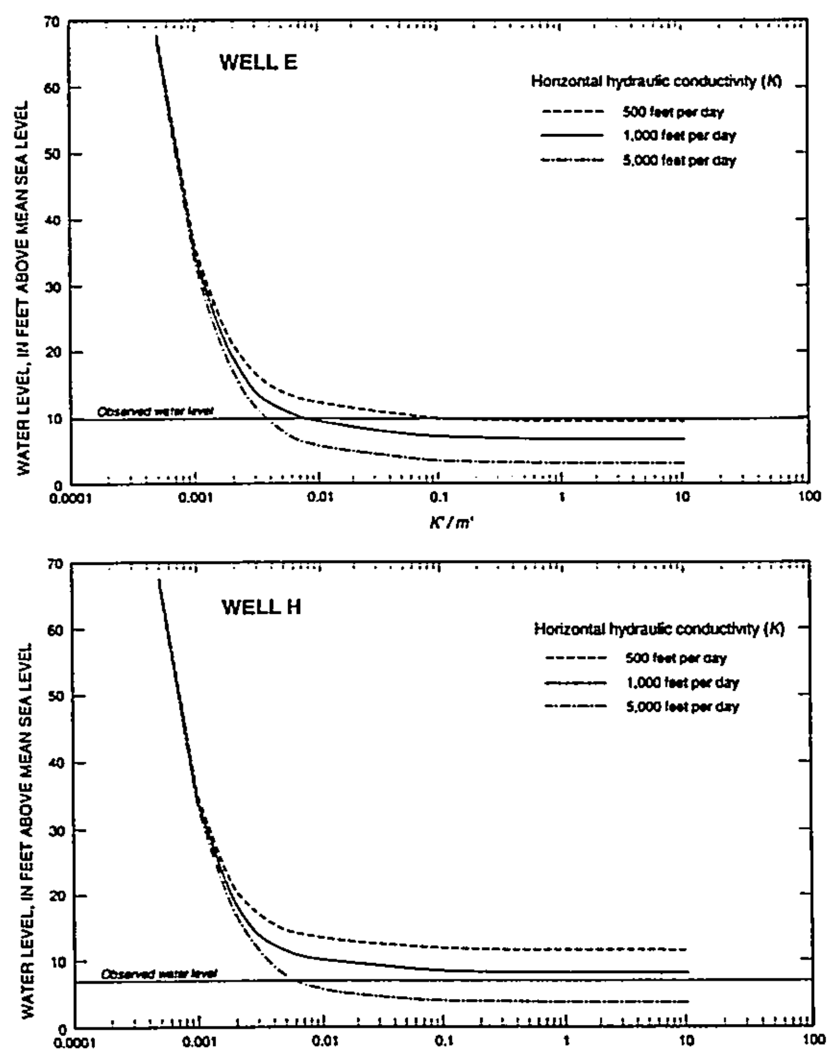


Figure 13. Model-calculated water levels at test wells E and H, for selected values of horizontal hydraulic conductivity and hydraulic connection, K'/m', between the basal aquifer and the ocean, Kohala area, Island of Hawaii (location of wells shown in figure 7).

of three of the model simulations from the initial series. These three simulations used a value for K of 500; 1,000; and 5,000 ft/d and a value for K'/m' equal to 0.01 ft/d/ft. Model-calculated and observed water levels were plotted on a scatter diagram (fig. 14A). The scatter diagram indicates any bias or trends in model-calculated water levels, such as all of the model-calculated water levels being higher or lower than observed.

The simulated value for K'/m' used for the above models (0.01 ft/d/ft) was selected for several reasons. First, as shown in figure 13, model-calculated water levels for all the wells are relatively insensitive to values of K'/m' greater than about 0.1 ft/d/ft, and model-calculated water levels become sensitive to values lower than 0.1 ft/d/ft. The model becomes increasingly sensitive to values of K'/m' less than about 0.01 ft/d/ft and for values lower than about 0.004 ft/d/ft, model-calculated water levels rise sharply beyond observed water levels for all values of simulated K. Second, when pumping is simulated, lower values of K'/m' result in greater model-simulated drawdowns and freshwater-saltwater interface rise for a given distribution and rate of ground-water pumpage, other things being equal. Therefore, for lower values of K'/m', the model becomes more conservative for estimation of ground-water availability. Finally, the value used for this analysis (0.01 ft/d/ft) also fell within the range of values (0.004 to 0.1 ft/d/ft) that resulted in model-calculated water levels matching observed water levels.

As expected, these simulations did not produce an acceptable match to observed water levels. For K equal to 500 ft/d, all of the model-calculated water levels were significantly higher than observed water levels. For K equal to 1,000 ft/d, a strong bias existed in the distribution of water levels; model-calculated water levels were significantly higher than observed on the western side of the aquifer (wells I, J, and H; fig. 14A) and very close to observed water levels on the eastern side (wells E, F, D, A, and B). For K equal to 5,000 ft/d, model-calculated water levels were somewhat higher than observed on the western side of the aquifer and significantly lower than observed on the eastern side. These trends in the model-calculated water levels indicate that to match observed water levels a relatively low K is required in the eastern part of the model and a relatively high K is required in the western part.

On the basis of the above analyses, the value of K of the aquifer was then varied spatially on the model with higher values in the western part of the model and lower values on the eastern part of the aquifer while K'/m' was held constant at 0.01 ft/d/ft. Various ranges and distributions of K (ranging from 250 to 8,000 ft/d across the model) were tested and nearly all of these simulations improved the model. The best match in this series of simulations resulted in a model with K varying from 650 to 5,000 ft/d (fig. 14B). The average difference between model-calculated and observed water levels for this distribution was 0.8 ft. Water levels calculated by the model were still relatively high at test wells I and J. To improve the match, K'/m' was increased from 0.01 to 0.1 ft/d/ft in the western part of the model (fig. 15); this resulted in a much better fit between model-calculated and observed water levels (fig. 14B). The average difference between model-calculated

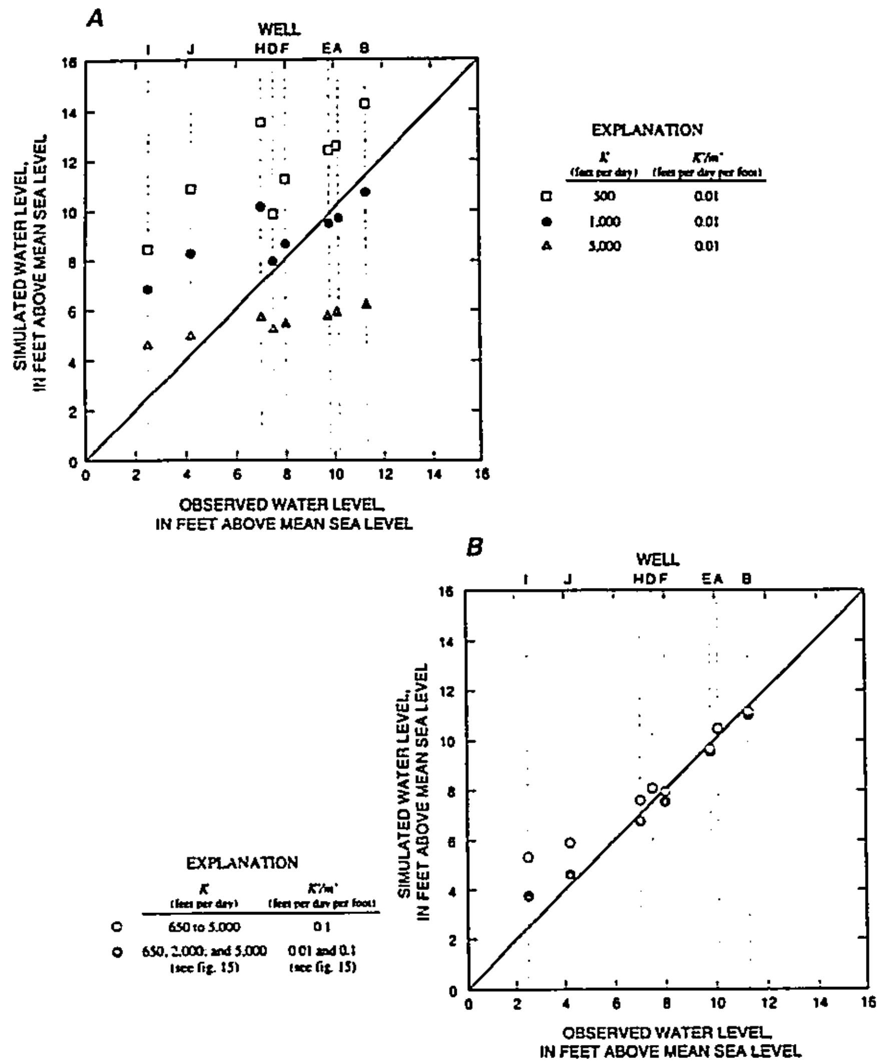


Figure 14. Model-calculated water levels and observed water levels for selected values of horizontal hydraulic conductivity (K) and the hydraulic connection between aquifer and ocean (K'/m'), Kohala area, island of Hawaii.

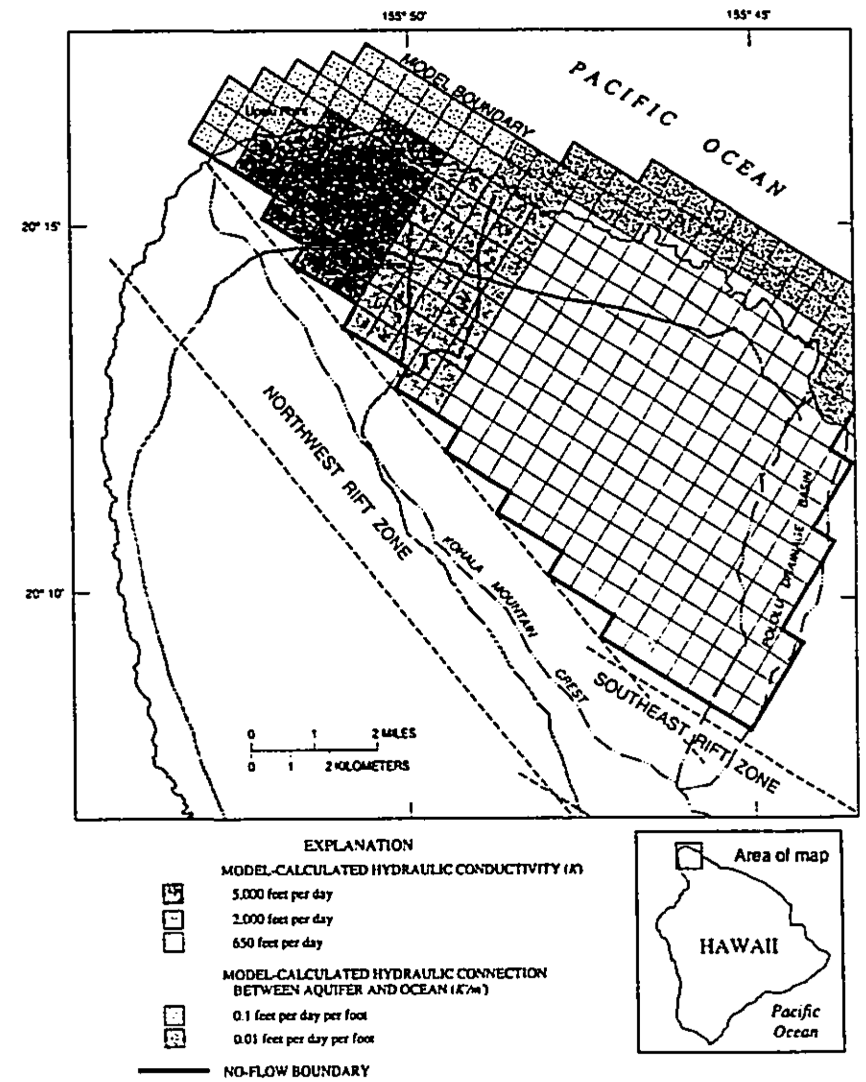


Figure 15. Distribution of horizontal hydraulic conductivity and hydraulic connection between the aquifer and ocean as modeled, Kohala area, island of Hawaii.

and observed water levels was about 0.5 ft and this version of the model was accepted as the best representation of the aquifer based on available data. Increasing K'/m' in the western part of the model was believed to be justified because of the higher value of K of this area as compared with the eastern part of the model. Model-calculated water-levels were compared with those from field data and are shown in figure 16. Model-calculated depth of the freshwater-saltwater interface is shown in figure 17.

The sources and discharges characterizing the steady-state simulation described above are summarized in table 5. The magnitude of the flow components shown in the table represent mean annual conditions. Shade (in press) has shown that these conditions vary significantly during an average year, but even so, the time response of the aquifer, in terms of changes in water levels is small (1 ft or less) relative to seasonal changes in the magnitude of the individual components of the water budget.

Table 5. Steady-state ground-water budget (existing pumpage) for the numerical model, Kohala area, Island of Hawaii

Ground-water sources		Million gallons per day
Direct infiltration of precipitation		60.3
High-level discharge into the basal aquifer		8.1
Kohala ditch seepage		2.0
Hydroelectric plant injection wells		8.0
	Total.........	78.4
Ground-water discharges		
Into ocean		77.8
Existing pumpage		0.6
	Total.........	78.4

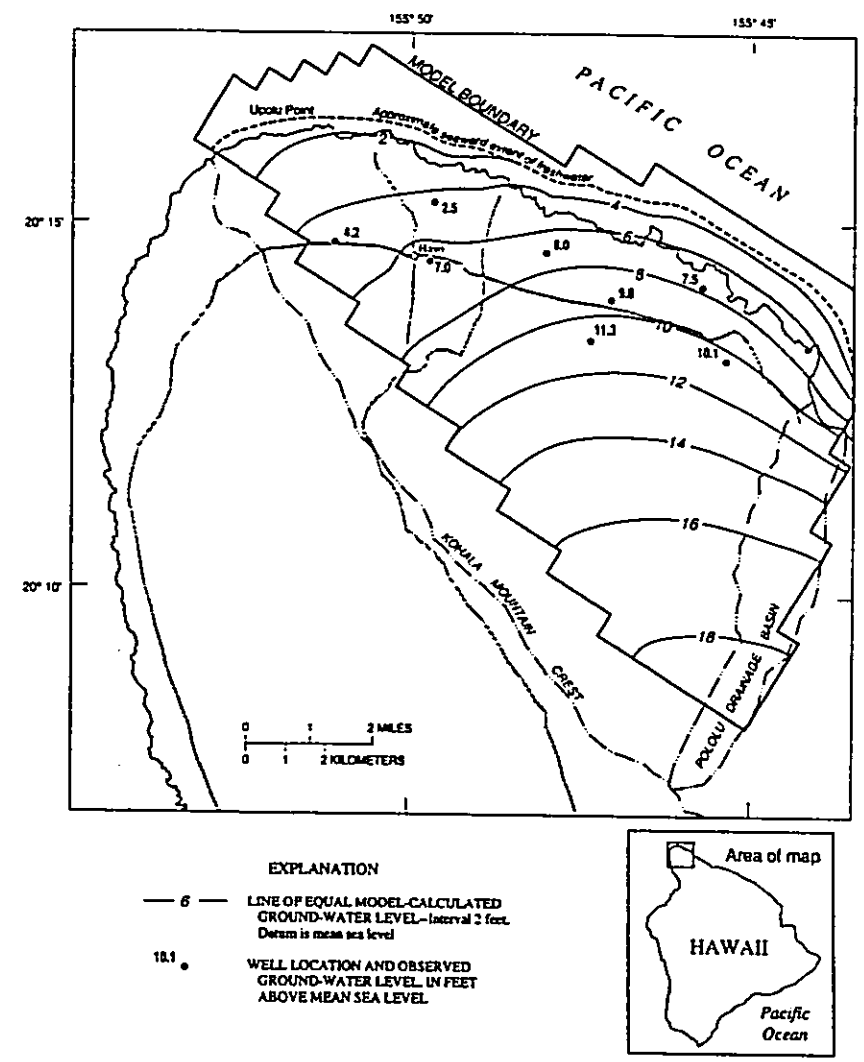


Figure 16. Model-calculated and observed ground-water levels, Kohala area, Island of Hawaii.

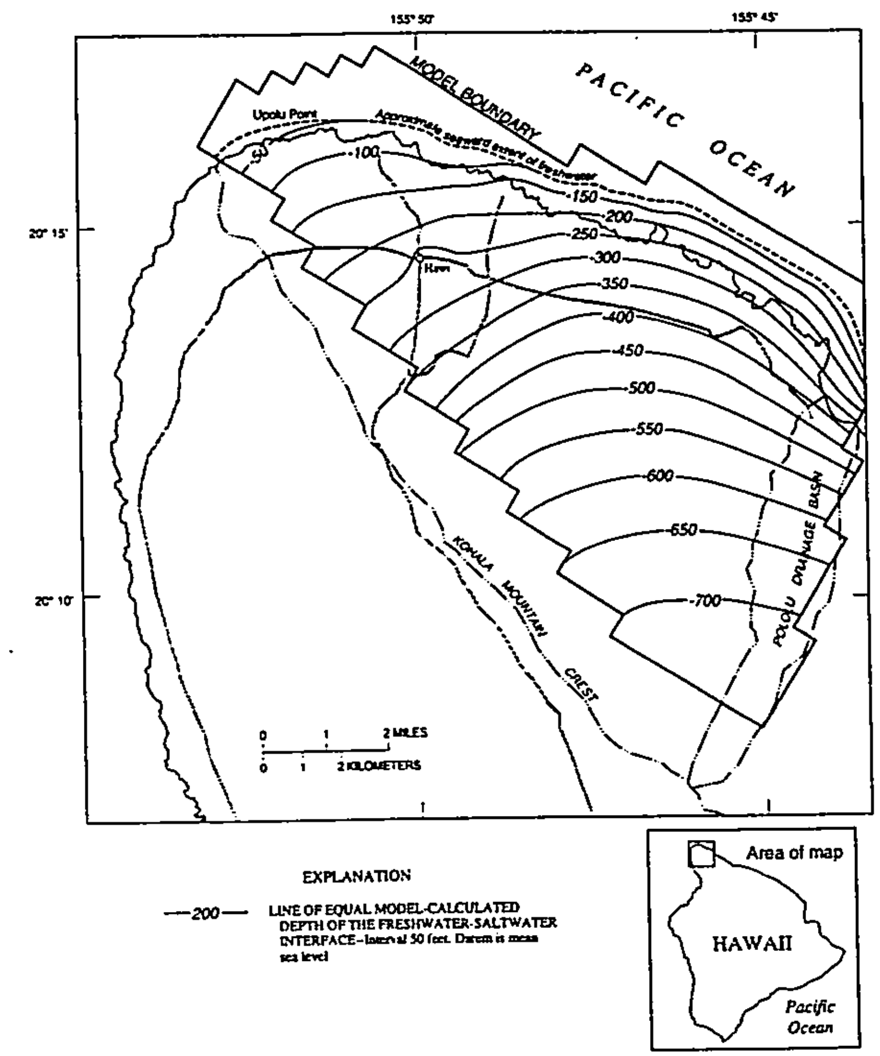


Figure 17. Model-calculated depth of the freshwater-saltwater interface, Kohala area, island of Hawaii.

The response of the basal aquifer to pumping 20 Mgal/d above that currently being withdrawn from the aquifer was simulated for two pumping scenarios. In each scenario, there are six pumping sites aligned roughly parallel to the coast, with the four inside sites each pumping 4 Mgal/d and two outside sites each pumping 2 Mgal/d. The location of pumping sites and pumping rates are shown in figure 18. The only difference between the two scenarios is the areal distribution of pumping. In the first scenario, the six pumping sites were located over a distance of 5 mi with the four sites pumping 4 Mgal/d in the middle 3 mi. In the second scenario, the six pumping sites were located over a distance of 3 mi with the four sites pumping 4 Mgal/d concentrated in the middle 1.5 mi. In general, the simulations show that increasing ground-water pumping results in (1) a decrease of discharge to coastal discharge boundary equal to the amount of pumpage (see tables 5 and 7); (2) a decline in water-table altitude (see figs.19 and 20); and (3) a decrease in the depth to the freshwater-saltwater interface (see figs. 17, 21, and 22).

In analyzing the model results in terms of water-level declines and the resulting rise in the freshwater-saltwater interface, a distinction needs to be made between model-calculated drawdown for a model node and the actual drawdown that would occur in a well or wells. The model-calculated drawdown represents the average drawdown in an area around the model node (see fig. 12) and in all cases drawdown in a well or wells will be greater. The actual difference between the two will depend on the number of wells that the withdrawal in a given node represents, the pumping rate of individual wells, and the construction details of the well. The model assumes full penetration of the pumped well and for a pumping rate of 1.0 Mgal/d per well, application of an equation developed by Prickett (1967) indicates that drawdown in a well would be about 0.3 ft greater than the model-calculated drawdown at a node. Wells in basal aquifers are typically constructed to depth ranging from 50 to 200 ft below sea level rather than penetrating the entire freshwater thickness of the aquifer, however, and the effects of partial penetration would increase actual drawdown in a well above values calculated from Prickett's equation. These considerations indicate that the model cannot directly address the subject of individual well yields compared with well depth and that this information must be gained from actual field experience or from more detailed "local scale" model analysis.

Model-calculated changes in water level.--The decline in ground-water levels estimated by the model for scenarios 1 and 2 are shown in figures 19 and 20, respectively. Water-level declines for the first scenario range from about 1 to 3.5 ft at the pumping centers and to about 0.1 ft near the extreme northwestern edge of the model. Water-level declines in the extended study area are about 1 ft.

Water-level declines for the second model scenario are similar to those of scenario 1 except that drawdown at the pumping centers ranges from about 2 to almost 5 ft, an increase of as much as 1.5 ft over the first scenario. The increase in drawdown is a result of more localized pumping.

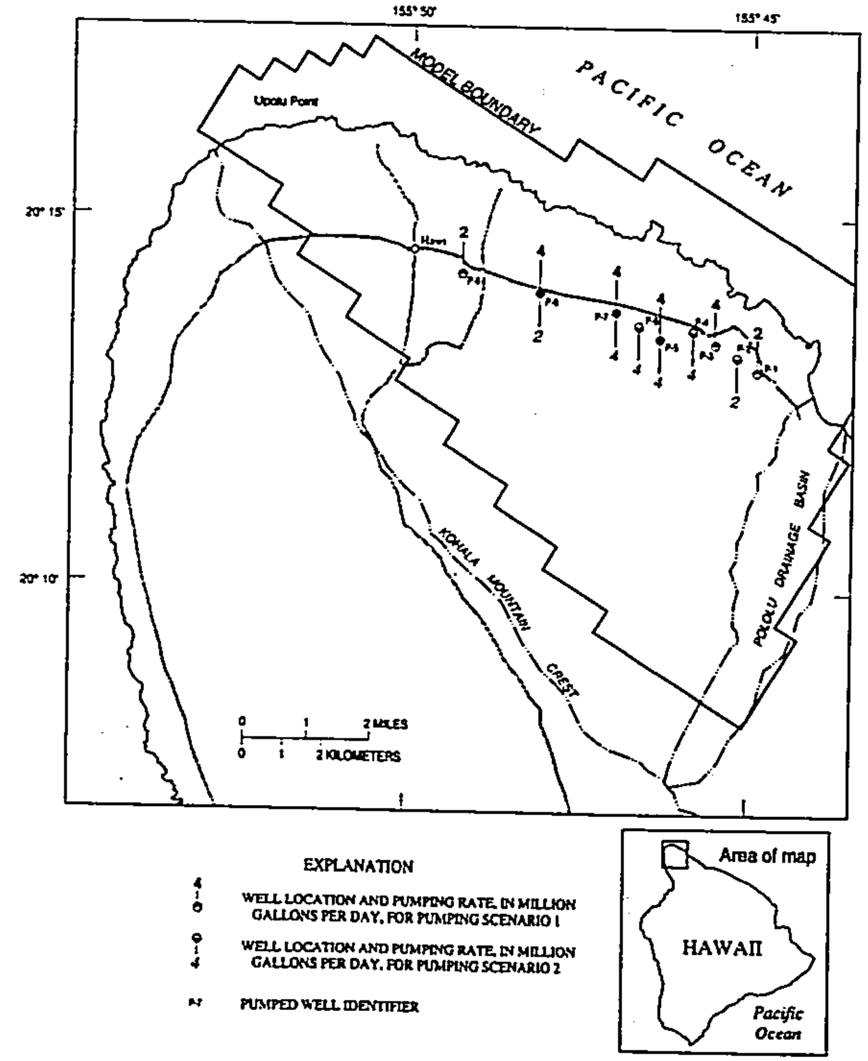


Figure 18. Pumping rates used for the two simulated pumping scenarios, Kohala area, island of Hawaii.

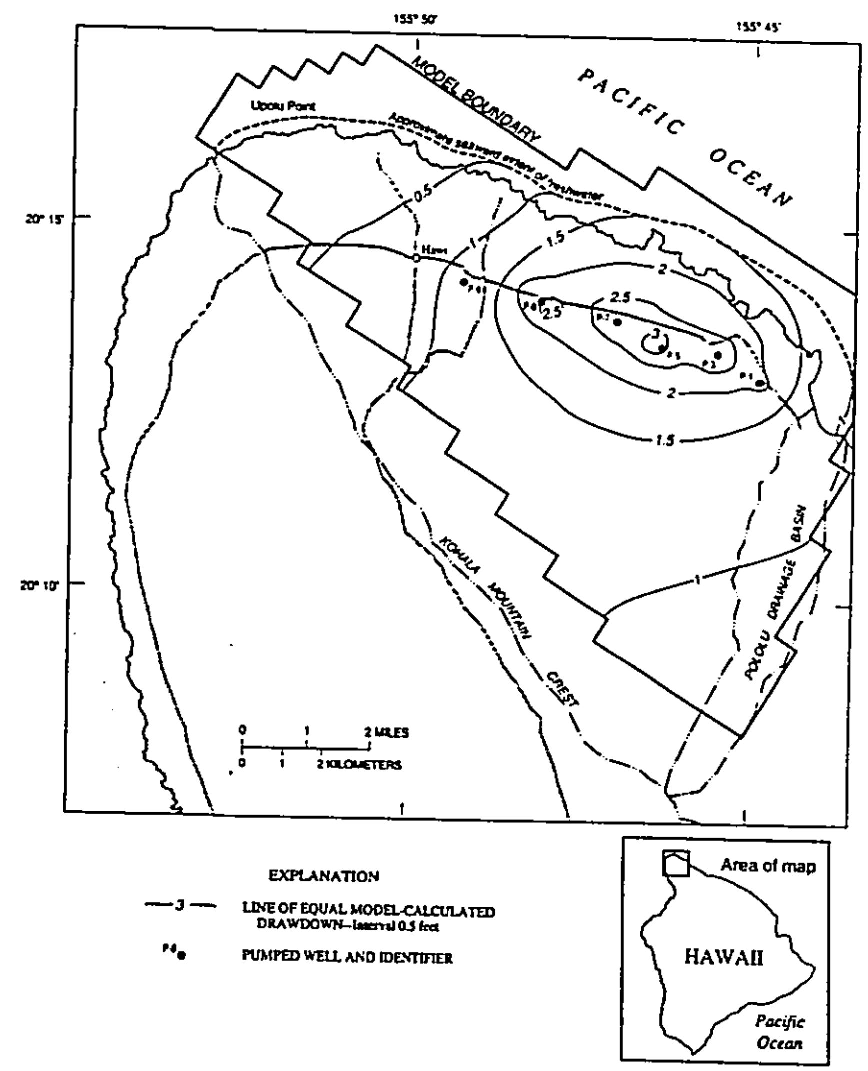


Figure 19. Model-calculated drawdown for pumping scenario 1, Kohala area, island of Hawaii.

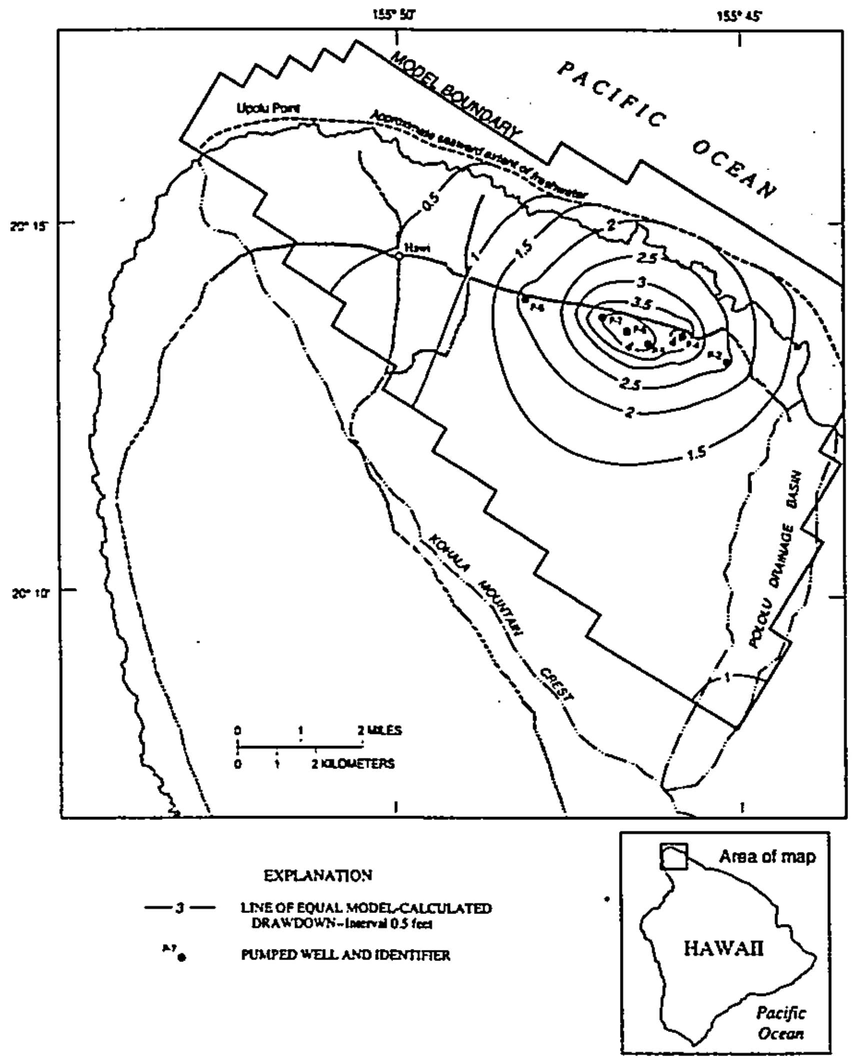


Figure 20. Model-calculated drawdown for pumping scenario 2, Kohala area, island of Hawaii.

Once again, model-calculated decline in water-level in Pololu drainage area is about 1 ft. The termination of the model at the eastern drainage divide of Pololu Stream precludes the induced movement of ground water from the excluded area into the modeled area, which would be presumed to occur under actual pumping conditions. The exclusion of this induced movement of ground water toward the pumping centers results in the model over-estimating water-level declines by about 0.5 ft. Over-estimating water-level declines makes model calculations of ground-water availability conservative.

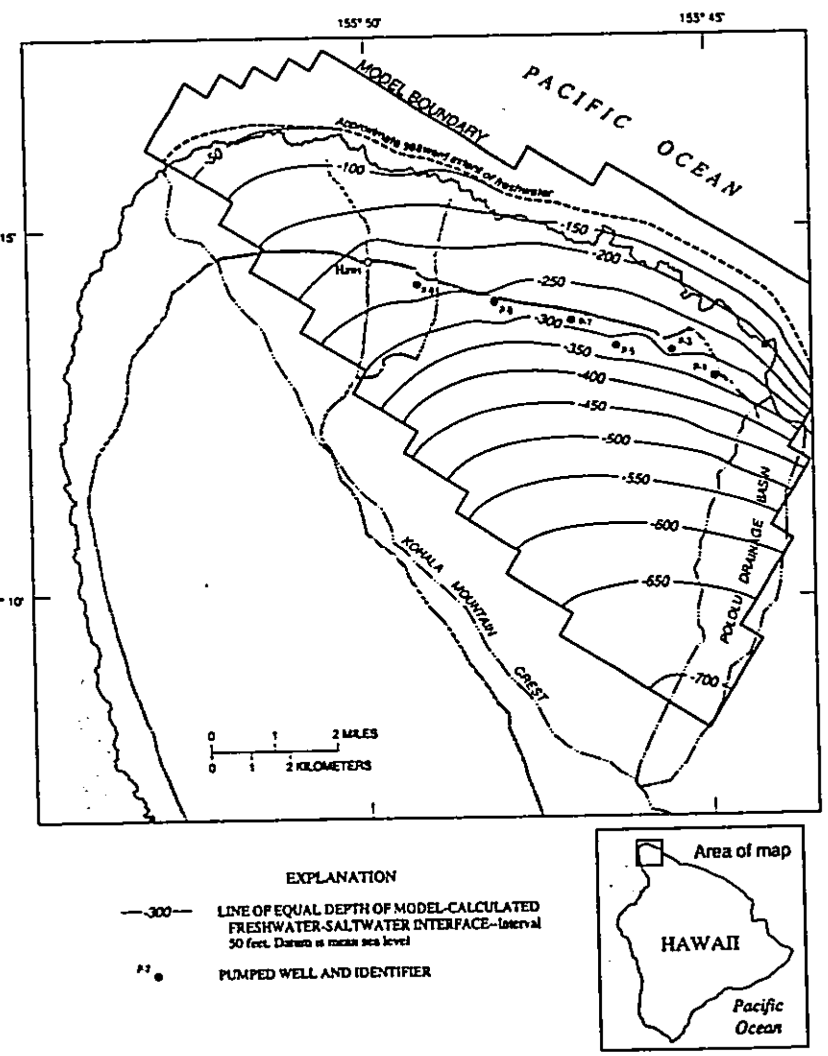
Model-calculated changes in depth to freshwater-saltwater interface.--As a result of pumping and subsequent decline of water levels, the freshwater-saltwater interface moves upward. The location of the interface is important because it is the best indicator of the limits on available water at the pumping sites. If the freshwater-saltwater interface rises near or into wells, the salinity of water pumped by the well may increase to levels unacceptable for domestic uses.

The pre-pumping position of the model-calculated freshwater-saltwater interface near the pumping sites is shown in figure 17 and the model-calculated position of the interface resulting from scenario 1 is shown in figure 21. The model-calculated position of the interface resulting from scenario 2 is shown in figure 22. Information on pre-pumping and pumping water levels and model-calculated depth to the freshwater-saltwater interface below sea level are given for each of the simulated pumping nodes in table 6 for scenarios 1 and 2.

The greatest model-calculated decline in water level for scenario 1 is about 3.5 ft at pumping node P-7 and the resulting model-calculated rise in the interface is about 140 ft. Depth to the freshwater-saltwater interface is least (227 ft below sea level) at pumping node P-9. If the thickness of the brackish zone above the interface is assumed to be about 80 ft as indicated at well D, the range in freshwater thickness at the pumping nodes would be about 153 to 252 ft.

The greatest model-calculated decline in water levels for scenario 2 is about 4.7 ft at pumping node P-6 and the resulting model-calculated rise in the interface is about 188 ft. Depth to the freshwater-saltwater interface is least (228 ft below sea level) at pumping node P-7. Using a thickness for the brackish zone equal to 80 ft above the interface as for scenario 1, the resulting range in freshwater thickness from is about 154 to 234 ft.

As discussed previously, wells in basal aquifers are typically constructed to depths ranging from about 50 to 200 feet below sea level. The above results indicate that if ground water is withdrawn in the areas simulated in the two model scenarios, deeper wells (about 200 ft below sea level) would likely experience saltwater intrusion at least at some locations, while shallower wells would tend to maintain a greater buffer of freshwater between the wells and the transition zone. The amount of freshwater buffer would depend on the actual depth, spacing, and pumping rates of these wells. Results also indicate that, as would be expected, the potential for saltwater intrusion increases as pumpage is concentrated.

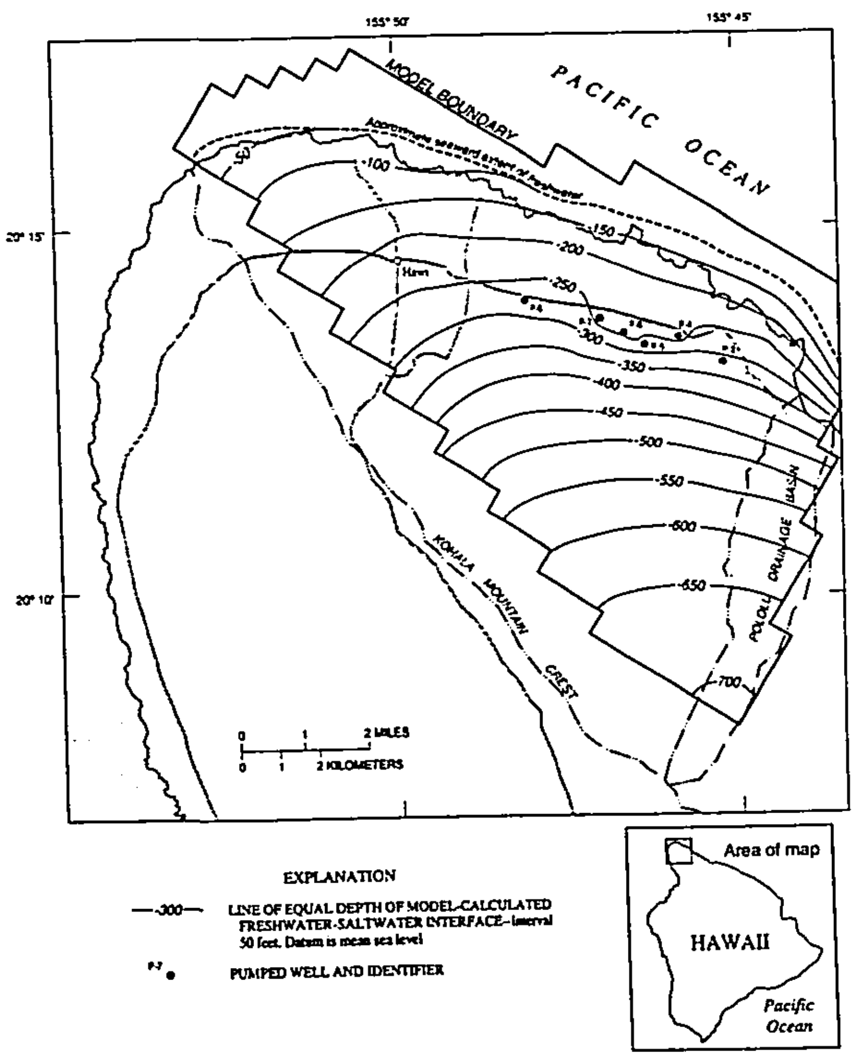


EXPLANATION

—300— LINE OF EQUAL DEPTH OF MODEL-CALCULATED FRESHWATER-SALTWATER INTERFACE--Interval 50 feet. Datum is mean sea level

• PUMPED WELL AND IDENTIFIER

Figure 21. Depth of model-calculated freshwater-saltwater interface for pumping scenario 1, Kohala area, Island of Hawaii.



EXPLANATION

—300— LINE OF EQUAL DEPTH OF MODEL-CALCULATED FRESHWATER-SALTWATER INTERFACE--Interval 50 feet. Datum is mean sea level

• PUMPED WELL AND IDENTIFIER

Figure 22. Depth of model-calculated freshwater-saltwater interface for pumping scenario 2, Kohala, Hawaii.

Table 6. Water levels and interface locations at simulated pumping sites, Kohala area, Island of Hawaii

Simulated pumping site (fig. 18)	Non-pumping: Water level (ft above sea level)	Non-pumping: Interface depth (ft below sea level)	Non-pumping: Approximate thickness of freshwater below water table (feet)	Pumping: Water level (ft above sea level)	Pumping: Interface depth (ft below sea level)	Pumping: Approximate thickness of freshwater below water table (feet)	Pumping: Water-level change (feet)
				Scenario 1			
P-1	10.3	413	343	8.1	324	252	2.2
P-3	10.3	412	342	7.0	281	208	3.3
P-5	10.9	436	367	7.5	300	228	3.4
P-7	10.1	405	335	6.6	266	193	3.5
P-8	9.0	360	289	5.9	236	162	3.1
P-9	7.0	281	208	5.7	227	153	1.3
				Scenario 2			
P-2	10.3	414	344	7.6	306	234	2.7
P-4	10.1	406	336	5.8	232	158	4.3
P-5	10.9	436	367	6.4	255	181	4.5
P-6	10.5	422	352	5.8	234	160	4.7
P-7	10.1	405	335	5.7	228	154	4.4
P-8	9.0	360	289	6.6	264	191	2.4

Table 7. Steady-state ground-water budget (existing plus simulated pumpage) for the numerical model, Kohala area, Island of Hawaii

Sources	Million gallons per day
Direct infiltration of precipitation	60.3
High-level discharge into the basal aquifer	8.1
Kohala ditch seepage	2.0
Hydroelectric plant injection wells	8.0
Total	78.4
Ground-water discharges	
Into ocean	57.8
Existing pumpage	0.6
Proposed pumpage	20.0
Total	78.4

Model results.--The main emphasis of this study was to determine if 20 Mgal/d of ground water can be withdrawn from the Hawi basal aquifer in addition to the existing use of 0.6 Mgal/d. The previous discussion indicates that this withdrawal is feasible, but spacing, depth, and pumping rates of individual wells are an important considerations in planning ground-water development. It is desirable to maintain as thick a body of freshwater beneath the wells as possible.

For existing conditions, water levels range from about 10 ft to 7 ft (see fig. 7) from east to west in the area of simulated pumpage shown in figure 18. Model-calculated steady-state water levels resulting from pumping an additional 20 Mgal/d for scenarios 1 and 2 are shown in figures 23 and 24. As can be seen, water levels are still highest (about 8 ft) in the eastern part of the area of simulated pumpage. Water levels in the western part of the area of simulated pumpage are about 6 ft.

Table 7 shows the components of the steady-state ground-water budget for the modeled area following the simulation of the 20 Mgal/d of additional pumpage for both scenarios. Comparison of table 7 with table 5 indicates that the source of water to the additional pumpage is from reduced ground-water discharge to the ocean by an amount equal to pumpage. Other components of the water budget are the same.

For both pumping scenarios, the model calculates a water-level decline of slightly more than 1 ft near the mouth of Pololu Stream where the stream discharges into the ocean. In this area, it is possible that Pololu Stream is hydraulically connected to the basal aquifer. As a result, a decline in water level near the mouth of Pololu Stream would be sufficient to cause a reduction in streamflow. Because the model terminates along the Pololu watershed boundary, the model would be expected to over-estimate the water-level decline in the area of Pololu Stream, perhaps by as much as 0.5 ft; but even so, the stream would still be affected assuming a hydraulic connection exists with the basal ground-water system.

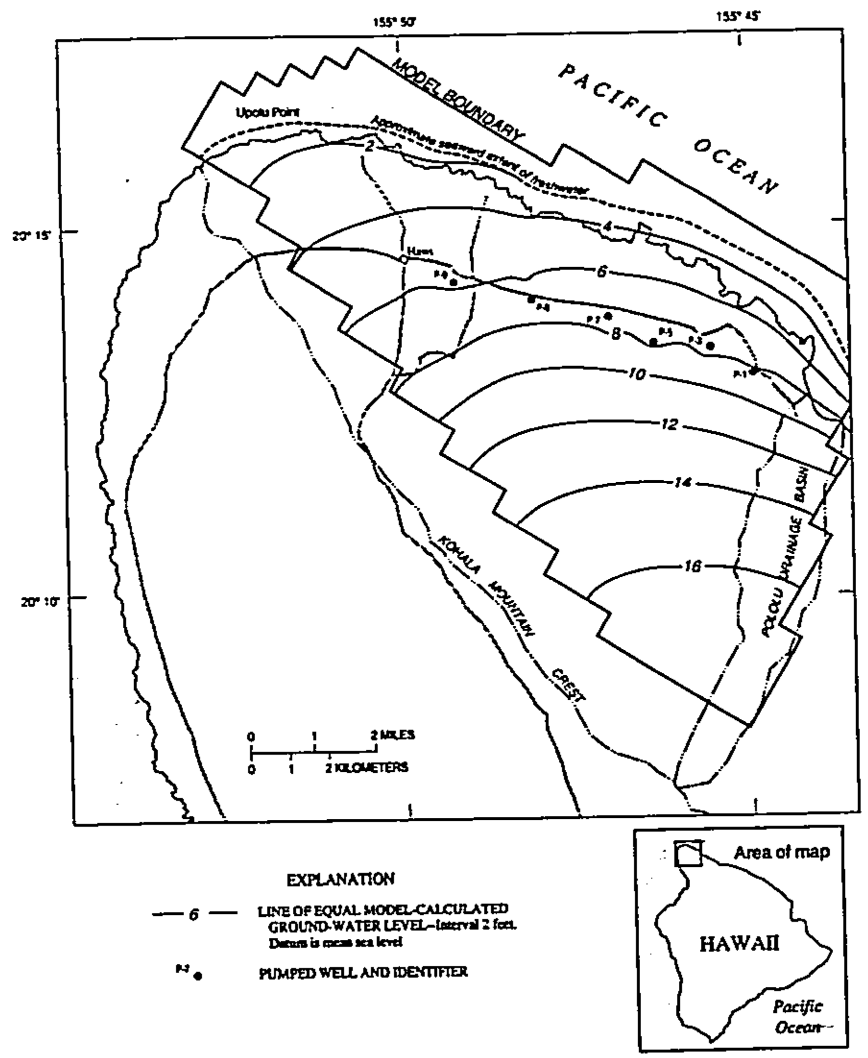


Figure 23. Model-calculated ground-water levels for pumping scenario 1, Kohala area, Island of Hawaii.

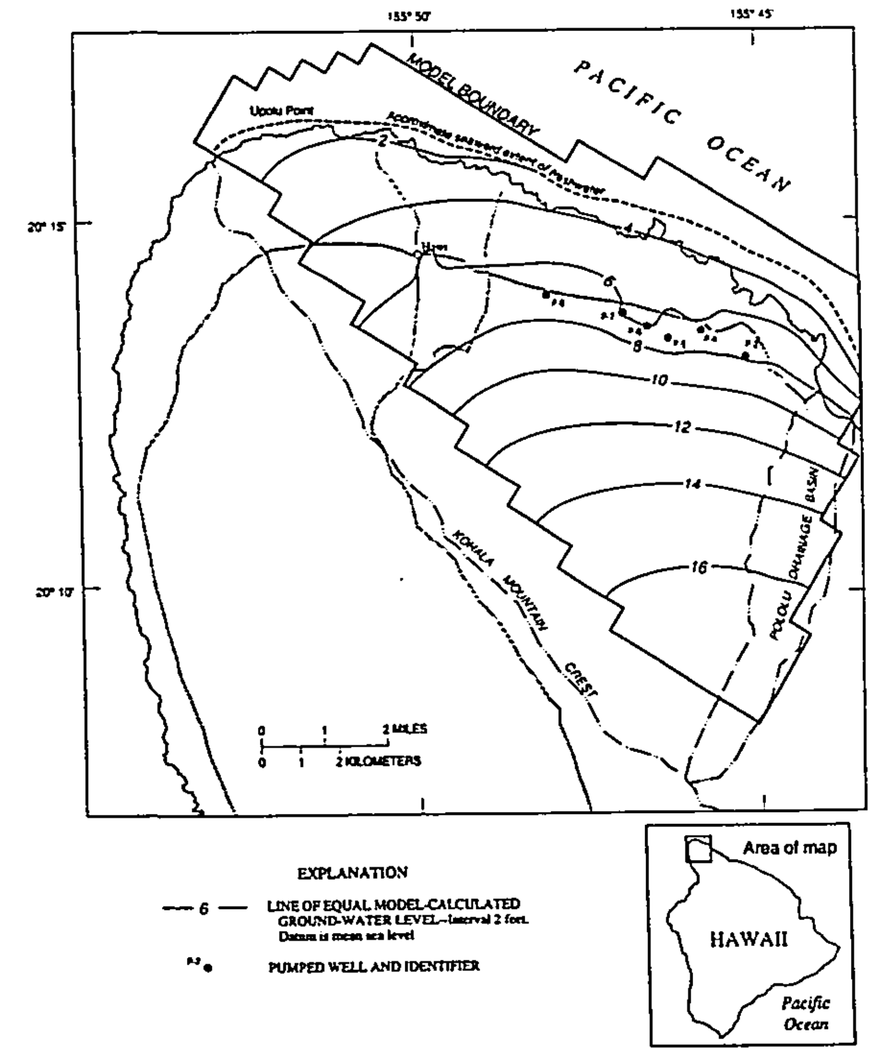


Figure 24. Model-calculated ground-water levels for pumping scenario 2, Kohala area, Island of Hawaii.

SUMMARY AND CONCLUSIONS

Model results indicate that ground-water withdrawal of 20 Mgal/d above the existing 0.6 Mgal/d withdrawal at the Hawaii County Department of Water Supply well is feasible from the Hawi basal aquifer, but that spacing, depth, and pumping rates of individual wells are important. If pumping is concentrated, the likelihood of saltwater intrusion is increased. Model results indicate that concentrating as much as 16 Mgal/d in a 1.5 mile stretch roughly parallel to the coast on the eastern side of the basal aquifer, and withdrawing an additional 2 Mgal/d within a mile on either side of this would provide a freshwater thickness of 154 to 234 ft below the areas of withdrawal. In this case, wells with depths of greater than 200 ft below sea level would likely experience saltwater intrusion. If the area of concentrated pumpage is increased from 1.5 to 3 miles and another 2 Mgal/d withdrawn on either side within a distance of about three-quarters of a mile from the area of concentrated pumpage, the freshwater thickness in the area of withdrawal would increase slightly to between 153 and 252 ft.

Under existing conditions, water levels in the basal aquifer range from about 10 to 7 ft above sea level in the area of simulated pumpage. Model results indicate that water levels would range from about 8 to 6 ft above sea level after water-level declines induced by the additional 20 Mgal/d of pumpage stabilized.

The model cannot directly address the subject of individual well yields compared with depth, and this information must be gained from field experience. Even so, it is clear from model results that 20 Mgal/d of additional ground-water withdrawal from the basal part of the Hawi aquifer is possible if pumping centers are spaced adequately apart and well depths are limited.

The withdrawal of 20 Mgal/d would result in a reduction of ground-water discharge to the ocean by an amount equal to pumpage. It is possible that pumping could cause some reduction of streamflow near the mouth of Pololu Stream, but because of a lack of field data concerning the hydraulic connection of this stream with the basal aquifer, the magnitude of the reduction cannot be addressed at this time.

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APPENDIX C

EFFECT ON GROUNDWATER DISCHARGE INTO THE MARINE ENVIRONMENT

ASSESSMENT OF IMPACTS TO WATER QUALITY AND MARINE COMMUNITY STRUCTURE

Effect on Groundwater Discharge Into the Marine Environment of the Proposed Kohala Water Transmission System

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February 1995

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Introduction

The analyses summarized in this report were undertaken to determine the changes in the quantity and quality of groundwater discharged into the marine environments in North and South Kohala as a result of the implementation of the Department of Water Supply's (DWS) proposed Kohala Water Transmission System (KWTS) project. A related study by Marine Research Consultants utilizes the results of this study to determine the potential effects of these changes on the marine environment.

The KWTS project would develop 10 to 12 wells in North Kohala and transport up to 19 million gallons per day (MGD) from these wells to various land uses in the South Kohala coastal region. The wells would be spaced over a distance of about four miles from Honopueo to Niulii. Their ultimate draft would be a significant fraction of the total groundwater flow in this area. As such, the natural discharge of groundwater into the marine environment downgradient from the wells would be significantly diminished.

A portion of the North Kohala water transported to South Kohala would become groundwater recharge in South Kohala in several ways: by direct disposal of wastewater in leach fields, seepage pits, and injection wells; by deep percolation of the fraction of the imported water used for landscape irrigation; and by deep percolation of the portion of wastewater effluent reused for golf course irrigation. Although these additions to the natural flow of groundwater to the South Kohala shoreline would not be as proportionately large as would be the reduction of groundwater flow in North Kohala, it could be locally significant in areas such as embayments where the mixing energy of waves and currents is less than for exposed shorelines.

Potential Reduction of Groundwater Discharged Into the Marine Environment in North Kohala Due to the KWTS Project

Potential reduction of the amount of groundwater discharged into North Kohala's marine environment was estimated in the following way:

- The area of North Kohala that would potentially be effected by the pumpage from the proposed wells was identified.
- The natural rate of groundwater flow due to rainfall recharge in this area was established.

- Contributions to groundwater recharge of surface water imported via the Kohala and Kehena Ditches was quantified.

- Reductions in groundwater flow due to well pumpage were computed to arrive at the net groundwater flow that would be discharged into the nearshore marine environment.

To provide the appropriate perspective of the proposed pumpage by the KWTS project, three time periods were analyzed: 1960, when sugarcane was still in production, when the importation of surface water by the Kohala and Kehena Ditches was maximized, and when there was full use of Kohala Sugar Company's wells; the present time with only one well (DWS') being used as surface water importation has been reduced; and at a future time when full use of the KWTS project is realized, probably some time beyond the year 2015.

Area of Analysis. Although the proposed wells span approximately 4.4 miles of coastline, a broader, 10-mile area from Pololu Valley to Upolu Point was selected because it defines a hydrologic unit and because it has been analyzed in several prior studies (Bowles, et al. 1974, Underwood and Shade, 1989, and George A.L. Yuen & Associates, 1992). The area is shown on Figure 1. It is bordered on the south and west by the mountain's northwest rift zone which creates the topographic divide, on the east by the west canyon wall of Pololu Valley, and on the north by the ocean. This 50-square mile area is designated Area II in the US Geological Survey study by Underwood and Shade (1989). It has also been designated as the Hawi Aquifer System (Code No. 80101) by the State Commission on Water Resource Management (Yuen & Associates, 1992).

Groundwater Flow Due to Rainfall Recharge. Bowles et al. (1974) estimated the natural groundwater flow to be 40 to 50 MGD along a somewhat shorter coastal segment than the chosen 10-mile section. A more detailed, hydrologic budget based on monthly data was made for the USGS study. It computed the rainfall recharge rate at 64 MGD. Yuen & Associates (1992), using average annual values for rainfall and other parameters, calculated this recharge to be 61 MGD. The 64 MGD flowrate of the USGS hydrologic budget is used in the computations which follow. Since the recharge varies significantly from the wetter end at Pololu to the drier west end near Upolu Point, division of the area into the seven mauka-makai corridors shown on Figure 2 was done to more accurately depict changes in the groundwater discharge before and after the KWTS project.

Recharge by Imported Surface Water in the Kohala and Kehena Ditches. Importation of surface water by the Kohala and Kehena Ditches, though not as great as during the plantation era, is still a significant factor in the region's hydrology. In the years around 1960, imported flows averaged 27

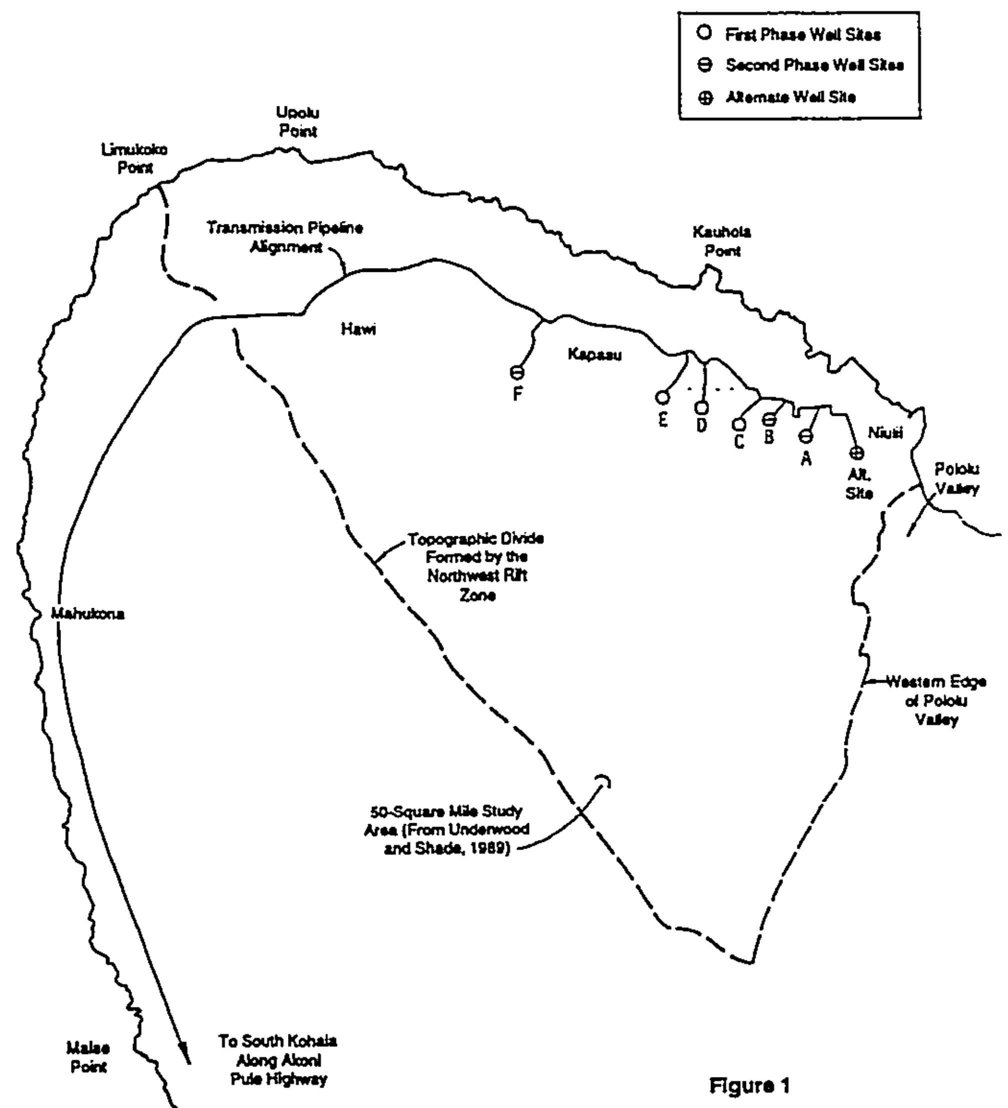

Figure 1
Wells and Transmission Pipeline Route of the Kohala Water Transmission Project
Scale 1:100,000

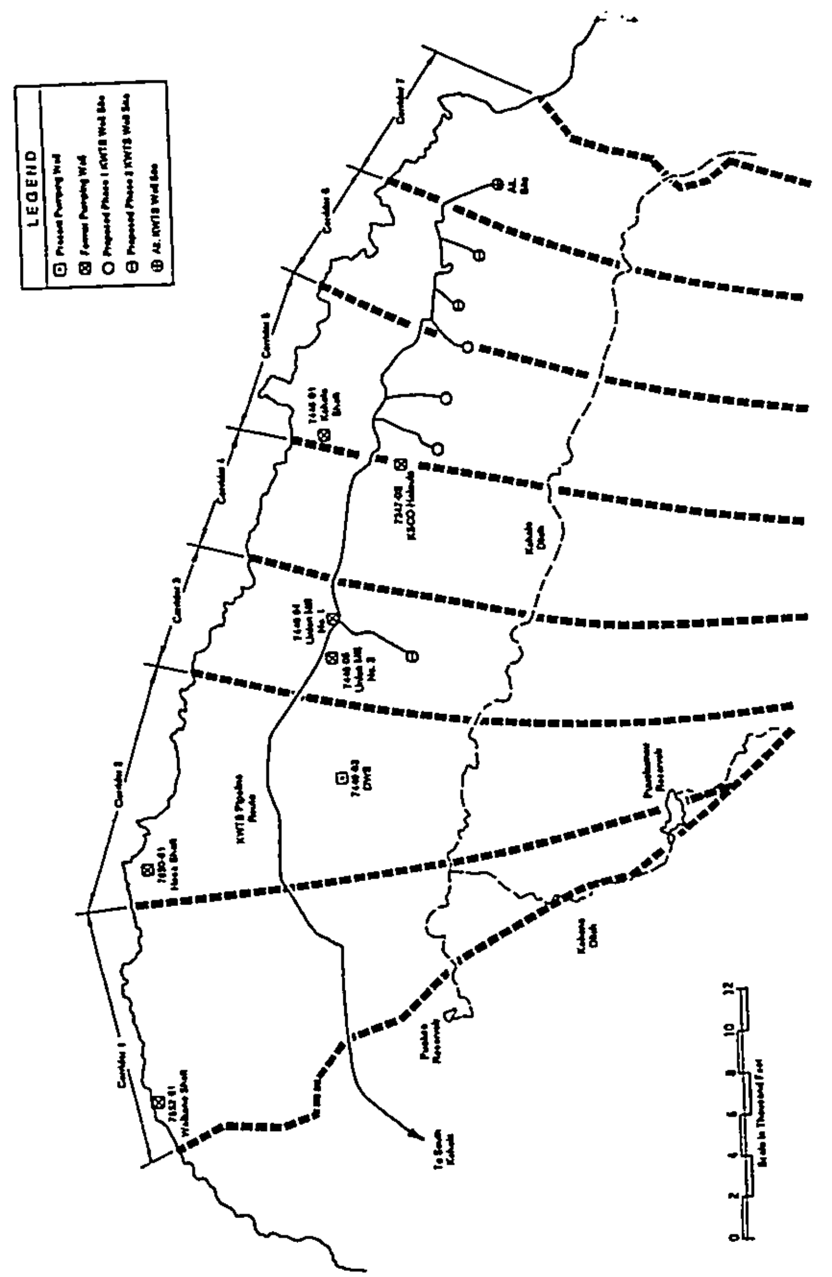

Figure 2
Mauka-Makai Corridors of the North Kohala Study Area

and 5 MGD for the Kohala and Kehena Ditches, respectively (USGS Gages 7510 and 7550). Flow of the Kohala Ditch is now about 10 MGD. Almost all of this now passes through the Hawi hydro-electric plant and is injected into the ground in shallow wells and pits. In other words, essentially all of the flow now becomes groundwater recharge in a very localized area. In the plantation era, only the portion which became irrigation return flow contributed to groundwater recharge. The flowrate of Kehena Ditch is no longer measured. Its present flow into the study area is estimated to average about 2 MGD. All of it is dumped in gulches and flows to the sea; its contribution to groundwater recharge is negligible.

Well Pumpage. In 1960, pumpage by the plantation was from three drilled wells and three shafts. Although records of this pumpage are not complete, reasonable approximations can be made. The total amount is estimated for the 1960 period at 10 MGD in Bowles et al. (1974) and 12.5 MGD in Underwood and Shade (1989). At the present time (and ignoring the higher elevation tunnels which tapped perched water bodies), only the DWS well near Hawi (State No. 7449-02) draws water from the basal lens. No other wells are active. In the future, draft by the proposed 10 to 12 wells of the KWTS could reach 19 MGD.

Accounting for Changes in Groundwater Discharge at the Shoreline. Tables 1, 2, and 3 provide a corridor-by-corridor accounting of shoreline discharges of groundwater in 1960, at present, and in the future when full use of the KWTS is realized. The rainfall-recharge rate used for each of these three periods is the same and is drawn from the USGS hydrologic budget in Underwood and Shade (1989); variations in imported surface water and groundwater pumpage account for the differences among the periods. In 1960, plantation operations moved water from the wetter east end of the area to the drier western side. The estimated groundwater amount discharging into the marine environment at that time reflects this re-distribution. In the accounting of groundwater discharge for the present time, injection of the 10 MGD Kohala Ditch supply downgradient of the Hawi hydro-electric plant is a significant factor. Except for leakage along the route of the ditch, virtually all of the present Kohala Ditch flow directly recharges groundwater in that corridor.

In the future after full development of the KWTS project, virtually all groundwater pumpage would be from the wetter, eastern part of the study area. For the 3.7 mile coastal segment of Corridors 4, 5, and 6 on the eastern end of the area, the 35 MGD rate of rainfall-recharge being discharged at the shoreline at present would be reduced by well pumpage to 17 MGD. It should be noted that the proposed well locations and pumping rates are preliminary. The initial groundwater modeling done by the USGS continues to be refined. However, the USGS has concluded that, based on its model results to date, such pumpage could be sustained by the wells without adverse water quality effects.

Table 1

Accounting for Shoreline Discharge of Groundwater for 1960 Conditions

Item	Mauka-Makai Corridor							Total For All Corridors
	1	2	3	4	5	6	7	
• Length of Coastline (Miles)	2.27	2.18	1.16	1.12	1.42	1.16	1.33	10.64
• Groundwater Recharge Due to Rainfall Recharge (MGD)	4.3	6.3	8.2	9.6	11.5	13.3	11.0	64.2
• Imported Surface Water for Irrigation								
- Kehena Ditch (MGD)	3	2						5
- Kohala Ditch (MGD)	7.3	6.3	5.3	4.3	3.3	0.3	0.2	27.0
• Active Pumping Wells in the Corridor	Waikane Shaft (No. 7652-01)	Hoea Shaft (No. 7650-01)	Union Mill Nos. 1 & 2 (Nos. 7448-04 & 05)	Halaula (No. 7347-02)	Kohala Shaft (No. 7446-01)			
• Estimated Average Well Pumpage (MGD)	1.0	2.0	3.5	0.3	5.0			11.8
• Estimated Irrigation Return Flow of Imported Surface Water and Groundwater Pumpage (MGD)	3.6	3.3	2.6	1.8	2.7	0.3	0.2	14.5
• Estimated Groundwater Discharge Along the Shoreline Corridor	6.9	7.6	7.5	10.9	9.2	13.6	11.2	66.9

Table 2

Accounting for Shoreline Discharge of Groundwater for Present (1994) Conditions

Item	Mauka-Makai Corridor							Total For All Corridors
	1	2	3	4	5	6	7	
• Length of Coastline (Miles)	2.27	2.18	1.16	1.12	1.42	1.16	1.33	10.64
• Groundwater Recharge Due to Rainfall Recharge (MGD)	4.3	6.3	8.2	9.6	11.6	13.3	11.0	64.2
• Imported Surface Water for Irrigation								
- Kehena Ditch (MGD)	1	1						2
- Kohala Ditch (MGD)	0.0	9.2	0.2	0.2	0.2	0.2	0.1	10.1
• Active Pumping Wells in the Corridor		DWS (No. 7449-02)						
• Estimated Average Well Pumpage (MGD)		0.3						0.3
• Estimated Irrigation Return Flow of Imported Surface Water and Groundwater Pumpage (MGD)	0.5	9.7	0.2	0.2	0.2	0.2	0.1	11.1
• Estimated Groundwater Discharge Along the Shoreline Corridor	4.8	15.7	8.4	9.6	11.7	13.5	11.1	75.0

Table 3

Accounting for Shoreline Discharge of Groundwater for Future Conditions

Item	Mauka-Makai Corridor 1	2	3	4	5	6	7	Total For All Corridors
• Length of Coastline (Miles)	2.27	2.18	1.16	1.12	1.42	1.16	1.33	10.64
• Groundwater Recharge Due to Rainfall Recharge (MGD)	4.3	6.3	8.2	9.6	11.5	13.3	11.0	64.2
• Imported Surface Water for Irrigation								
- Kehena Ditch (MGD)	1	1						2
- Kohala Ditch (MGD)	0.0	9.2	0.2	0.2	0.2	0.2	0.1	10.1
• Active Pumping Wells in the Corridor		DW3 (No. 7449-02)	Proposed Well F		Proposed Wells C, D, and E	Proposed Wells A and B	Replacement Site	
• Estimated Average Well Pumpage (MGD)		0.5	1.0	0.0	12.0	6.0	0.0	19.5
• Estimated Irrigation Return Flow of Imported Surface Water and Groundwater Pumpage (MGD)	0.5	9.8	0.2	0.2	0.2	0.2	0.1	11.2
• Estimated Groundwater Discharge Along the Shoreline Corridor	4.8	15.6	7.4	9.8	(-)0.3	7.5	11.1	55.9

Nutrients Discharged by Groundwater Into the North Kohala Marine Environment

To translate the computed groundwater discharge rates to the equivalent weights of dissolved nitrogen and phosphorus carried into the marine environment, sampling and water quality analyses were undertaken for virtually all of the accessible wells and test holes in North Kohala. Only one of these, DWS' Well 7449-02, is an active pumping well. All other water quality analyses are of grab samples. Table 4 lists these wells and the laboratory results for nitrogen, phosphorus, silica, and salinity. On Table 5, these wells are located within their respective mauka-makai corridors to indicate representative nitrogen and phosphorus concentrations of groundwater in each of the corridors.

On Table 6, the representative concentrations of each corridor in Table 5 are applied to the computed groundwater discharge rates for 1960, at present, and at full use of the KWTS some time in the future. This assumes, of course, that present nutrient concentrations in groundwater were the same in 1960 and will be the same at full use of the KWTS. In all likelihood, nutrient concentrations of groundwater in 1960 -- the height of sugarcane cultivation -- were higher than at present. However, available data are not sufficient to demonstrate this. On the other hand, in the absence of widespread land use changes in the future, present groundwater concentrations of nitrogen and phosphorus should be reasonably representative of future levels.

Estimated Increase in Groundwater Discharged Into the South Kohala Marine Environment Due to the KWTS Project

Estimating the change in the quantity of groundwater discharged along the South Kohala shoreline due to the KWTS project is more complicated than for North Kohala. The KWTS' effect in South Kohala will be indirect. A portion of the imported water will become groundwater recharge through wastewater disposal and another portion will become recharge as landscape irrigation return flow. A portion of this irrigation return flow will be applied directly from DWS potable system. The balance will be wastewater from various treatment plants within the resorts and residential developments which is reused for irrigation. To be consistent with the North Kohala computations, South Kohala is also analyzed for three time periods: 1960; at present; and at the future, full use of the KWTS. Also, the 12-mile South Kohala coast (from district boundary to district boundary), is divided into six mauka-makai corridors to depict within-area variations.

Present and Future Water Consumption in South Kohala. Future water use by KWTS customers is compiled in Appendix G of the Draft EIS for the project. Table 7 draws from that compilation and also includes other developments in the area whose activities will impact groundwater directly by

Table 4

Groundwater Chemistry of North Kohala Wells

State Well No.	Date Sampled	Nitrogen: NO_3 (µM)	Nitrogen: NH_4 (µM)	Nitrogen: Total N (µM)	Phosphorus: PO_4 (µM)	Phosphorus: Total P (µM)	Silica (µM)	Salinity (PPT)
7348-04	11-25-84	108.01	0.30	124.05	1.55	1.93	612	1.828
7445-01	11-25-84	370.70	0.13	405.60	0.50	0.70	668	0.487
7347-03	12-04-84	273.00	0.56	273.85	2.88	2.90	722	0.238
7347-05	12-04-84	78.65	0.80	86.75	3.05	2.25	619	0.183
7448-07	11-25-84	90.93	0.00	93.27	1.45	1.62	668	0.207
7449-02	11-25-84	51.28	0.01	51.44	2.39	2.45	802	0.169
7449-03	12-04-84	50.65	1.10	58.65	2.60	2.65	804	0.170
7549-03	11-25-84	66.87	0.07	74.14	6.80	6.89	774	0.312
7451-01	12-04-84	68.60	1.40	73.70	2.70	5.00	758	0.258

Note: All samples collected by Tom Nance Water Resource Engineering and analyzed by Marine Analytical Specialists.

Table 5

Concentrations of Nitrogen and Phosphorus in Groundwater Within the Seven Mauka-Makai Corridors of North Kohala

Mauka-Makai Corridor No.	Indicator Well	Sampled Concentrations: Total Nitrogen (µM)	Sampled Concentrations: Total Phosphorus (µM)	Concentrations Used for Corridor Calculations: Nitrogen (Lbs./Day/MGD)	Concentrations Used for Corridor Calculations: Phosphorus (Lbs./Day/MGD)
1	7451-01	73.7	5.60	6.8	1.50
2	7449-02	54.9	2.55	6.3	0.60
3	7448-07	93.3	1.62	10.9	0.42
4	7347-05	86.8	2.25	10.1	0.58
5	7347-03	273.8	2.90	12.3	0.75
6	7348-04	124.0	1.93	14.5	0.50
7	None	N/A	N/A	14.8	0.50

Table 6

Changes in the Amounts of Nitrogen and Phosphorus Discharged into the North Kohala Marine Environment by Groundwater in 1960, at Present, and at Full Use of the KWTS

Mauka-Makai Corridor No.	Total Nitrogen Discharge at the Shoreline (Lbs./Day): 1960	At Present	Future	Total Phosphorus Discharge at the Shoreline (Lbs./Day): 1960	At Present	Future
1	69.3	41.3	41.3	10.3	7.2	7.2
2	47.0	98.9	90.3	3.3	11.0	10.9
3	81.9	81.6	80.7	3.0	3.4	3.0
4	110.1	93.6	89.0	6.5	5.9	5.8
5	113.2	143.0	None	6.4	8.2	None
6	107.2	108.6	106.8	6.6	6.0	3.8
7	182.4	181.0	181.0	8.8	8.6	6.0

Table 7

Present and Future Water Supply Requirements for the South Kohala Coastal Region

Land Ownership / Land Use	Present Use: Potable (MGD)	Present Use: Non-Potable (MGD)	Future Full Use of the KWTS: Potable (MGD)	Future Full Use of the KWTS: Non-Potable (MGD)
Prospective Customers of the KWTS				
• DHHL Kawaihae Master Plan Area	0.00	0.00	7.05	5.04
• Kawaihae Harbor Area	0.05	0.00	0.23	0.00
• Kawaihae Village	0.22	0.00	0.22	0.00
• Queen Emma Foundation	0.00	0.00	1.00	1.00
• Nansay-Ouli	0.00	0.00	0.74	0.00
• Mauna Kea Properties	0.95	1.50	2.48	1.50
• Hapuna State Park	0.02	0.20	0.04	0.85
• Puako Beach Lots	0.24	0.00	0.24	0.00
• Puako Beach Resort Parcels	0.00	0.00	0.25	0.00
• Tri-Kohala	0.00	0.00	0.37	0.00
• Mauna Lani Resort	1.34	3.30	3.56	6.50
• Nansay-Puako	0.00	0.00	2.52	3.23
Subtotal for KWTS Customers	2.82	4.80	18.70	17.13
Other Water Users				
• Landmark Estates	0.10	0.00	0.10	0.00
• Waikoloa Village and Highlands	1.51	0.70	4.90	2.50
• Waikoloa Beach Resort	2.13	3.55	5.10	5.10
Total for the South Kohala Region	6.56	9.05	28.80	24.73

pumpage or indirectly through irrigation return. Locations of all included land uses are shown in Figure 3. At present, virtually all water use in South Kohala is supplied by potable and brackish wells in the region. DWS imports only a very limited amount of surface water from Waimea Town to serve residences along the Waimea-Kawaihae Road. The area's three major resorts, Waikoloa, Mauna Lani, and Mauna Kea, make extensive use of treated wastewater to supplement brackish groundwater for golf course irrigation.

When the KWTS is operational, it is DWS' intention to phase out pumpage from its Lalamilo well field in South Kohala. The wells of the KWTS in North Kohala would have 500- to 600-foot pumping lifts. These would cost significantly less to operate than the 1100-foot pumping lifts of the Lalamilo wells. The Lalamilo wells would be relegated to backup sources of supply with negligible pumpage. The private Waikoloa Water Company would continue to supply Waikoloa Village, Highlands, and Beach Resort with its own potable and brackish wells and wastewater reuse.

Rainfall-Recharge in South Kohala. The natural flow of groundwater in the portion of South Kohala south of Kawaihae Harbor has been estimated in varying levels of detail in a number of studies: Cox, et al. 1969; Kanehiro and Peterson, 1977; Kay et al., 1977; Nance 1981 and 1992; Underwood and Shade, 1989; and George A.L. Yuen and Associates, 1992. The three most detailed of these studies (Kay et al., 1977, Kanehiro and Peterson, 1977, and Nance, 1981) are in close agreement that the natural flow of groundwater is approximately 6.5 MGD per coastal mile or about 60 MGD for the 9.4-mile segment coastline south of Kawaihae Harbor to the South Kohala-North Kona district boundary.

Although the 2.9 miles of shoreline extending from Kawaihae Harbor north to the district boundary is not as well studied, the rate of groundwater flow is significantly less than for the remainder of South Kohala. The areal extent of the inland watershed, experience with the several wells that have been drilled (none of which have been continuously pumped), and evidences of coastal discharge all indicate that the groundwater flow along this section of the coast is very limited. Estimates in George A.L. Yuen & Associates (1992), Nance (1992), and Underwood and Shade (1990), put the flow at 2.1, 1.7 and 1.0 MGD per coastal mile, respectively. An approximate average of these, 1.67 MGD per mile, is used as the rainfall-recharge rate for this section of the South Kohala coastline.

Distribution of Groundwater Flow from Kawaihae to Anaehoomalu. In addition to differentiating the groundwater flow north and south of Kawaihae Harbor, further distinctions in the flow along the coast from Kawaihae to Anaehoomalu are appropriate. Studies such as Cox, D. C. et al. (1969), Adams et al. (1969), Lao, et al. (1968), Fischer, et al. (1966) identify site specific shoreline discharges of groundwater using conductivity measurements, infrared aerial photography, and visual observations.

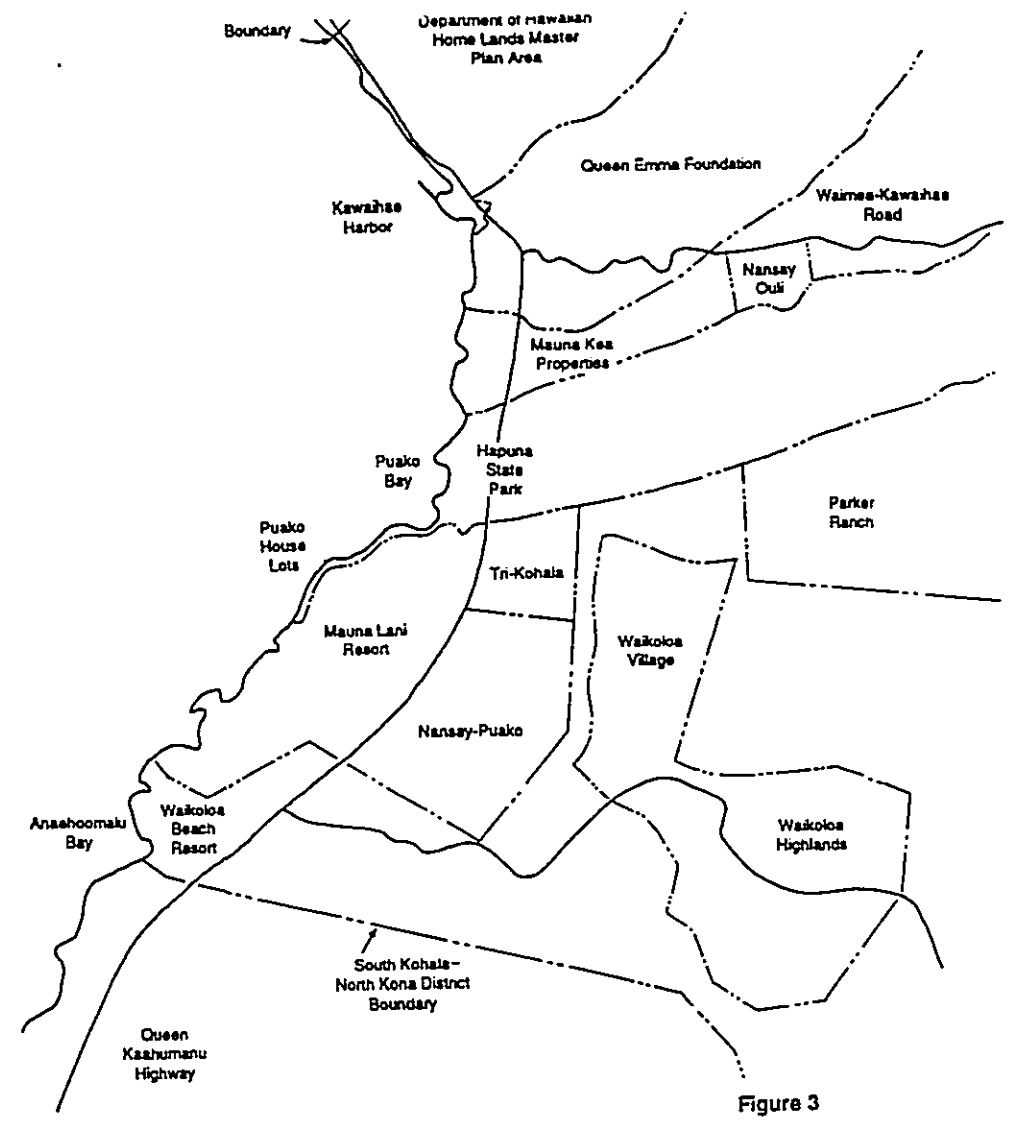

Figure 3
Land Ownerships and Project Areas in the South Kohala Coastal Region
Scale 1:100,000

However, the correlation among these studies is not particularly good and several significant discharge points known to the author of this study were missed in these surveys. The performances of wells, specifically their drawdown, initial water quality, and long term quality changes due to continuous pumping are the primary basis for the distribution of groundwater discharge in the mauka-makai corridors shown on Figure 4 and Table 8.

Groundwater Recharge due to Present and Future Water Uses. Water use patterns in South Kohala are unique. Plant evapotranspiration is very high -- potentially over 100 inches per year in a large portion of the resort development area -- and rainfall is as low as 10 inches per year (Figure 5). The ash soils are not extensive and their deposits are typically thin. Also, they have minimal moisture retention capability. Much of the present and forecast development is resort related, a land use which has substantially greater landscape irrigation requirements than other types of land uses. Despite the fact that the resorts make extensive use of brackish wells and recycled wastewater for irrigation, relatively small amounts of the potable water delivered to hotels and condominiums in the resorts returns to wastewater treatment plants. A large fraction of the potable supply delivered to these parcels is used for landscape irrigation.

At present, only 23 and 33 percent of the potable supply delivered to parcels within the Mauna Lani and Waikoloa Beach Resorts, respectively, returns to the wastewater treatment plants and is therefore available for reuse to irrigate golf courses. Most of the portion which does not appear at the treatment plants is used for landscape irrigation and a percentage of that, on the order of 25 to 30 percent, percolates to groundwater as irrigation return flow. A lesser amount of the potable supply is consumed by within-building uses at projects which are not connected to the centralized sewer system. This water use is delivered to individual treatment wastewater systems for which disposal is by cesspools, leach fields, and seepage pits. All of this water becomes direct groundwater recharge. Considering all these possibilities, is it estimated that 35 percent of potable water use in the resorts ultimately becomes groundwater recharge, either through irrigation return flow or by direct disposal from individual wastewater systems.

The pattern of potable water use in non-resort development in South Kohala is not as well documented. Waikoloa Village is the only such development for which quantification of water use and wastewater flowrates is possible. Approximately 40 percent of the Village's total water use is by customers connected to one or the other of the wastewater treatment plants along Auwaiakeakua and Kamakoa Gulches. Approximately 40 percent of the potable water delivered to these customers returns to these treatment plants. None of the effluent of either of these plants is presently reused; all of it is disposed of in shallow pits and becomes direct groundwater recharge. As a result, the fraction

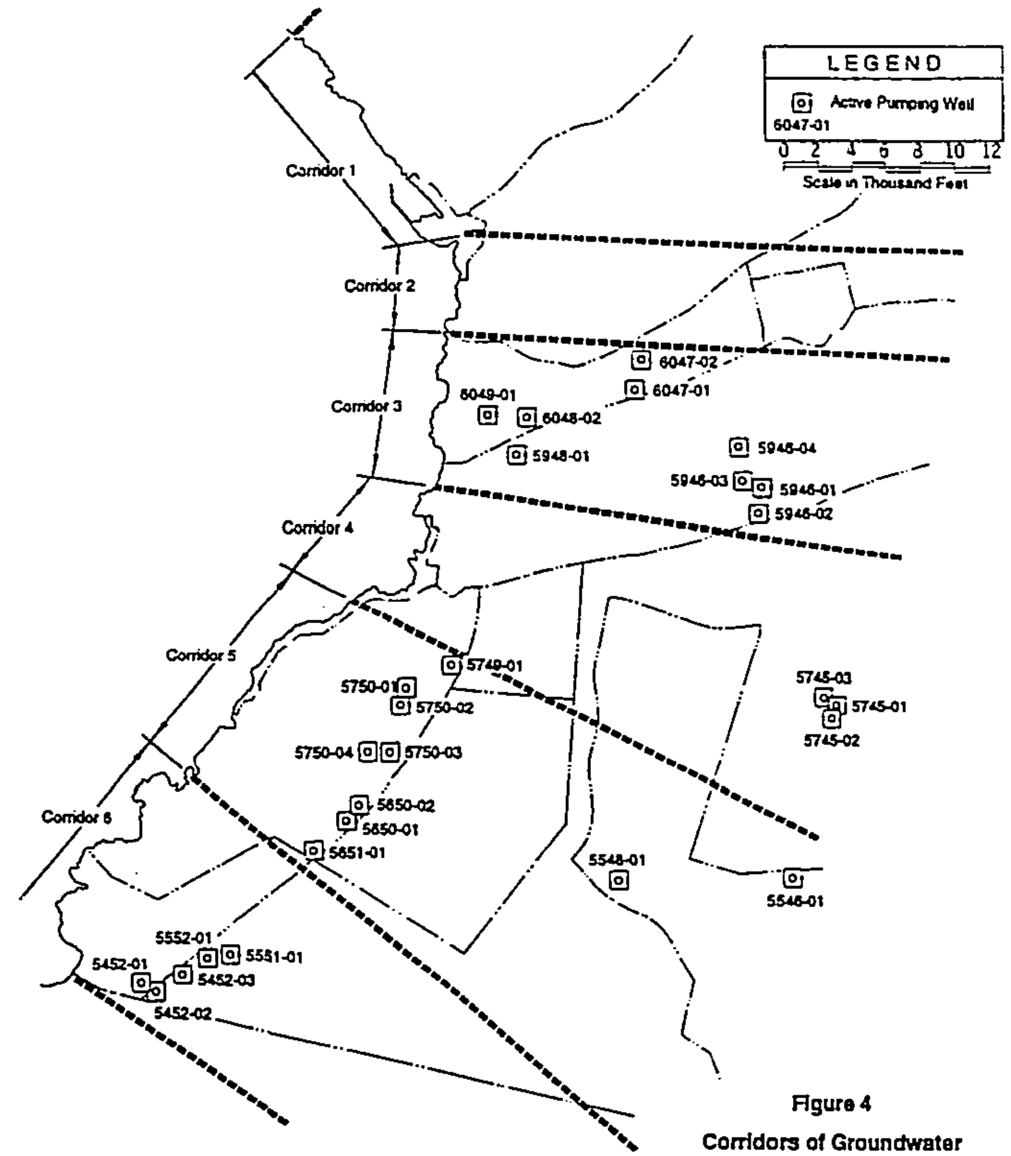

Figure 4
Corridors of Groundwater Flow in the South Kohala Coastal Region

Table 8

Distribution of Natural Groundwater Flows in South Kohala's Six Mauka-Makai Corridors

Corridor No.	Location	Coastline Length (Miles)	Rainfall-Recharge (MGD)
1	Kaiopae Point to Puukohala Heiau	2.93	5
2	Puukohala Heiau to Waiulaula Point	1.06	6
3	Waiulaula Point to Hapuna Bay	1.67	11
4	Hapuna Bay to Puako Point	1.52	14
5	Puako Point to Makaiwa Bay	2.61	11
6	Makaiwa Bay to Anaehoomalu Bay	2.51	18
	Totals	12.30	65

Notes:

1. Well development in Corridor 1 has included failures and moderate success inland (Wells 6448-01 and 6549-03 on DHHL property) and hot water (90° F) near the shoreline (Wells 6249-01 and 6250-04 and -05) which show no thermal input to the nearshore zone.

2. Less than the regional average flow in Corridor 2 is based on the pumping history of Wells 6148-01 and -02.

3. DWS' four Lalamilo wells (Nos. 5946-01 to -04), Mauna Kea Properties' four irrigation wells (Nos. 6048-01, 6049-01, and 6047-01 and -02), and the State's Hapuna Park well (No. 5948-01) have reasonable operating histories. Groundwater flow approximates the regional average.

4. Waikoloa's north well field (Wells 5745-01 to -03), Mauna Lani Resort's Parker wells (No. 5846-01 and -02), and MLR's north irrigation well (No. 5749-01) all suggest a high flow in Corridor 4 than the regional average.

5. The numerous wells in Corridor 5 all show poorer performance than the regional average: No. 5546-01 and 5548-01 in Waikoloa; No. 5648-04 in Nansay-Puako; and MLR's wells 5651-01, 5650-01 and -02; and 5750-01 to -04.

6. Waikoloa Beach Resort's irrigation wells are the region's best performing makai irrigation wells (Nos. 5452-01 to -03, 5551-01, and 5552-01). They demonstrate above average groundwater flow in Corridor 6.

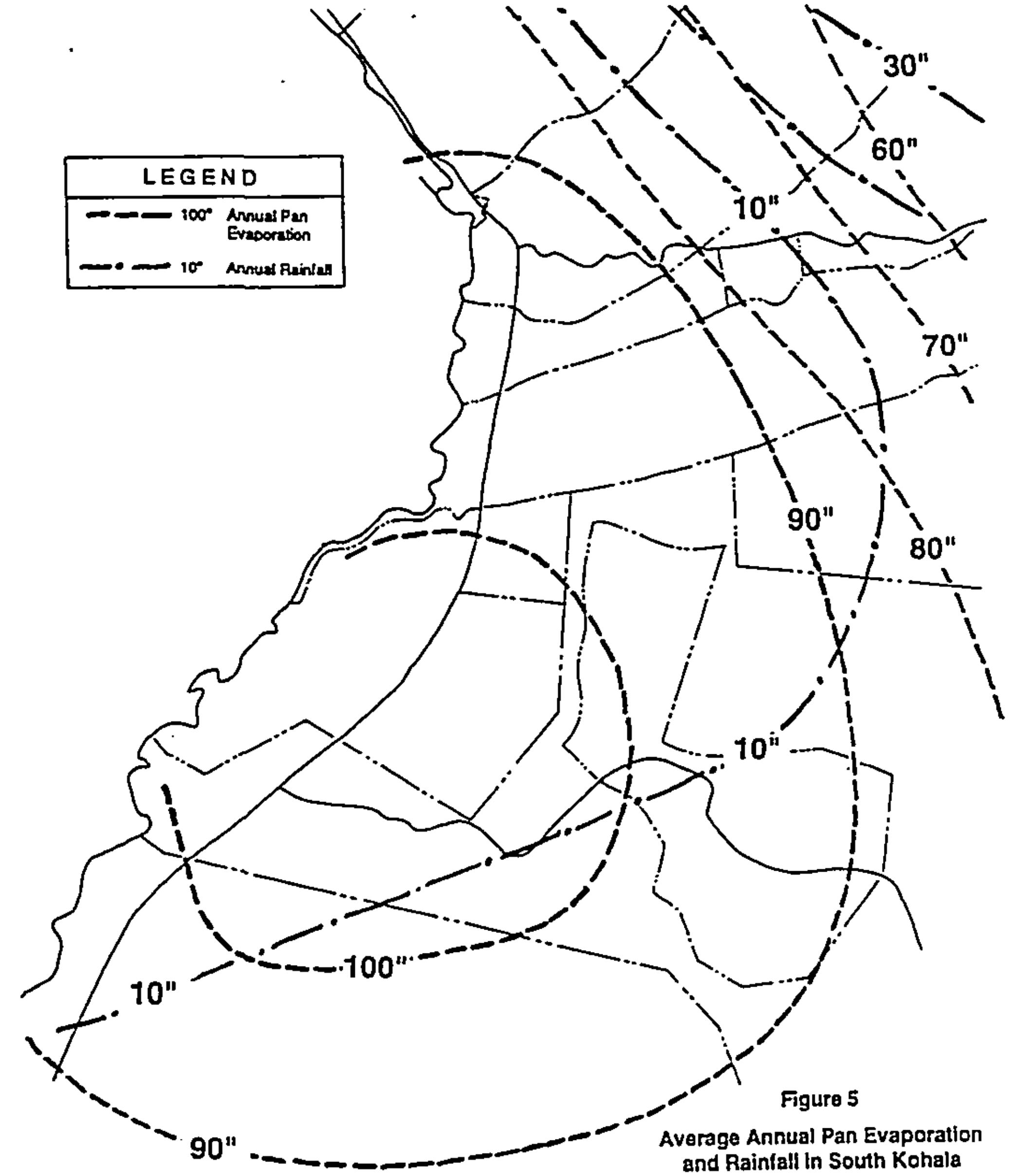

Figure 5

Average Annual Pan Evaporation and Rainfall in South Kohala

Scale 1:100,000

of potable use which becomes groundwater recharge is on the order of 55 percent (refer to the tally below). It is anticipated that future residential development will have a higher percentage of potable water customers connected to central sewer systems and that virtually all of the WWTP effluent will ultimately be reused for golf course or common area irrigation. These trends will bring the portion of potable supply that ultimately become groundwater recharge down to the same range that prevails in the resorts.

Present Disposition of Potable Water Use in Waikoloa Village
(Based on 1 MGD Rate of Supply)

	Plant Evapotranspiration (MGD)	Percolation to Groundwater (MGD)
Customers Connected to WWTP (40% of Total Supply)		
• Used for Landscape Irrigation (60%)		
• Plant Evapotranspiration (75%)	0.18	
• Deep Percolation (25%)		0.06
• Appears at WWTP; Disposal by Deep Percolation (40%)		0.16
Customers Not Connected to WWTP (60% of Total Supply)		
• Used for Landscape Irrigation (60%)		
• Plant Evapotranspiration (75%)	0.27	
• Deep Percolation (25%)		0.09
• Wastewater to Individual Treatment and Disposal Systems (40%)		
• Deep Percolation		0.24
Totals	0.45	0.55

Rates of golf course irrigation vary widely in South Kohala. At one extreme are the four courses at Mauna Lani Resort and Waikoloa Beach Resort where the application rates average about 1.5 MGD per 18-hole course. These courses have substantial areas in turf and their soils have generally poor moisture retention. Because the courses also experience high wind and solar radiation, these higher application rates are necessary to keep the courses green. At the other irrigation extreme is Mauna Kea's new "target" course at Hapuna. It has only 78 turf acres, reasonably good soil conditions, a fully automated (and monitored) irrigation system, and relatively low salinity water for

irrigation. Use by the Hapuna course averages 0.5 to 0.6 MGD. If it is assumed that evapotranspiration of turf grass is equal to the pan evaporation rate and if credit for all rainfall being fully utilized by the grass is made, the following per acre, average supply requirements for golf courses in South Kohala emerge:

Present or Future Golf Course Location	Average GPD/Acre
• Mauna Lani, Waikoloa Beach Resort and Village, and Nansay-Puako	6,700
• Mauna Kea Beach Hotel, Hapuna, and Waikoloa Heights and Highlands	6,300
• Nansay-Ouli	5,800

Estimates of groundwater recharge rates within existing and future golf courses listed in Table 9 are the difference between these plant requirements and the actual and anticipated application rates.

Resulting Changes to the Shoreline Discharge of Groundwater. Prior to 1960, there was no pumpage of groundwater in South Kohala and the import of surface water was limited to small amounts brought down from Waimea to Kawaihae Harbor and house lots along Puako Beach Road. The prevailing discharge of groundwater into the coastal environment was due almost exclusively due to rainfall recharge. This amount, distributed in the six mauka-makai corridors, is shown on Table 8. The total discharge along the 12.3-mile coastline of South Kohala is estimated to have been 65 MGD.

At the present time, all drinking water in the region except for minor amounts in Landmark Estates is supplied by deep (1200-foot) wells at Lalamilo and Waikoloa. Golf course irrigation is supplied by brackish wells and treated sewage effluent. Total potable and brackish pumpage of groundwater is approximately 15 MGD (see Table 10). Applying the water use and wastewater reuse patterns discussed above, computations of the present shoreline discharge of groundwater is presented on Table 11. This amount is approximately 10 MGD lower than in 1960. All of the reductions have occurred within the coastal segment from Waiulaula Point (near the Mauna Kea Beach Hotel) to Anaehoomalu Bay, an area which includes South Kohala's three major resorts. Only minimal development has occurred in the two northernmost corridors and it has had very little impact on groundwater.

The estimate of the change in groundwater discharge into the marine environment when full use of the KWTS is achieved incorporates the following assumptions:

Table 9

Estimates of Groundwater Recharge by Golf Course Irrigation

Existing or Future Golf Course	Plant Evapotranspiration (%)	Groundwater Recharge (%)
• Mauna Lani Resort (Existing)	60	40
• Mauna Lani Resort (Future)	70	30
• Waikoloa Beach Resort (Existing)	60	40
• Waikoloa Beach Resort (Future)	70	30
• Waikoloa Village, Heights, and Highlands	85	15
• Mauna Kea Beach Hotel	85	15
• Hapuna - MKP	90	10
• Nansay - Ouli	85	15
• Nansay - Puako	75	25
• DHHL	80	20
• Hapuna - State Park	85	15

Table 10

Summary of Present Pumping Wells In South Kohala

State Number	Owner	Area Supplied	Average Pumping Rate (MGD)
5546-01 5745-01 5745-02 5745-03	Waikoloa Water Company	Drinking water for Waikoloa Village and Waikoloa Beach Resort	3.64
5946-01 5946-02 5946-03 5946-04	Hawaii County DWS	Drinking water for Kawaihae, Mauna Kea, Puako, and Mauna Lani Resort	2.82
5548-01	Waikoloa Water Company	Village Golf Course Irrigation	0.7
5452-01 5452-02 5452-03 5551-01 5552-01	Waikoloa Water Company	Irrigation of the two Waikoloa Beach Resort Golf Courses and Some Roadway Landscaping	3.0
5651-01 5650-01 5650-02 5750-01 5750-02 5750-03 5750-04 5749-01	Mauna Lani Resort	Irrigation of Mauna Lani's two golf courses and some roadway landscaping	3.0
5948-01	State of Hawaii	Irrigation of Hapuna Park	0.2
6048-02 6049-01 6047-01 6047-02	Mauna Kea Properties	Irrigation of two golf courses and roadway landscaping	1.5
Total Groundwater Pumpage			14.9

Table 11

Estimated Groundwater Discharge at the Shoreline for Present Land Use and Groundwater Pumpage

Item	Present Development in the Mauka-Makai Corridor						Total For All Six Corridors
	1	2	3	4	5	6	
Land Uses in the Mauka-Makai Corridor	Kawaihae Harbor	Kawaihae Village Landmark Estates	Mauna Kea Resort South Kohala Resort Hapuna State Park (Portion)	Hapuna State Park (Portion)	Puako Beach Lots Mauna Lani Resort (Portion) Waikoloa Village	Mauna Lani Resort (Portion) Waikoloa Beach Resort	
Natural Flow of Groundwater in the Mauka-Makai Corridor (MGD)	5.00	6.00	11.00	14.00	11.00	18.00	65.00
Water Use in the Corridor:							
• Potable (MGD)	0.04	0.20	1.04	0.00	3.05	2.13	6.46
• Non-Potable (MGD)	0.00	0.00	1.90	0.00	2.48	3.55	7.93
Groundwater Pumpage in the Corridor:							
• Potable (MGD)	0.00	0.00	2.82	2.90	0.75	0.00	6.47
• Brackish (MGD)	0.00	0.00	1.70	0.00	3.70	3.00	8.40
Groundwater Recharge by Water Uses in the Corridor (MGD)	0.02	0.10	0.56	0.00	2.49	1.92	5.09
Resulting Groundwater Discharge at the Shoreline (MGD)	5.02	6.10	7.04	11.10	9.04	16.92	55.22

- All drinking water supplied by the County DWS will be imported through the KWTS. DWS' Lalamilo wells will be standby sources and will have essentially negligible pumpage.

- Non-potable supply requirements within the DHHL Master Plan area will be supplied by Kehena Ditch and, to a lesser extent, wastewater reuse. No onsite brackish wells will be developed in this area. The Kehena Ditch is available to DHHL and groundwater conditions underlying the property are not conducive to well development.

- As depicted in Table 12, reuse of wastewater for golf course and other landscaping will be more extensive in the future than at present. The impetus for this will be provided by diminishing brackish groundwater quality (in Corridor 5 particularly), regulatory restrictions on wastewater disposal inland of the UIC line, and the economics of reuse in comparison to the alternatives.

- Waikoloa Water Company will continue to supply all requirements of Waikoloa Village, Waikoloa Highlands, and the Waikoloa Beach Resort using wells within its property. Its future requirements are 9.9 MGD of potable groundwater pumpage and 7.6 MGD of non-potable supply, the latter to be supplied by wastewater reuse as well as brackish wells.

The accounting of future groundwater discharge into the marine environment is presented on Table 13. Imported supplies of 19.3 MGD by the KWTS and 4.3 MGD by the Kehena Ditch are offset by total groundwater pumpage of 24.4 MGD. As a result, the change in the amount of groundwater discharged at the shoreline is relatively modest. Total discharge along the 12.3-mile shoreline would be 57.8 MGD, just 2.6 MGD or 4.7 percent higher than at present and 7.2 MGD or 11 percent lower than prevailed in 1960. However, significant changes would occur in several of the mauka-makai corridors. The largest change would be along the 2.9 coastal miles of Corridor 1 north of Kawaihae Harbor where the discharge would be more than double the present rate. In this corridor, 11 MGD of potable and non-potable water would be brought into the DHHL property area and there would be no groundwater pumpage.

For the combined 4.1 coastal miles of Corridors 4 and 5, groundwater discharge would be reduced from 25 MGD in 1960 and 20.1 MGD at present to 13 MGD at full use of the KWTS. These corridors contain all of Waikoloa's drinking water wells and would have 14 golf courses when fully developed (5 courses in Mauna Lani Resort, 6 in Nansay-Puako, and the Waikoloa Village, Heights, and Highlands courses).

Table 12

Forecast Future Reuse of Wastewater for Golf Course Irrigation, Reducing the Prospective Pumpage From Brackish Wells

Land Ownership / Land Use	Disposal of Wastewater
• Department of Hawaiian Home Lands • Kawaihae Harbor • Kawaihae Village • Puako House Lots • Tri-Kohala • Nansay-Ouli • Waikoloa Highlands • Mauna Kea Uplands	100% to Direct Groundwater Recharge
• Mauna Lani Resort • Puako Resort • Waikoloa Beach Resort • Mauna Kea Resort (Except the Uplands)	80% to Centralized Treatment Plant and Golf Course Reuse; Balance to Direct Groundwater Recharge
• Waikoloa Village →	40% to Centralized Treatment Plant, half of which is Golf Course Reuse; Balance to Direct Groundwater Recharge
• Nansay-Puako →	40% to Centralized Treatment Plant and Golf Course Reuse; Balance to Direct Groundwater Recharge

Table 13

Estimated Groundwater Discharge at the Shoreline for Future Land Use and Groundwater Pumpage

Item	Present Development in the Mauka-Makai Corridor						Total For All Six Corridors
	1	2	3	4	5	6	
Land Ownership and/or Land Uses in the Mauka-Makai Corridor	DHHL Kawaihae Harbor	Queen Emma Foundation Kawaihae Village Landmark Estates Nansay-Ouli Mauna Kea Uplands (Portion)	Mauna Kea Resort South Kohala Resort Mauna Kea Uplands (Portion) Hapuna State Park (Portion)	Hapuna State Park (Portion) Tri-Kohala Waikoloa Heights	Puako Beach Lots Puako Resort Mauna Lani Resort (Portion) Nansay-Puako Waikoloa Village and Highlands	Mauna Lani Resort (Portion) Waikoloa Beach Resort	
Natural Flow of Groundwater in the Mauka-Makai Corridor (MGD)	5.00	6.00	11.00	14.00	11.00	18.00	65.00
Water Use in the Corridor:							
• Potable (MGD)	7.24	2.30	2.00	2.52	9.47	5.63	29.16
• Non-Potable (MGD)	5.04	1.00	1.83	1.22	10.83	6.00	25.92
Groundwater Pumpage in the Corridor:							
• Potable (MGD)	0.00	0.00	0.00	6.00	4.00	0.00	10.00
• Brackish (MGD)	0.00	0.70	1.31	0.30	8.55	3.57	14.43
Groundwater Recharge by Water Uses in the Corridor (MGD)	4.48	1.21	1.06	1.13	6.07	3.30	17.25
Resulting Groundwater Discharge at the Shoreline (MGD)	9.48	6.51	10.75	8.83	4.52	17.73	57.82

Nutrients Discharged by Groundwater Into the South Kohala Marine Environment

To translate the computed groundwater discharge rates to the equivalent weights of nitrogen and phosphorus carried into the marine environment, past water quality analyses were compiled and sampling and testing of a number of wells were undertaken. Table 14 is a compilation of recent water quality analyses, including those undertaken for this study. Data for wells within Mauna Lani Resort, Waikoloa Beach Resort, Waikoloa Village, and Mauna Kea Resort are averages of sampling from the extensive monitoring programs carried out for each of these resorts. The Mauna Lani Resort program, which was done by Marine Research Consultants (Dr. Steven Dollar), includes monthly results over a two-year period (1992-93). Waikoloa monitoring is being done by Dr. Richard Brock. Its values in Table 14 are the average of three quarterly samplings in 1994. Data wells within Mauna Kea Resort are the average of five samplings from April 1992 to February 1994 by Marine Research Consultants.

Table 15 is a compilation of historic water quality data from the 1960s through the 1980s. For wells listed in both Tables 14 and 15, the data provide an indication of historic trends in water quality, some of which may be attributable to development in the intervening years. Table 16 compares nutrient levels in Waikoloa Beach Resort irrigation wells located mauka of Queen Kaahumanu Highway with the nutrient levels in anchialine ponds located within and makai of the Resort's two golf courses. It indicates that the golf courses may increase nitrogen levels by about 25 percent. However, the apparent increase in phosphorus is not attributed to the golf courses. Natural processes, not yet completely understood, create levels as high as 6 µM for total phosphorus in anchialine ponds in pristine areas beyond man's influence (Richard Brock, personal communication).

Utilizing the data in Tables 14, 15, and 16 and anticipating the influence of future development on groundwater quality, different levels of nitrogen and phosphorus concentrations are assigned for each of the six corridors and for the three time periods (1960, at present, and at future, full use of the KWTS). These levels are compiled in Table 17. The final step matches these concentrations with the appropriate groundwater flowrates by corridor and development period to estimate the amounts of nutrients discharged into the marine environment. These results are compiled in Table 18. For both nitrogen and phosphorus, present nutrient discharge is 5 to 7 percent less than it was in 1960. Future discharges with full use of the KWTS would be 15 percent higher than in 1960. The significance of these changes is evaluated in a companion study by Marine Research Consultants.

Table 14

Recent Analyses of the Groundwater Chemistry of South Kohala Wells

State Well No.	Date Sampled	Sample Type	Nitrogen: NO_3 (µM)	Nitrogen: NH_4 (µM)	Nitrogen: Total N (µM)	Phosphorus: PO_4 (µM)	Phosphorus: Total P (µM)	Silica (µM)	Salinity (PPT)	Source of Data
Kawaihae Cogen	11-28-94	Grab	78.84	0.14	80.84	0.98	1.04	874	2.748	TNWRE/Marine Analytical Specialists
6250-04	11-14-94	Grab	88.74	0.22	89.07	0.52	0.88	862	3.289	
6047-01	Ave. of Five Samples	Pumped	69.07	0.18	71.36	2.21	2.26	839	0.753	Mauna Kea Properties Monitoring Program by Marine Research Consultants
6047-02	April 92 to Feb. 94	Pumped	78.08	0.09	81.04	2.69	2.40	841	0.961	
6048-02	April 92 to Feb. 94	Pumped	83.64	0.36	88.47	3.82	3.88	854	1.106	
6049-01	April 92 to Feb. 94	Pumped	81.78	0.10	85.82	2.41	2.46	828	1.222	
6848-01	11-28-94	Pumped	78.31	0.05	91.29	2.02	2.09	892	1.253	TNWRE/Marine Analytical Specialists
5946-01	11-14-94	Pumped	84.47	0.02	88.82	2.80	2.97	767	0.343	
5946-03	11-14-94	Pumped	84.85	0.84	88.40	4.00	4.08	767	0.378	
5946-04	11-14-94	Pumped	84.88	0.08	87.22	2.71	2.82	762	0.501	
5850-01	Ave. for 1992-93	Pumped	70.29	0.70	73.54	1.05	1.13	700	2.004	Mauna Lani Resort Monitoring Program by Marine Research Consultants
5850-02	Ave. for 1992-93	Pumped	99.08	0.07	102.54	1.43	1.53	850	1.826	
5750-01	Ave. for 1992-93	Pumped	87.83	0.08	91.59	1.86	1.74	851	2.018	
5750-02	Ave. for 1992-93	Pumped	115.85	0.83	121.42	1.81	1.98	855	1.861	
5750-03	Ave. for 1992-93	Pumped	108.88	0.07	112.78	1.40	1.46	853	2.065	
5750-04	Ave. for 1992-93	Pumped	153.94	0.06	157.89	2.38	2.45	792	1.959	
5749-01	Ave. for 1992-93	Pumped	84.40	0.14	87.88	1.57	1.66	811	1.601	
5745-03	Ave. for 1993	Pumped	89.11	0.08	92.72	2.12	2.24	895	0.234	
5546-01	Ave. for 1993	Pumped	88.89	0.11	93.31	2.00	2.12	910	0.411	
5548-01	Ave. for 1993	Pumped	68.28	0.15	72.81	1.14	1.25	884	1.390	
5452-03	Ave. for 1994	Pumped	39.56	0.20	48.22	1.62	1.77	874	1.307	Waikoloa Beach Resort Monitoring Program by Dr. Richard Brock
5552-01	Ave. for 1994	Pumped	43.05	0.41	51.83	1.61	1.78	890	1.212	

Table 15

Available Well Water Quality Data From the 1960s Through the 1980s

State Well No.	Mauka-Makai Corridor	Sample Date	Nitrate Nitrogen (NO_3 - N) MG/L	Nitrate Nitrogen (NO_3 - N) µM	Silica (SiO_2) MG/L	Silica (SiO_2) µM	Total Dissolved Solids (PPT)	Source of Data
6147-01	2	6-25-63	0.65	47	89.2	1484	0.796	DOWALD (1963)
6148-01	2	3-22-72	0.86	61	66	1098	0.741	Swain (1973)
5946-01	3	7-19-77	--	--	55	915	0.285	USGS Files
5946-02	3	5-9-80	1.8	129	58	965	0.212	USGS Files
5946-03	3	11-2-81	1.32	94	57	948	0.284	TNWRE Files
		7-20-81	1.22	87	--	--	0.249	TNWRE Files
5946-04	3	1-11-85	0.85	60	--	--	0.285	TNWRE Files
5948-01	3	4-9-70	1.20	86	49	790	0.921	Swain (1973)
6048-02	3	5-17-72	0.43	31	51	849	0.838	Swain (1973)
6049-01	3	5-17-72	0.86	61	51	849	0.837	Swain (1973)
5745-01	4	6-29-70	1.35	97	56	932	0.206	Swain (1973)
		4-5-72	0.86	61	80	1331	0.234	Swain (1973)
5548-01	5	2-7-69	0.45	32	--	--	1.205	Fett (1969)
		10-27-71	0.86	61	56	932	1.180	Swain (1973)
		4-3-72	0.70	50	82	1364	1.230	Swain (1973)
5750-01	5	8-28-68	0.45	32	--	--	1.360	Fett (1968)
		12-14-78	1.01	72	--	--	1.450	TNWRE Files

Table 16

Comparison of the Water Quality of "Upstream" Brackish Irrigation Wells and "Downstream" Anchialine Ponds at Waikoloa Beach Resort

Sample Date	Sample Type	Total N (µM)	Total P (µM)	Silica (µM)	Salinity (PPT)
3-31-94	Average of Three Wells	52.3	1.94	827	1.43
	Average of 5 Anchialine Pools	63.9	4.53	721	7.40
6-7-94	Average of Three Wells	43.9	1.64	916	1.43
	Average of 5 Anchialine Pools	59.3	4.08	797	6.56
10-10-94	Average of Three Wells	52.6	1.60	874	1.41
	Average of 5 Anchialine Pools	66.0	4.08	718	7.49

Note: All data from periodic Waikoloa monitoring reports prepared by Dr. Richard Brock.

Table 17

Nitrogen and Phosphorus Concentrations Used to Compute Nutrient Input of Groundwater to the Marine Environment

Corridor No.	Indicator Wells	Total Nitrogen (μM)			Total Phosphorus (μM)		
		1960	At Present	Future	1960	At Present	Future
1	6250-04 and Kawaihae Cogen	85	85	100	0.9	0.9	1.1
2	6147-01 and 6148-01	70	85	100	1.5	1.8	2.1
3	5946-01, -03, & -04; 6047-01 & -02; 6048-02; 6049-01; and 5948-01	80	85	100	2.6	2.8	3.2
4	5745-01 & -03 and 5749-01	85	90	110	1.9	2.0	2.4
5	5546-01; 5548-01; 5750-01, -02, -03, & -04; and 5650-01 & -02	90	100	120	1.5	1.7	2.0
6	5452-03 and 5552-01	50	62	75	1.4	1.8	2.2

Table 18

Changes in the Amounts of Nitrogen and Phosphorus Discharged Into the South Kohala Marine Environment by Groundwater In 1960, at Present, and at Full Use of the KWTS

Mauka-Makai Corridor No.	Total Nitrogen Discharge at the Shoreline (Lbs./Day)			Total Phosphorus Discharge at the Shoreline (Lbs./Day)		
	1960	At Present	Future	1960	At Present	Future
1	50	50	111	1.2	1.2	2.7
2	49	61	76	2.3	2.8	3.5
3	103	70	126	7.4	5.1	8.9
4	139	117	114	6.9	5.7	5.5
5	116	106	63	4.3	4.0	2.2
6	105	123	155	6.5	7.9	10.1
All Six	562	537	645	28.6	26.7	32.9

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ASSESSMENT OF IMPACTS TO WATER QUALITY AND MARINE COMMUNITY STRUCTURE FROM THE PROPOSED KOHALA WATER TRANSMISSION SYSTEM, KOHALA COAST, ISLAND OF HAWAII

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I. EXECUTIVE SUMMARY

The proposed Kohala Water Transmission System will divert approximately 20 MGD of potable groundwater from the Hawi aquifer of North Kohala to South Kohala. The project will take place in two phases with each phase diverting approximately 10 MGD. This action will decrease the discharge of groundwater at the shoreline in North Kohala, and increase discharge in some areas of South Kohala. Discharge will also decrease in some areas of South Kohala because of increased usage.

Several studies were conducted to determine the potential effect of the proposed project on water chemistry and marine community structure. Of particular interest with respect to marine communities were edible benthic algae (limu) in North Kohala and reef-building corals in South Kohala. Concern for these two aspects of the marine ecosystem were centered on the perceptions that: 1) limu depend on nutrients from land for growth, and a reduction of these nutrients will result in decreased algal abundance, and; 2) corals can be negatively impacted by changes in water chemistry as a result of input of materials from land.

The studies revealed that there appears to be no potential for negative impacts to marine ecosystems in either North or South Kohala from the diversion of groundwater. The primary reasons for this conclusion stem from the physical properties of the marine environments in both districts. Direct exposure to tradewind generated wind and swells, as well as long period swells from the north result in extremely well-mixed nearshore environment in North Kohala. As a result, groundwater diffusing to the ocean is rapidly diluted by the infinitely large reservoir of ocean water to background oceanic concentrations. Measurements made during rare conditions when seas were relatively calm showed only relatively small horizontal and vertical gradients of groundwater constituents (freshwater, NO_3^- and PO_4^{3-}). Reducing these gradients by the amount of groundwater that is proposed to be pumped South Kohala would have virtually no qualitative effect on nearshore water chemistry. During typical conditions, the effect of such pumpage would likely not even be measurable. In addition, the effects of the project will be insignificant because the primary input of freshwater to the coastal region of North Kohala is by surface flow (streams) which will not be affected by the alteration in groundwater flow.

Measurements of the ratio of stable isotopes $^{15}N/^{14}N$ have proven to provide a reliable tracer for the origin of nutrients incorporated into tissue of marine plants. Measurements of $\delta^{15}N$ in marine algae (limu) collected in coastal areas revealed that plants growing in freshwater (streams or groundwater) have a distinctly different $\delta^{15}N$ signature than plants growing in oceanic waters. Limu collected on the rocks in the area of mixing between

freshwater and ocean water had ratios that were primarily oceanic in nature. While sampling was limited due to dangerous sea conditions, the isotopic ratio of limu kohu collected offshore revealed that tissue N was totally of oceanic origin. These results indicate that marine waters without influence from land contain sufficient nutrients for growth of limu that is used as a foodsource. Owing to the intense mixing that characterizes the nearshore area of North Kohala, groundwater is rapidly diluted to oceanic concentrations within the zone that most algae grows. In addition, because of the diffuse discharge characteristics of groundwater in the North Kohala area, limu responding to freshwater are generally growing with input from point source stream discharge which will not be affected by the proposed project. These results indicate that changes in groundwater discharge will not have any affect on marine algae.

As reef corals typically grow in oceanic water, it is important to consider the potential for negative effects from changes in groundwater input that will occur as a result of the proposed project. There will be no effects to reef corals or associated communities in North Kohala where groundwater input to the ocean will be decreased. While groundwater input will increase with the project in parts of South Kohala, the scientific literature documents that corals can tolerate decreases in salinity and increases in nutrients to certain levels. Measurements of the gradients of salinity and nutrients at the South Kohala study sites indicate that while there are steep gradients of salinity and nutrients near the shoreline, there is no effect to coral abundance. With the increase in groundwater flux associated with the project, water chemistry will not change from present conditions with respect to exceeding the physiological tolerances of corals. At present, well-developed coral communities exist in the regions of highest groundwater input. In addition, regardless of the level of input, groundwater that enters the ocean and is not diluted with ocean water persists as a surface layer that is not exposed to bottom-dwelling organisms. In sum, it is clear that the projected changes in groundwater flux from the Kohala Water Transmission System will not have any effect on nearshore marine communities.

II. PROJECT BACKGROUND

The purpose of the Kohala Water Transmission System (KWTS) project is to supplement the Hawaii County, South Kohala Kawaihae-Lalamilo-Puako water system with 20 million gallons per day (mgd) of potable groundwater from the Hawi aquifer in North Kohala. South Kohala is the only district on the island where the estimated future water need is greater than sources available within the district. The proposed KWTS project would also upgrade the existing county water systems in North Kohala to utilize only groundwater (rather than the existing dependency on surface water) to improve supply and reliability, and to meet safe drinking water regulations.

As proposed, the project will consist of a 25 mile, 36 inch underground pipeline that will extend from North Kohala (between Niulii and Honomakau) to South Kohala (Puako). The well sites are projected to be developed in two phases with a capacity of 10 mgd for each phase. Reservoirs will also be constructed at four sites (Puakea, Kawaihae, Kaunaoa and Lalamilo) along the route in conjunction with Phases 1 and 2 well development needs. A single pressure reducing reservoir will be located in the area north of Kohala Ranch. The timetable of first phase of the project estimates completion in approximately 1998, with the completion of the second phase beyond approximately 2005.

Because the proposed project will alter to some extent input of groundwater at both the North Kohala source and South Kohala receiving sites, it is important to address the potential changes that such alteration in groundwater dynamics may have on the marine ecosystem. Thus, as part of the preliminary documentation to address effects of the proposed project, studies were conducted to assess the marine ecosystems off both North and South Kohala. The objectives of these studies are threefold:

1) to determine what the effect of the project will be on nearshore water chemistry. Because biotic communities are affected by the composition of the water in which they live, it is important to understand the alteration to horizontal and vertical gradients of salinity and dissolved materials that would occur as a result of the project;

2) to determine the effect of the project on the abundance of marine algae (limu) in the coastal areas of North Kohala. This study was conducted to address concerns that the project will decrease nutrient input to a degree that algal stocks will be diminished. Stable isotopes of nitrogen were used as the analytical tool to determine the source of nitrogen in the tissues of limu presently growing along the North Kohala coastline;

3) to determine the potential effect of the project on the growth and abundance of reef-building corals in the donor and receiving sites. As stony corals are considered a "keystone" species on which much of remaining community components rely for food and shelter, understanding the effects to corals will provide an important basis for evaluating the effect of the project on the entire marine ecosystem.

These studies provide the basis for evaluation of possible environmental consequences of the proposed project. Presented below are the methods, results and discussion of the assessment of the marine environment in the vicinity of Kohala Water Transmission System.

III. WATER CHEMISTRY

A. METHODS

The primary result of the proposed activity will be alteration of the present scenario of groundwater efflux to the coastal ocean; efflux will be reduced somewhat in North Kohala, and increased in South Kohala. In order to determine the potential effect of such alterations, a baseline of pre-project water chemistry conditions was established. The sampling rationale of the study was designed to evaluate input of groundwater to the coastal ocean from the shoreline, and the fate of this groundwater once it enters the ocean. Based on the results of these evaluations, as well as estimates of alteration of groundwater discharge resulting from the project, it is possible to predict what the changes to nearshore water chemistry will be with the project in effect.

Water samples were collected at the surface and near the bottom at 6 sites; 2 of the sites were located off North Kohala and 4 sites were located off South Kohala. Because the emphasis of the present studies is to determine the effects of alteration of groundwater efflux from pumpage of wells in specific areas, sampling sites were selected in areas with no influence from streamflow. Such site selection was difficult in the North Kohala area as numerous permanent streams reach the shoreline along much of the coast downslope from the projected well locations. Inspection of the area downslope from the projected Phase I and II revealed limited areas that were neither subjected to stream runoff nor offshore of cliffs that formed the shoreline. Cliffed areas were avoided because such regions are not generally sites of measurable groundwater input, owing to both intense mixing and low groundwater discharge. Geographical regions where groundwater is known to enter the ocean in relatively high quantities are inlets with low-lying coastal area.

In the North Kohala region, the two areas selected for study appeared to have the composite properties to receive measurable groundwater input. Site 1 was located in Kapana

Bay off of Kaheo Point, while Site 2 was in Keawaeli Bay off of Kauhola Point (See Figure 1). These sites also lie directly below the locations of the proposed Phase 1 and Phase 2 well sites.

Sampling sites in South Kohala were based on somewhat different criteria because there are few permanent streams in the area. Sites were selected off of areas of known high and low groundwater input, and in areas of high and low exposure to physical mixing processes (e.g. sheltered areas in coves, and exposed open coastal areas). Site 3 was located off the Kawaihae Lighthouse in an area of low groundwater input and open coastal exposure; Site 4 was located off Spencer Beach Park in an area of high groundwater input and open coastal exposure; Site 5 was located in Puako Bay in an area of high groundwater input and low mixing; and Site 5 located in Honokaope Bay was an area of low groundwater input and low mixing (See Figure 2).

Water sampling was conducted on August 7, 1994 at the South Kohala sites, and on September 2, 1994 at the North Kohala sites. Sea conditions during the sampling at both locations consisted of light and variable winds and very little swell. While such conditions are typical of the South Kohala region, they are clearly atypical for North Kohala. As a result of direct exposure to tradewinds and tradewind generated seas, typical marine conditions off North Kohala are high winds and pounding surf on the shoreline. These conditions obviously result in very vigorous mixing of land-derived freshwater and oceanic water in the coastal zone. Thus, the day selected for sampling with mild winds and swell represents conditions of minimal mixing where dilution of effluxing freshwater with seawater is substantially lower than during typical tradewind conditions. As a result, the survey results during calm conditions provide a representative estimate of what can be considered "end-point" conditions revealing maximum gradients of freshwater-seawater mixing. During typical tradewind weather gradients between freshwater and seawater will be far less pronounced.

Sampling was at both regions done using a 19-foot boat, and by divers swimming from the boat to the shoreline. Water samples were collected from the boat using a 1.8 liter Niskin-type oceanographic sampling bottle. The bottle was lowered to the desired sampling depth with endcaps cocked in an open position so that water flowed freely through the bottle. At the desired depth a weighted messenger released from the surface tripped the endcaps closed, isolating a volume of water from the desired sampling depth. At all sampling stations, two water samples were collected; a surface sample from within 10 centimeters (cm) of the air-sea interface, and a deep sample within 50 cm of the ocean floor. Inshore samples were collected by swimmers who filled 1-liter polyethylene bottles at the desired locations.

Water quality constituents that were evaluated include the 10 specific criteria designated for open coastal waters in Chapter 11-54, Section 06 (Pearl Harbor waters) of the Water

Quality Standards, Department of Health, State of Hawaii. These criteria include: total dissolved nitrogen (TDN), nitrate + nitrite nitrogen ($NO_3^- + NO_2^-$), ammonium (NH_4^+), total dissolved phosphorus (TDP), chlorophyll a (Chl a), turbidity, salinity, pH and temperature. In addition, orthophosphate phosphorus (PO_4^{-3}) and silica (Si) are also reported because these constituents can be indicators of biological activity and the degree of groundwater or streamwater mixing.

Subsamples for nutrient analyses were immediately passed through sub-micron filters (GF-F) into 125-milliliter (ml) acid-washed, triple rinsed, polyethylene bottles and stored on ice until returned to the laboratory. Analyses for NH_4^+, PO_4^{3-}, NO_3^-, and Si were performed using a Technicon autoanalyzer according to standard methods for seawater analysis (Strickland and Parsons 1968, Grasshoff 1983). TDN and TDP were analyzed in a similar fashion following oxidative digestion. Dissolved organic nitrogen (DON) and dissolved organic phosphorus (DOP) were calculated as the difference between TDN and dissolved inorganic N, and TDP and dissolved inorganic P, respectively. The level of detection for the dissolved nutrients is 0.2 μM for TDN and Si, 0.02 μM for TDP, and 0.01 μM for PO_4^{3-}, NO_3^- and NH_4^+.

Water for other analyses was subsampled from 1-liter polyethylene bottles and kept chilled until analysis. Turbidity was determined on 60-ml subsamples fixed with $HgCl_2$ to terminate biological activity. Fixed samples were kept refrigerated until turbidity was measured on a Monitek Model 21 90-degree nephelometer, and reported in nephelometric turbidity units (ntu) (level of detection 0.01 ntu). Chl a was measured by filtering 300 ml of water through glass fiber filters; pigments on filters were extracted in 90% acetone in the dark at -5° C for 12-24 hours, and the fluorescence before and after acidification of the extract was measured with a Turner Designs fluorometer (level of detection 0.01 μg/L). Salinity was determined using an AGE Model 2100 laboratory salinometer with a precision of 0.0003 ‰.

Water temperature was measured in the field with a hand-held mercury thermometer with a readability of 0.1°C. pH was determined using a field meter with a combination electrode with precision of 0.01 pH units. Continuous profiles of temperature and salinity through the water column were acquired using an Ocean Sensors Model 100 CTD.

Nutrient, turbidity, Chl a and salinity analyses were conducted by Marine Analytical Specialists (Laboratory Certification NO: HI-0009) of Honolulu, HI.

B. RESULTS OF WATER CHEMISTRY ANALYSES

1. Horizontal and Vertical Stratification

Tables 1 and 2 show results of all water chemistry analyses for samples collected at the 6 sites off North and South Kohala. Table 1 shows concentrations of nutrients in micromolar units (μM), while Table 2 shows the same data in units of micrograms per liter (μg/L). Also shown in Tables 1 and 2 are the concentrations of State of Hawaii Department of Health water quality criteria for open coastal waters under "wet" conditions.

Concentrations of eight dissolved nutrient constituents, salinity, turbidity, Chl a, and temperature in surface and deep samples are plotted as functions of distance from shore in Figures 3-14. It can be seen in Tables 1 and 2, and Figures 3-14 that with few exceptions, horizontal gradients of dissolved nutrients are steeper at the South Kohala sites compared to the North Kohala sites. Another result that is nearly universal at all of the sampling sites is that water composition is essentially uniform beyond 25 m from the shoreline. The single exception to this observation is at Site 4 (Spencer Park) where salinity was depressed and nutrients elevated up to 75 m from the shoreline.

It can be seen in Figures 3, 4 and 5 that on all of the transects, Si and NO_3^- decrease with distance from the shoreline, while salinity shows corresponding increases. These gradients are relatively small on transects at Sites 1 and 2 (North Kohala), with a difference of only about 1.0 μM for Si, 0.1 μM for NO_3^- and 0.05‰ salinity between the samples collected at the shoreline, and those collected farthest from shore. The near exact mirror images of patterns of salinity and NO_3^- indicate that the lower values at the sampling stations closest to the shoreline compared to 10 m offshore is a result of input and mixing, rather than uptake by marine plants.

Compared to the North Kohala sites, horizontal gradients of NO_3^-, Si and salinity were substantially greater on sampling transects at Sites 3-6 off South Kohala, with differences of between about 20 to 670 μM for Si, 2 and 62 μM for NO_3^-, and 1-24‰ salinity. Concentrations of PO_4^{3-} were lowest in the samples collected closest to shore at Sites 1 and 2, but were elevated in nearshore samples at Sites 3-6.

Because the sampling sites were selected in areas removed from stream flow, these horizontal gradients in water composition are a result of mixing of low salinity groundwater (typically 0.1-0.3‰) with saline oceanic water (typically 34-35‰). Low salinity groundwater, which contains high concentrations of the inorganic nutrients Si, NO_3^-, and PO_4^{3-}

, percolates to the ocean at the shoreline resulting in a nearshore area of mixing. Groundwater input is greatest at Sites 4 (Spencer Beach Park) and 5 (Puako). At transect Sites 1 and 2, it is apparent that the input of groundwater is substantially less (or mixing substantially greater) than at Sites 3-6. However, the seaward extension of the mixing zones is similar at both the North and South Kohala sites. As described above, calm sea conditions occurred during the periods of sampling. Such calm conditions minimize turbulent mixing, resulting in maximization of horizontal and vertical gradients of groundwater nutrients and salinity.

The patterns of distribution of other dissolved nutrients which are not found in high concentrations in groundwater do not display the same tendencies with respect to distance from shore as the nutrients found in groundwater (TDN and TDP reflect concentrations of NO_3^- and PO_4^{3-}, respectively). Horizontal distributions of NH_4^+, DON and DOP do not show the same patterns of increased values in the nearshore water as Si and NO_3^-. The patterns of distribution of NH_4^+ along the transects is somewhat random with no noticeable trends with respect to distance from shore.

Turbidity at the North Kohala sites showed no variation as a function of distance from shore, and was uniformly low ($\leq$ 0.08 n.t.u.) across the entire sampling regime (Figure 12). All four sites off South Kohala had higher turbidity values in the nearshore samples ($\leq$0.25 n.t.u. within 25 m of the shoreline). Overall, all measurements of turbidity were lower on the North Kohala transects compared to South Kohala transects. Similarly, concentrations of Chl a were uniformly lower at the North Kohala sites compared to the South Kohala sites (Figure 13). At Sites 4 and 5, nearshore concentrations of Chl a were approximately an order of magnitude higher than at other sites. The elevated concentrations of Chl a may reflect the high nutrient concentrations at these stations, or more likely, the reduced circulation and longer residence time of water in the nearshore area. Temperature was slightly lower at the nearshore stations of the North Kohala transects, and generally slightly higher at the nearshore sites on the South Kohala transects (Figure 14).

Figures 15-16 show vertical profiles of salinity and temperature, respectively, at each of the sampling sites. In areas where lower density groundwater percolates to the nearshore ocean, a region of mixing of groundwater and ocean water is often characterized by a surface lens with lower salinity and higher nutrient content relative to subsurface water. The surface layer is clearly apparent in the distributions of salinity at Sites 4-6, with lowered values in the upper meter of the water column. Examination of Figures 3-6 reveal similar results with lower salinity and elevated nutrients in the surface relative to deep samples at nearshore stations within 25 m of the shoreline. Beyond this distance, both the vertical profiles and discrete samples reveal no detectable vertical stratification of salinity or nutrients.

At the North Kohala sampling sites (Sites 1 and 2), there is no indication of vertical stratification on any of the vertical profiles (Figure 15). Profiles of temperature (Figure 16) reveal no distinct patterns at any of the sites.

4. Compliance with DOH Criteria

Tables 1 and 2 show State of Hawaii Department of Health (DOH) water quality standards for the "not to exceed 2% and 10% of the time" criteria for open coastal waters under "wet" conditions, which is the category applicable to the North and South Kohala Districts. While the 2% and 10% criteria are not technically meaningful with only a single sampling at each location, comparison of the data with these limits is useful for gaining a general understanding of the water quality of the area.

Inspection of Tables 1 and 2 indicates that at Sites 1 and 2 (North Kohala) none of the samples exceeds any of the water quality standards. At Site 3-6 (South Kohala) nearshore samples exceed the DOH limits for NO_3^-. At Site 3, only samples within 2 m of the shoreline exceed the limits; at Site 5, samples within 25 m of the shoreline exceed the limits; and at Sites 4 and 6, samples within 75 m of the shoreline exceed at least one specific limit. In addition, TDP, TDN and Chl a are exceeded at the most shoreward sampling stations at Sites 4 and 5. Thus, it can be seen that under present conditions, water quality in many of the areas of South Kohala exceed water quality standards.

As noted in the section above water chemistry gradients, NO_3^- is a natural component of groundwater. In areas that receive substantial input of groundwater there is typically a zone of mixing near the shoreline where NO_3^- concentrations may consistently exceed DOH criteria as long as salinity remains low. Thus, it appears that natural processes can result in water quality that exceeds specified DOH limits.

5. Effects to Water Chemistry from the Kohala Water Transmission System

Nance has estimated the change in groundwater discharge, in terms of mass emission and nutrient content, to the ocean under several scenarios for both the North and South Kohala areas. In this analysis, natural groundwater flow is divided into six mauka-makai corridors in the South Kohala area, and seven mauka-makai corridors in the North Kohala area. Considering North Kohala, total groundwater discharge at present is estimated at 75.0 MGD; during 1960 when agricultural irrigation was higher than at present groundwater discharge was estimated at 66.9 MGD; the projected future discharge with pumpage to South Kohala is 55.9 MGD. Thus, while the change in overall discharge from present to future scenario will be a reduction of about 25%, the change will represent about a 16% reduction in discharge compared to the period with high agricultural usage of water. Considering only the corridors above the sampling stations (4, 5, and 6) where most of the pumping will take place, groundwater efflux at the shoreline could be reduced by about 50% over the either the present flow, or the 1960 conditions.

As mentioned above, the data from the present water chemistry assessment represents the most conservative conditions of groundwater mixing yielding the maximum gradients under minimal mixing conditions. The maximum gradients observed on the North Kohala transects were about 1.5°/oo, 0.3 μM NO_3^- and 0.2 μM PO_4^{3-}. Reducing these gradients by 50% would result in insignificant changes to the water chemistry of the nearshore zone. Reducing input of groundwater by 50% during typical conditions of tradewind weather would likely result in undetectable changes in water chemistry. As none of the measured constituents exceeded DOH water quality standards under present conditions of minimal mixing, it is evident that reducing groundwater discharge will not have any effect on water quality standards. Thus, it does not appear that the proposed project will have any effect on nearshore water chemistry in North Kohala.

Total estimated groundwater discharge in South Kohala is projected to increase by about 4% over present conditions. This would represent a change of about 1.4°/oo from oceanic salinity of 34°/oo. Measurements of salinity on the four transects at South Kohala showed gradients of up to 24°/oo, or 70% of oceanic salinity. However, even with such high inputs of groundwater, mixing processes diluted the freshwater to background oceanic levels within 25 meters of the shoreline, with no negative effects to marine community structure. With this natural gradient of mixing between groundwater and ocean water, the relatively small projected increases in groundwater would not alter the marine environment.

IV. ISOTOPIC EVALUATION OF ALGAL NUTRIENT SOURCES

A. INTRODUCTION

There is concern among the North Kohala community that a decrease in groundwater that reaches the nearshore ocean will reduce the nutrient efflux to the ocean to a point where macroalage will be reduced in abundance. This concern is particularly acute for those algae that are harvested as food sources by the local populace. The reason for concern is based on the premise that these algae rely primarily on nutrients from groundwater for growth.

Macroalgae take up nitrogen and phosphorus compounds dissolved in the water surrounding their tissues. Algae do not discriminate whether these nutrients come from land

(groundwater or streamwater) or ocean water. It is important to emphasize that the availability of nutrients to marine algae is a function of the delivery rates of nutrients from the various sources to the algae. Thus, in areas of vigorous mixing where the exchange of water is rapid, the relatively low concentration of nutrients in oceanic water is sufficient to supply adequate nutrients to plants for optimal growth.

An estimate of the relative availability of groundwater nutrients versus ocean water nutrients can be made by estimating the delivery rates of nutrients to the coastline. Nitrogen delivery by groundwater by corridor is 0.9 to 2.4 mol N per meter of coast per day (calculated from Table 6 of Nance) with an overall value in North Kohala of 1.6 mol N per meter of coast per day. An estimate of N uptake by a macroalgal community is 0.1-0.5 mol N per meter of coast per day (Bilger and Atkinson 1995, Atkinson et al. 1995), or roughly half the delivery of N by groundwater (assuming the community has an area of 10-50 meter squared per meter of coast). Assuming, however, that breaking waves move water into and away from the coast at an estimated rate of 0.1 meter per second (a very low estimate during normal tradewind conditions), the ocean can deliver about 17 to 86 mol N per meter per day. This estimate is based on algal cover of 10-50 square meters per meter of coastline, with an average water depth of 2 meters. This volume of water has a concentration of N of at least 0.1 mmol per cubic meter, and is exchanged at a net rate of 0.1 meters per second. Thus, the flux of N from groundwater that is available for algal uptake is likely to be at a maximum 10% of the ocean flux of available N. All of the assumptions for this calculation were extremely conservative; in the average situation, it is likely that the available N from groundwater is less than 1% of that available from oceanic sources.

To directly test these estimates we measured nutrient concentrations and salinity in the coastal water, and the ratios of $^{15}N/^{14}N$ in macroalgae from several locations along the North Kohala coastline. ^{15}N is a natural stable isotope of nitrogen that occurs everywhere on earth with a natural abundance of about 0.3% of the more common ^{14}N. The ratio of $^{15}N/^{14}N$ is higher in water draining terrestrial ecosystems compared to ocean water as a result of fractionation from denitrification (Miyake and Wada 1967). As a result, algae that grow in freshwater have a higher ratio of ^{15}N to ^{14}N than algae that grow in open ocean water. Measuring the ratios of ^{15}N to ^{14}N is a means of estimating the origin of the nutrients that are taken up by algal populations.

For this method to be effective, it is necessary for the isotopic ratios of the various end-point materials to be different enough to be clearly distinguishable. In order to establish an oceanic endpoint, numerous samples of benthic marine algae from Hawaiian waters have been analyzed by the University of Hawaii, producing an endpoint $\delta^{15}N$ of 3.7 (Chun Smith 1994). The terrestrial $\delta^{15}N$ endpoint was determined to be ≥ 8 by our analyses of algae growing in streams and freshwater seeps in North Kohala. Algal samples growing in the groundwater spring had a somewhat higher $\delta^{15}N$ (8.8) than those in streamwater (8.2). Because the objectives of the present study are to determine the effect of alteration of groundwater input, the terrestrial endpoint is considered to be 8.8. The spread in these endpoint values indicates that $\delta^{15}N$ is a viable method of determining origin of nitrogen in marine plants.

B. METHODS

Collected algae were dried in ovens and ground to a fine powder. A modified Dumas sealed tube method was used for isotopic analysis as described by (Minagawa et al. 1985). Sample splits estimated to contain 0.25-0.75 mg particulate N were placed in 9 mm outer diameter Vycor brand quartz tubes along with approximately 3 g of precombusted cupric oxide and approximately 1 g of copper wire. The tubes were evacuated, sealed and combusted at 660°C overnight, followed by one hour at 500°C. Following combustion, tubes were allowed to cool slowly to room temperature. Slow cooling insures that the oxides of nitrogen are converted to N_2. Nitrogen gas was isolated by cryogenic distillation using silica gel to adsorb the N_2 (Mariotta 1983). Samples were analyzed on an automated, dual inlet, multi-collector mass spectrometer (Finnegan-MAT 252). Tank N_2 was used as a working standard which was calibrated with IAEA N1 and N2 and USGS 25 and 26 to give a value of ^{15}N versus air, which is assigned a value of 0.0°/oo. Stable isotope ratios were calculated in terms of $\delta^{15}N$ as follows:

$$\delta^{15}N=(R_{sample}/R_{std-1}) \times 1000$$

where $R = {}^{15}N/{}^{14}14$.

Percentage composition derived from terrigenous sources of nitrogen (X) was derived by the equation:

$$\delta^{15}N(S) = X(\delta^{15}N8.8) + (1-X)(\delta^{15}N3.7)$$

where S represents the isotopic ratio of the sample.

C. RESULTS

Four sites were selected for sampling, based on recommendations of community members. Figure 1 is a map showing the locations where samples were collected. The primary consideration of site selection was to sample algae that were exposed to varying levels of freshwater. Unfortunately, weather and surf conditions during the sampling (strong tradewinds and large surf) made sampling beyond the shoreline area very difficult. Sample sites were at

Kepuhi Point (also known as Hoea Flats), Kauhole Point, Keawaeli Bay (off Kauhole Stream), and a cliffed area between Kalalae Point and Akoakoa Point. At each site, water for nutrients, turbidity, salinity was collected along with several species of algae. The results of water sample analyses are shown in Table 3, while the results of algal nutrient composition values of ^{15}N, and the percentage of N from freshwater are ocean sources shown in Table 4.

The sampling station at Kepuhi Point was a wave-swept basaltic bench shoreline, with numerous tidepools. Algae, particularly *Asparagopsis taxiformis* (limu kohu) were abundant in cracks on the shoreline bench. Five water samples were collected; 1 in a tidepool, 2 on the algal bench behind the shoreline cliff, and 2 at the edge of the shoreline cliff in the area of wave impact. Nutrient concentrations (PO_4^{3-}, NO_3^-) were in general low, but slightly elevated above typical oceanic values of 0.1 µM. Dissolved Si was lower in the shoreline samples than on the bench, while salinity was slightly higher offshore. These results indicate a source of freshwater at this site. As there were no streams anywhere in the vicinity, the freshwater input is from groundwater entering the ocean near the shoreline. Inorganic nutrients in the tidepool, however, were lower than on the nearshore bench, while organic nutrients were higher indicating uptake by algal populations within the tidepool.

Four algal species were collected at Kepuhi Point; a mixed green-red turf community, *Asparagopsis taxiformis*, *Sargassum polyphyllum*, and *Sargassum obtusifolium*. The N content of these specimens was all typical of marine algae (647-899 µmol N/g dry weight) (Atkinson and Smith 1983), except *Asparagopsis*. Limu kohu was 2-3 times higher in N content than other species (2030 µmol N/g dry weight). Contrary to N content, the ^{15}N ratio of *Asparagopsis* was similar to the other species (3.7-4.0). These results indicate the N from groundwater contributed only about 1-7% of the N content of the algae. The remaining 93-99% of the N content of the algae is from oceanic sources that are not associated with land.

Water samples from Kauhole Point near the Lighthouse had nutrient and salinity concentrations typical of open ocean water, with no indication of any input from groundwater. Such a result is not surprising as the point is actually a small peninsula that juts several hundred meters offshore from the primary shoreline. Similarly, algal samples collected off the point had ^{15}N values that were lower than the oceanic endpoint of 3.7. As a result, algal growing off Kauhole Point are not using any N from freshwater sources on land.

Kauhole Stream water had very low salinity (0.19°/oo) with NO_3^- values 280 times higher than water collected at Kauhole Point. Stream water that reaches the shoreline is rapidly diluted with seawater in the nearshore mixing zone. Algae collected on the rocks in the mouth of the stream behind the beach had a high N content (1540 µmol N per gram dry weight) and high ^{15}N ratio (8.2) substantiating that the N content is a result of uptake of freshwater flow from terrestrial sources. Algae collected on rocks on the beach (in the mixing zone) had lower N content and ^{15}N (1030 μmol N per gram dry weight, and 6.2, respectively), reflecting the dilution of fresh stream water with ocean water. Thus, within a distance of approximately 5 meters from the stream mouth, the percentage input of N from land sources dropped from 100% to 56%. As discussed above, further offshore at Kauhole Point, there was no contribution of land-derived N to algal composition. These data indicate that while there is some input of terrestrial N in the nearshore zones of mixing, there is no effect to algal populations growing beyond the shoreline where streamwater and groundwater is completely diluted to background oceanic values.

Samples from the area between Kalalae and Akoakoa Points were collected in a groundwater seep on the shoreline cliff above a rocky wave swept beach. Water collected from the groundwater seep had a salinity of 1.17‰ and a NO_3^- content of 167 μM, some 2780 times greater than the concentration in the ocean water collected off Kauhole Point. The N content of the green periphyton sampled from the rocks under the groundwater seep was 2290 μmol N per gram dry weight, with a very high $\delta^{15}N$ of 8.8. Owing to the location of the algae in the groundwater seep several meters above sea level there is little doubt that 100% of the N in the algae comes from groundwater. Thus, the highest values of ^{15}N of any sample verifies the experimental assumptions of using the stable isotope as an means of distinguishing sources of N. Macroalgae scraped from the rocks at the beach below the groundwater seep had 1/2 to 1/3 the N content of algae growing in groundwater, indicating that algae on the beach derived about 10% to 17% of N from terrigenous sources.

Based on the data and results described above (Tables 3 and 4) several generalizations can be made regarding nutrient/algal relationships:

1) water in the nearshore groundwater mixing zones had higher nutrient concentrations than offshore oceanic water;

2) there are sufficient dissolved nutrients in typical coastal ocean water to support vigorous, and abundant stocks of marine algae, as long as the physical conditions (habitat and mixing) are suitable.

3) algae growing in water with higher nutrient concentrations generally had higher N content (P content was not measured). The exception is *Asparagopsis taxiformis* at Site 1, which had very high N content growing in low N water. This algae probably had high N content because of exposure to very high water motion on a reef platform;

4) algae growing in freshwater (either streamwater or groundwater) had $\delta^{15}N$ values above 8, while algae growing seaward of the shoreline had ^{15}N generally less than 4. This result indicates that only a small percentage of N in marine algae originates from terrestrial sources (Table 4). Two algae samples had more than 10% N from land, and these two were collected from rocks that were on the beach and immediately in the flow of freshwater from the a stream (Site 3) and from groundwater (Site 4). Algae (limu kohu) collected beyond the shoreline had no contribution of land-derived N.

We conclude that these macroalgae, including the species harvested as food, rely very little on nutrients in groundwater. In fact, the densest growth of limu kohu was observed in areas exposed only to oceanic water with virtually no input from terrestrial sources. While our sampling was limited, it is readily apparent that the only areas where there the source of nitrogen is a mixture of terrestrial and oceanic sources is in the nearshore zone of mixing which, in North Kohala generally does not extend beyond the shoreline owing to the very high rates of mixing that occur along the coast. A 10% decrease in the delivery rate of groundwater to the coast will probably only decrease the available N by about 1%. In addition, there will be no decrease in surface water delivery (streamflow) to the coastal zone, which is much more concentrated with respect to area of input than diffuse groundwater seepage. From these results, there are no indications that the reduction in groundwater input from the proposed project would have any effect on growth or abundance of algae in the coastal zone.

Parenthetically, it has been a concern that the proposed project may have an adverse effect on populations of opihi (*Patella sandvicensis*) that are collected from rocky shorelines. Dr. Alison Kay, leading expert on Hawaiian mollusks states that these organisms are capable of withstanding little variation from oceanic salinity. Thus, lowering the input of groundwater in North Kohala will have no adverse effect on opihi populations.

V. CORAL COMMUNITY ASSESSMENT

A. INTRODUCTION

When considering environmental changes caused by altered land use, benthic (bottom-dwelling) communities are probably the most useful biological assemblages for direct evaluation of marine environmental impacts. Because benthos are generally long-lived, immobile, and can be significantly affected by exogenous input of potential pollutants, these organisms must either tolerate the surrounding conditions within the limits of adaptability or die.

In Hawaiian nearshore communities, hermatypic (stony corals) are considered "keystone species" as they provide the framework for the physical structure of the reef, as well as the basis of the food web for many associated reef organisms. In turn, coral communities are structured in response to the predominant physical and chemical conditions of the environment. Concussive force from wave stress is probably the major natural determinant in shaping coral community structure by causing breakage of adult colonies and prevention of planular settlement on empty substrata. Suspended sediment loading is another important natural factor in defining coral community structure, as sediment accumulation can bury living corals, and prevent settlement on shifting substrata. Moving sediment, such as shifting sands can cause abrasion and mortality of adult colonies.

In considering the Kohala Water Transmission System, the only physical/chemical factor that may be altered is input of groundwater in the nearshore ocean. As corals are adapted to grow in open ocean conditions, lowering the input of groundwater will have no effect on corals. As discussed above, increases of groundwater input can result in a zone of mixing where salinity is lowered and inorganic nutrient concentration is elevated over open coastal oceanic conditions. In order to evaluate the potential effects of these potential changes to coral communities, surveys of coral community structure at representative sites were conducted. Based on the composition of the communities at these sites, the known physiological tolerances of reef corals, and the projected effects of the Kohala Water Transmission System to groundwater input, it is possible to predict what, if any, changes may take place to coral communities.

B. METHODS

All fieldwork was carried out on August 7, 1994 (South Kohala) and September 2, 1994 (North Kohala), and was conducted from a 19-foot boat using SCUBA gear. Biotic structure of benthic (bottom dwelling) communities inhabiting the reef environment was evaluated by establishing a descriptive and quantitative baseline in the region between the shoreline and approximately the 30 foot depth contour. In the North Kohala region, surveys were conducted off the same areas where water chemistry was evaluated: Site 1 was located in Kapana Bay, while Site 2 was off Kauhola Point (Lighthouse) and Keawaeli Bay.

In the South Kohala region, coral surveys were also conducted in the same areas as the water quality analyses based on general circulation patterns and groundwater input. Site 3 off the Kawaihae Lighthouse is considered an open coastal area with low groundwater input; Site 4 off Spencer Beach is considered an open coastal area with high groundwater input; Site 5 in Puako Bay is considered a sheltered area with high groundwater input; while Site 6 in Honokaope Bay is a sheltered area with low groundwater input.

Initial qualitative reconnaissance surveys were conducted that by divers towing behind a slowly moving boat. These reconnaissance surveys were useful in making relative comparisons between areas, identifying any unique or unusual biotic resources, and providing a general picture of the physiographic structure and benthic assemblages occurring throughout the region of study. Following the preliminary survey, two quantitative transect stations were selected at each site. A shallow station was selected in the most shoreward area where coral communities occurred. Such shallow stations were selected because this is area that is most likely to be affected by alteration of groundwater input and mixing. A second station was selected in deeper water in areas deemed to have optimum coral cover. While slightly deeper, these stations also were judged to be in the nearshore zone that could be affected by alterations from activities on shore. Within the hard bottom areas where transects were conducted, care was taken to place transects in random locations that were not biased toward either localized patches of either peak or low coral cover.

Quantitative benthic surveys were conducted by stretching a 50-m long surveying tape in a straight line over the reef surface. An quadrat frame with dimensions of 1 m by 0.66 m was sequentially placed over 10 random marks on the transect tape so that the tape bisected the long axis of the frame. At each quadrat location a color photograph recorded the segment of reef area enclosed by the quadrat frame. In addition, a diver knowledgeable in the taxonomy of resident species visually estimated the percent cover and occurrence of organisms and substratum type within the quadrat frame. No attempt was made to disturb substrata to observe organisms, and no attempt was made to identify and enumerate cryptic species dwelling within the reef framework. Only macrofaunal species greater than approximately 2 centimeters were noted.

In the laboratory, accurate estimates of benthic cover of biota and substrata were obtained by overlaying a grid on the quadrat photographs and summing cover of each species and substratum type. This information was combined with the *in-situ* cover estimates and the combined assessment provide the data base for the benthic community structure analysis. The photo-quadrat data was augmented by *in-situ* observations of small individuals or colonies that were not distinguishable in the photos. Thus, the resultant data set has the advantage of including small and rare organisms that occurred within the quadrats, as well as accurate estimates of area coverage of large organisms or colonies that comprised substantial area within the quadrats. Few, if any other quantitative transect survey technique has the advantage of including both of these parameters.

The photo-quadrat transect method is a modification of the technique described in Kinzie and Snider (1978), and has been employed in numerous field studies of Hawaiian reef communities (e.g. Dollar 1982, Grigg and Dollar 1980, Grigg and Maragos 1974), and has proven to be particularly useful for quantifying coverage of attached benthos such as corals and large epifauna (e.g. sea urchins, sea cucumbers).

C. RESULTS AND DISCUSSION

Results of the seven quantitative line transects provide a data base characterizing coral community structure. Tables 5 and 6 show the quantitative summary of coral community structure from the North and South Kohala transects, respectively, while Appendices A and B show individual quadrat results.

In total, 9 species of "stony" corals were encountered on transects. The number of coral species on a single transect ranged from 2 to 6. Coral cover on transects ranged from 0.8% (Keawaeli Bay, 15') to 75.5% (Honokaope Bay, 8'). When all transects were combined, total coral cover constituted 59% of bottom cover at the South Kohala sites, and 13% of cover at the North Kohala sites. The most abundant species throughout the South Kohala study area was *Porites lobata*, which comprised 64% of coral cover, and 38% of bottom cover. In South Kohala *Pocillopora meandrina* was second in abundance, comprising 9% of coral cover and 5% bottom cover. On the North Kohala transects, the order of abundance of the two most common species was reversed with *Pocillopora meandrina* the most abundant coral comprising 59% of coral cover and 8% of bottom cover, while *Porites lobata* comprised 37% of coral cover and 5% of bottom cover. Thus, the remaining species encountered on transects comprised about 27% of coral cover in South Kohala, and 4% of coral cover in North Kohala.

Considering the South Kohala transect sites, it can be seen in Table 6 that coral cover at all locations was greater than 40%. At the sites of high groundwater input (Spencer Park and Puako) cover ranged from 40 to 64%, while at the low groundwater input sites (Kawaihae Lighthouse and Honokaope Bay) cover ranged from 46% to 75%. Thus, while coral cover was somewhat higher at the sites with low groundwater input, there was still relatively high coral cover at the high input area. Considering shelter, the open coastal sites (Kawaihae Lighthouse and Spencer Park) had cover ranging from 40% to 62%, while the more protected areas (Puako and Honokaope) had cover ranging from 57% to 75%. As it has been well documented (Dollar 1982, Dollar and Tribble 1992) that wave stress is the primary determinant of coral community structure in Hawaii, it is not surprising to see coral cover higher in the more protected locales. However, it can also be seen that the diversity of the coral communities at the protected sites is consistently below 1.0, while at the unprotected Kawaihae sites, diversity is somewhat greater. At the Spencer Park sites, diversity is very low at the shallow inshore transect (0.02) as nearly the entire coral community consisted of a single species (*Porites compressa*).

Coral cover at the North Kohala sites was higher at both of the deeper transect stations compared to the shallow stations (Table 5). As discussed above, the North Kohala coastline is typically subjected to much more rigorous conditions of waves and swell than South Kohala which limit colonization of corals in the nearshore areas.

With respect to the effect of the Kohala Water Transmission System on coral communities, it is accepted knowledge that reef corals typically occur in oceanic water with no influence from land. In fact, in some situations, input from land has resulted in negative effects to coral reefs from such factors as sediment and freshwater. Thus, reducing groundwater input in the North Kohala region will have no effect on coral community structure. This is especially true owing the present limitations on coral community structure owing to intense wave activity.

In South Kohala, however, because the proposed project will add groundwater to the coastal zone, it is important to estimate the potential effect to corals and coral reef community structure. The two components of groundwater that can have potentially negative effects to corals are freshwater and increased inorganic nutrients. Experimental work has shown that the salinity tolerances of most corals falls outside the range of most naturally occurring open ocean salinities (Stoddart 1969). In other words, naturally occurring ocean salinities do not have any negative effect on corals. However, lower salinities than open ocean conditions caused by locally intense freshwater runoff and percolation may affect coral distributions. Prolonged laboratory exposure to seawater diluted below 75% of normal was damaging and sometimes lethal (Edmondson 1928, Kawaguti 1940). In Kaneohe Bay, Hawaii, salinity reduced below 20‰ was damaging to corals (P. Jokiel, personal communication).

At the South Kohala sites, it can be seen that salinity was reduced below 20‰ at only one site (Puako Bay), and only within 2 meters of the shoreline. At all of the South Kohala sites, the lowest salinity measured beyond 2 meters from the shoreline was 32‰, approximately 95% of normal oceanic salinity (34‰). Thus, at present, the only apparent area where decreased salinity may be a factor in restricting coral growth in the South Kohala area is within 2 meters (6 feet) of the shoreline. It should be noted that within this zone, there are other factors which are probably more important to restricting coral growth, such as exposure during low tides, wave impact, and sand scour.

Estimates by Nance indicate that the increase in total groundwater discharge from the present to a future condition with input of water from North Kohala will be about 4%. Considered by sector, Nance estimates that changes groundwater input following completion of the project will range from increases of 47% to decreases of 100%. In the two sectors which show potential decreases in groundwater, which includes the study area at Puako, any potential effects from salinity reduction would obviously be eliminated. The sectors where freshwater input is projected to increase include Kawaihae (47%) Spencer Park (6%) and Honokaope Bay (4%). Lowering the salinity gradients observed at the shoreline stations in these areas during the current investigation by these respective percentages results in reduction in the lowest salinities of 0.77‰ at Kawaihae, 0.8‰ at Spencer Park, and 0.05‰ at Honokaope Bay. These salinity decreases of less than 1‰ all fall well within the range of natural variability as a result of factors such as local hydrology and tidal fluctuations.

In addition to all of these considerations, in areas where freshwater input near the shoreline is not rapidly mixed to background oceanic conditions by physical forces, the freshwater remains as a surface layer that is not in contact with benthos. Thus, there are cases where even with consistently high input of freshwater that could potentially be damaging to benthos, bottom dwelling organisms never are in contact with the low salinity surface lens. Such is the case at Keauhou Bay, in the North Kona District, where constant input of groundwater into the Bay results in a discrete surface layer that sometimes is nearly pure freshwater. However, coral communities growing on solid substratum in the outer parts of the Bay appear to flourish because they are not exposed to the surface layer of water (Dollar and Atkinson 1991).

The situation for increased nutrients from groundwater subsidies following completion of the Kohala Water Transmission System is similar to that of salinity. Total input of nitrogen is expected to increase by 17%, and by 19% for phosphorus. In the sector containing Puako, nutrient loading is expected to decrease, eliminating consideration of nutrient subsidies. Based on data collected in this survey, total nitrogen could increase at the shoreline by about 1 μM at Kawaihae, 10 μM at Spencer Park, and 1 μM at Honokaope Bay. Total phosphorus could increase by 0.1 μM at Kawaihae, 0.2 μM at Spencer Park, and 0.01 μM at Honokaope Bay. All of these increases are well below the existing range of nutrients in the nearshore area measured at Puako during this study. In addition, as described above, the horizontal gradients in nutrients and salinity are very steep in the nearshore zone, returning to near oceanic conditions within 10 m of the shoreline. Thus, the small increases in nutrient concentration that could accompany additional groundwater discharge would be mixed to background conditions before contact with the benthic community.

As a final note, recent work conducted at the Waikiki Aquarium has shown that reef corals can grow unimpeded in water with nutrient concentrations on the order of 100 times greater than oceanic conditions as long as benthic algae are kept in check by grazers (Atkinson and Carlson, in press). Thus, in appears that even if the nutrient subsidies associated with increased groundwater reached the coral communities, there is no reason to expect negative

effects. In sum, it does not appear that any aspect of the Kohala Water Transmission System has the potential to affect coral reef communities at any location.

VI. CONCLUSIONS

The proposed Kohala Water Transmission System will divert approximately 20 MGD of potable groundwater from the Hawi aquifer of North Kohala to South Kohala. The project will take place in two phases with each phase diverting approximately 10 MGD. This action will decrease the discharge of groundwater at the shoreline in North Kohala, and increase discharge in some areas of South Kohala. Discharge will also decrease in some areas of South Kohala because of increased usage.

Several studies were conducted to determine the potential effect of the proposed project on water chemistry and marine community structure. Of particular interest with respect to marine communities were edible benthic algae (limu) in North Kohala and reef-building corals in South Kohala. Concern for these two aspects of the marine ecosystem were centered on the perceptions that: 1) limu depend on nutrients from land for growth, and a reduction of these nutrients will result in decreased algal abundance, and; 2) corals can be negatively impacted by changes in water chemistry as a result of input of materials from land.

The studies revealed that there appears to be no potential for negative impacts to marine ecosystems in either North or South Kohala from the diversion of groundwater. The primary reasons for this conclusion stem from the physical properties of the marine environments in both districts. Direct exposure to tradewind generated wind and swells, as well as long period swells from the north result in extremely well-mixed nearshore environment in North Kohala. As a result, groundwater diffusing to the ocean is rapidly diluted by the infinitely large reservoir of ocean water to background oceanic concentrations. Measurements made during rare conditions when seas were relatively calm showed only relatively small horizontal and vertical gradients of groundwater constituents (freshwater, NO_3^- and PO_4^{3-}). Reducing these gradients by the amount of groundwater that is proposed to be pumped South Kohala would have virtually no qualitative effect on nearshore water chemistry. During typical conditions, the effect of such pumpage would likely not even be measurable. In addition, the effects of the project will be insignificant because the primary input of freshwater to the coastal region of North Kohala is by surface flow (streams) which will not be affected by the alteration in groundwater flow.

Measurements of the ratio of stable isotopes $^{15}N/^{14}N$ have proven to provide a reliable tracer for the origin of nutrients incorporated into tissue of marine plants. Measurements of $\delta^{15}N$ in marine algae (limu) collected in coastal areas revealed that plants growing in freshwater (streams or groundwater) have a distinctly different $\delta^{15}N$ signature than plants growing in oceanic waters. Limu collected on the rocks in the area of mixing between freshwater and ocean water had ratios that were primarily oceanic in nature. While sampling was limited due to dangerous sea conditions, the isotopic ratio of limu kohu collected offshore revealed that tissue N was totally of oceanic origin. These results indicate that marine waters without influence from land contain sufficient nutrients for growth of limu that is used as a foodsource. Owing to the intense mixing that characterizes the nearshore area of North Kohala, groundwater is rapidly diluted to oceanic concentrations within the zone that most algae grows. In addition, because of the diffuse discharge characteristics of groundwater in the North Kohala area, limu responding to freshwater are generally growing with input from point source stream discharge which will not be affected by the proposed project. These results indicate that changes in groundwater discharge will not have any affect on marine algae.

As reef corals typically grow in oceanic water, it is important to consider the potential for negative effects from changes in groundwater input that will occur as a result of the proposed project. There will be no effects to reef corals or associated communities in North Kohala where groundwater input to the ocean will be decreased. While groundwater input will increase with the project in parts of South Kohala, the scientific literature documents that corals can tolerate decreases in salinity and increases in nutrients to certain levels. Measurements of the gradients of salinity and nutrients at the South Kohala study sites indicate that while there are steep gradients of salinity and nutrients near the shoreline, there is no effect to coral abundance. With the increase in groundwater flux associated with the project, water chemistry will not change from present conditions with respect to exceeding the physiological tolerances of corals. At present, well-developed coral communities exist in the regions of highest groundwater input. In addition, regardless of the level of input, groundwater that enters the ocean and is not diluted with ocean water persists as a surface layer that is not exposed to bottom-dwelling organisms. In sum, it is clear that the projected changes in groundwater flux from the Kohala Water Transmission System will not have any effect on nearshore marine communities.

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TABLE 1. Water chemistry measurements at six sites off the North and South Kohala coastline collected August 7 and September 2, 1994. Abbreviations as follows: S=surface; D=deep; BDL=below detection limit. For chemical abbreviations, see text. Shaded values exceed DOH 10% criteria for open coastal waters under "wet" conditions. pH was not measured at Sites 1 and 2. For sampling site locations, see Figures 1 and 2.

Table 1 (cont.)

SITE NO.		DFS (m)	PO4 (μM)	NO3 (μM)	NH4 (μM)	Si (μM)	DOP (μM)	DON (μM)	TDP (μM)	TDN (μM)	TURB (NTU)	SALINITY (o/oo)	CHL a (μg/L)	TEMP deg.C)	pH
NK-1-	1S	0	0.09	0.16	0.04	2.19	0.30	7.96	0.39	8.16	0.06	34.466	0.15	26.8	
	2S	2	0.10	0.17	0.06	2.12	0.22	7.66	0.32	7.89	0.06	34.467	0.15	26.7	
	3S	10	0.13	0.27	0.09	2.56	0.24	9.15	0.37	9.51	0.05	34.440	0.15	27.0	
	3D	10	0.12	0.17	0.10	1.69	0.26	7.41	0.38	7.66	0.05	34.503	0.13	26.8	
	4S	25	0.12	0.21	0.09	1.81	0.24	7.89	0.36	8.19	0.05	34.510	0.12	27.0	
	4D	25	0.11	0.20	0.07	1.56	0.21	6.19	0.32	6.46	0.07	34.516	0.12	27.0	
	5S	75	0.10	0.12	0.06	1.41	0.25	6.31	0.35	6.49	0.06	34.571	0.15	27.0	
	5D	75	0.09	0.13	0.02	1.32	0.26	6.82	0.37	6.97	0.06	34.565	0.15	27.1	
	6S	200	0.10	0.09	0.02	1.36	0.25	6.36	0.35	6.47	0.08	34.580	0.16	27.1	
	6D	200	0.09	0.09	0.03	1.22	0.25	5.73	0.34	5.85	0.05	34.578	0.15	27.0	
NK-2-	1S	0	0.08	0.10	0.11	1.52	0.27	6.80	0.35	7.01	0.05	34.553	0.24	27.3	
	2S	2	0.08	0.09	0.08	1.34	0.20	5.75	0.28	5.92	0.06	34.537	0.24	27.3	
	3S	10	0.09	0.10	0.17	1.15	0.21	6.51	0.30	6.78	0.06	34.542	0.28	27.3	
	3D	10	0.09	0.09	0.12	1.24	0.20	6.31	0.29	6.52	0.07	34.541	0.20	27.3	
	4S	25	0.17	0.05	0.23	1.28	0.22	5.55	0.39	5.83	0.05	34.545	0.19	27.6	
	4D	25	0.10	0.10	0.13	1.08	0.22	6.02	0.32	6.25	0.05	34.545	0.15	27.3	
	5S	75	0.12	0.03	0.07	1.08	0.19	5.30	0.31	5.40	0.05	34.534	0.20	27.5	
	5D	75	0.12	0.09	0.15	0.94	0.16	6.30	0.30	6.54	0.08	34.563	0.13	27.3	
	6S	200	0.15	0.01	0.14	1.15	0.14	4.81	0.29	4.96	0.05	34.536	0.20	27.3	
	6D	200	0.12	0.06	0.10	1.20	0.16	4.71	0.28	4.67	0.06	34.535	0.19	27.1	
SK-3-	1S	0	0.15	1.96	0.03	39.61	0.29	4.86	0.44	6.69	0.19	33.473	0.68	27.4	8.21
	2S	2	0.09	1.45	0.06	34.37	0.30	5.07	0.39	6.60	0.14	33.697	0.33	27.3	8.21
	3S	10	0.10	0.44	0.04	8.44	0.31	5.34	0.41	5.82	0.11	34.418	0.38	27.6	8.20
	3D	10	0.08	0.38	0.03	6.32	0.30	5.53	0.38	5.94	0.13	34.464	0.30	27.5	8.21
	4S	25	0.07	0.27	0.01	6.18	0.28	5.38	0.35	5.66	0.14	34.484	0.49	27.4	8.22
	4D	25	0.08	0.09	0.02	2.61	0.24	5.19	0.32	5.30	0.12	34.548	0.34	27.3	8.24
	5S	75	0.07	0.16	0.03	5.33	0.25	5.01	0.32	5.20	0.13	34.500	0.49	27.4	8.23
	5D	75	0.06	0.11	0.02	4.23	0.27	5.09	0.33	5.22	0.11	34.515	0.44	27.3	8.24
	6S	200	0.07	0.14	0.08	2.63	0.30	5.31	0.37	5.53	0.10	34.551	0.33	27.3	8.24
	6D	200	0.06	0.15	0.04	2.28	0.26	4.79	0.32	4.98	0.07	34.549	0.25	27.3	8.24
SK-4-	1S	0	0.46	27.12	BDL	329.84	0.25	3.28	0.71	30.40	0.22	22.302	2.21	27.4	8.00
	2S	2	0.20	12.24	0.01	173.14	0.21	3.62	0.41	15.87	0.25	28.036	0.53	27.5	8.03
	3S	10	0.09	3.74	BDL	55.46	0.23	4.45	0.32	8.19	0.17	32.611	0.25	27.8	8.06
	3D	10	0.07	1.17	0.05	21.06	0.24	5.20	0.31	6.42	0.21	33.880	0.47	27.8	8.09
	4S	25	0.17	7.13	0.05	86.34	0.25	5.29	0.42	12.47	0.16	31.717	0.33	27.5	8.07
	4D	25	0.06	1.19	0.08	14.35	0.24	5.34	0.30	6.61	0.14	34.176	0.28	27.6	8.11
	5S	75	0.17	8.88	0.08	103.85	0.21	5.42	0.36	14.38	0.15	31.133	0.34	27.3	8.07
	5D	75	0.08	1.55	0.04	16.39	0.21	5.51	0.29	7.10	0.12	34.120	0.28	27.8	8.08
	6S	200	0.08	0.74	0.09	5.87	0.25	5.17	0.33	6.00	0.08	34.459	0.20	27.5	8.17
	6D	200	0.10	0.68	0.09	5.54	0.24	4.90	0.34	5.67	0.08	34.456	0.22	27.4	8.17
SK-5-	1S	0	1.51	62.23	0.04	679.73	0.02	3.27	1.53	65.54	0.14	10.093	0.24	27.3	7.90
	2S	2	0.98	40.67	0.14	459.55	0.02	3.20	1.00	43.97	0.18	18.232	0.51	27.4	8.07
	3S	10	0.20	3.47	0.23	58.58	0.20	3.13	0.40	6.83	0.20	32.769	0.39	27.4	8.21
	3D	10	0.13	0.69	0.14	13.06	0.22	5.10	0.35	5.93	0.15	34.255	0.26	27.3	8.20
	4S	25	0.14	1.29	0.34	26.17	0.24	5.08	0.38	6.71	0.14	33.727	0.16	27.2	8.18
	4D	25	0.10	0.48	0.15	6.16	0.25	5.45	0.35	6.08	0.12	34.350	0.17	27.1	8.21
	5S	75	0.11	0.43	0.09	3.66	0.22	5.63	0.33	6.15	0.06	34.498	0.26	27.2	8.21
	5D	75	0.11	0.42	0.15	3.82	0.19	5.45	0.30	6.02	0.08	34.511	0.25	27.1	8.20
	6S	200	0.09	0.18	0.10	6.71	0.19	5.38	0.28	5.66	0.06	34.522	0.30	27.3	8.23
	6D	200	0.10	0.11	0.10	3.03	0.21	5.25	0.31	5.48	0.08	34.531	0.27	27.3	8.24
SK-6-	1S	0	0.15	2.65	0.16	26.50	0.21	7.59	0.36	10.40	0.22	33.675	0.87	27.4	8.25
	2S	2	0.13	2.58	0.18	23.96	0.17	6.11	0.30	8.87	0.22	33.748	1.14	27.3	8.27
	3S	10	0.17	3.92	0.16	30.26	0.18	5.73	0.35	9.81	0.14	33.503	0.48	26.9	8.23
	3D	10	0.09	0.29	0.17	4.80	0.18	5.17	0.27	5.63	0.08	34.487	0.51	26.9	8.23
	4S	25	0.14	2.55	0.20	22.28	0.18	5.50	0.32	8.25	0.13	33.604	0.43	27.0	8.22
	4D	25	0.09	0.24	0.19	4.03	0.18	5.46	0.27	5.91	0.10	34.498	0.43	27.0	8.23
	5S	75	0.10	1.01	0.14	12.00	0.19	5.26	0.29	6.41	0.06	34.192	0.42	27.0	8.22
	5D	75	0.09	0.18	0.14	3.58	0.16	5.26	0.25	5.58	0.08	34.507	0.38	27.0	8.24
	6S	200	0.09	0.26	0.16	3.77	0.18	5.12	0.27	5.54	0.08	34.496	0.32	27.1	8.23
	6D	200	0.08	0.11	0.16	2.30	0.18	5.23	0.26	5.50	0.08	34.546	0.29	27.0	8.24
DOH WATER QUALITY STANDARDS															
NOT TO EXCEED 10%				1.00	0.61				1.29	17.86	1.25		0.90		
NOT TO EXCEED 2%				1.78	1.07				1.93	25.00	2.00		1.75		

TABLE 2. Water chemistry measurements (in µg/L) at six sites off the North and South Kohala coastline collected August 7 and September 2, 1994. Abbreviations as follows: S=surface; D=deep; BDL=below detection limit. For chemical abbreviations, see text. Shaded values exceed DOH criteria for open coastal waters under "wet" conditions. pH was not measured at Sites 1 and 2. For sampling site locations, see Figures 1 and 2.

SITE	NO.	DFS (m)	PO4 (µg/L)	NO3 (µg/L)	NH4 (µg/L)	SI (µg/L)	DOP (µg/L)	DON (µg/L)	TDP (µg/L)	TDN (µg/L)	TURB (NTU)	SALINITY (o/oo)	CHL a (µg/L)	pH
NK-1	1S	0	2.79	2.24	0.56	61.54	9.30	111.44	12.09	114.24	0.06	34.466	0.15	
	2S	2	3.10	2.38	0.84	59.57	6.82	107.24	9.92	110.46	0.06	34.467	0.15	
	3S	10	4.03	3.78	1.26	71.94	7.44	128.10	11.47	133.14	0.05	34.440	0.15	
	3D	10	3.72	2.38	1.40	53.11	8.06	103.74	11.78	107.52	0.05	34.503	0.13	
	4S	25	3.72	2.94	1.26	50.86	7.44	110.46	11.16	114.66	0.05	34.510	0.12	
	4D	25	3.41	2.80	0.98	44.40	6.51	86.66	9.92	90.44	0.07	34.516	0.12	
	5S	75	3.10	1.68	0.84	39.62	7.75	88.34	10.85	90.86	0.06	34.571	0.15	
	5D	75	2.79	1.82	0.28	37.09	8.68	95.48	11.47	97.58	0.06	34.565	0.15	
	6S	200	3.10	1.26	0.28	38.22	7.75	89.04	10.85	90.58	0.08	34.580	0.16	
	6D	200	2.79	1.26	0.42	34.28	7.75	80.22	10.54	81.90	0.05	34.578	0.15	
NK-2	1S	0	2.48	1.40	1.54	42.71	8.37	95.20	10.85	98.14	0.05	34.553	0.24	
	2S	2	2.48	1.26	1.12	37.65	6.20	80.50	8.68	82.88	0.06	34.537	0.24	
	3S	10	2.79	1.40	2.38	32.32	6.51	91.14	9.30	94.92	0.06	34.542	0.26	
	3D	10	2.79	1.26	1.68	34.84	6.20	88.34	8.99	91.28	0.07	34.541	0.20	
	4S	25	5.27	0.70	3.22	35.41	6.82	77.70	12.09	81.62	0.05	34.545	0.19	
	4D	25	3.10	1.40	1.82	30.35	6.82	84.28	9.92	87.50	0.05	34.545	0.15	
	5S	75	3.72	0.42	0.98	30.35	5.89	74.20	9.61	75.60	0.05	34.534	0.20	
	5D	75	3.72	1.26	2.10	26.41	5.58	88.20	9.30	91.56	0.08	34.563	0.13	
	6S	200	4.65	0.14	1.96	32.32	4.34	67.34	8.99	69.44	0.05	34.536	0.20	
	6D	200	3.72	0.84	1.40	33.72	4.96	65.94	8.68	68.18	0.06	34.535	0.19	
SK-3	1S	0	4.65	27.72	0.42	1113.04	8.99	68.32	13.64	96.46	0.19	33.473	0.68	8.21
	2S	2	2.79	20.30	1.12	965.80	9.30	70.98	12.09	92.40	0.14	33.697	0.33	8.21
	3S	10	3.10	6.16	0.56	237.16	9.61	74.76	12.71	81.48	0.11	34.418	0.38	8.20
	3D	10	2.48	5.32	0.42	177.59	9.30	77.42	11.78	83.16	0.13	34.464	0.30	8.21
	4S	25	2.17	3.78	0.14	173.66	8.68	75.32	10.85	79.24	0.14	34.484	0.49	8.22
	4D	25	2.48	1.26	0.28	73.34	7.44	72.66	9.92	74.20	0.12	34.548	0.34	8.24
	5S	75	2.17	2.24	0.42	149.77	7.75	70.14	9.92	72.80	0.13	34.500	0.49	8.23
	5D	75	1.86	1.54	0.28	118.86	8.37	71.26	10.23	73.08	0.11	34.515	0.44	8.24
	6S	200	2.17	1.96	1.12	73.90	9.30	74.34	11.47	77.42	0.10	34.551	0.33	8.24
	6D	200	1.86	2.10	0.56	64.07	8.06	67.06	9.92	69.72	0.07	34.549	0.25	8.24
SK-4	1S	0	14.26	379.68	BDL	9268.50	7.75	45.92	22.01	425.60	0.22	22.302	2.21	8.00
	2S	2	6.20	171.43	0.14	4865.23	6.50	50.70	12.70	222.28	0.25	28.036	0.53	8.03
	3S	10	2.79	52.36	BDL	1558.99	7.13	62.30	9.92	114.66	0.17	32.611	0.25	8.06
	3D	10	2.17	16.38	0.70	591.79	7.44	72.80	9.61	89.88	0.21	33.880	0.47	8.09
	4S	25	5.27	99.82	0.70	2426.15	7.75	74.06	13.02	174.58	0.16	31.717	0.33	8.07
	4D	25	1.86	16.66	1.12	403.24	7.44	74.76	9.30	92.54	0.14	34.178	0.28	8.11
	5S	75	5.27	124.32	1.12	2918.19	6.51	75.88	11.78	201.32	0.15	31.133	0.34	8.07
	5D	75	2.48	21.70	0.56	460.56	6.51	77.14	8.99	99.40	0.12	34.120	0.28	8.08
	6S	200	2.48	10.36	1.26	164.95	7.75	72.38	10.23	84.00	0.08	34.459	0.20	8.17
	6D	200	3.10	9.52	1.26	155.67	7.44	68.60	10.54	79.38	0.08	34.456	0.22	8.17

TABLE 2 (cont.)

SITE	NO.	DFS (m)	PO4 (µg/L)	NO3 (µg/L)	NH4 (µg/L)	SI (µg/L)	DOP (µg/L)	DON (µg/L)	TDP (µg/L)	TDN (µg/L)	TURB (NTU)	SALINITY (o/oo)	CHL a (µg/L)	pH
SK-5	1S	0	46.81	871.22	0.56	19100.41	0.62	45.78	47.43	917.66	0.14	10.093	0.24	7.90
	2S	2	30.38	568.82	1.96	12913.36	0.62	44.80	31.00	615.58	0.18	18.232	0.51	8.07
	3S	10	6.20	48.58	3.22	1569.90	6.20	43.82	12.40	95.62	0.20	32.769	0.39	8.21
	3D	10	4.03	9.66	1.96	366.99	6.82	71.40	10.85	83.02	0.15	34.255	0.26	8.20
	4S	25	4.34	18.06	4.76	735.38	7.44	71.12	11.78	93.94	0.14	33.727	0.16	8.18
	4D	25	3.10	6.72	2.10	229.30	7.75	76.30	10.85	85.12	0.12	34.350	0.17	8.21
	5S	75	3.41	6.02	1.26	108.47	6.82	78.62	10.23	86.10	0.08	34.498	0.26	8.21
	5D	75	3.41	5.88	2.10	107.34	5.89	76.30	9.30	84.28	0.08	34.511	0.25	8.20
	6S	200	2.79	2.52	1.40	188.55	5.89	75.32	8.68	79.24	0.06	34.522	0.30	8.23
	6D	200	3.10	1.54	1.40	85.14	6.51	73.50	9.61	76.44	0.08	34.531	0.27	8.24
SK-6	1S	0	4.65	37.10	2.24	744.65	6.51	106.26	11.16	145.60	0.22	33.675	0.87	8.28
	2S	2	4.03	36.12	2.52	673.28	5.27	85.54	9.30	124.18	0.22	33.748	1.14	8.27
	3S	10	5.27	54.88	2.24	850.31	5.58	80.22	10.85	137.34	0.14	33.503	0.46	8.23
	3D	10	2.79	4.06	2.38	134.88	5.58	72.38	8.37	78.82	0.08	34.487	0.51	8.23
	4S	25	4.34	35.70	2.80	626.07	5.58	77.00	9.92	115.50	0.13	33.804	0.43	8.22
	4D	25	2.79	3.36	2.66	113.24	5.58	76.72	8.37	82.74	0.10	34.498	0.43	8.23
	5S	75	3.1	14.14	1.96	337.20	5.89	73.64	8.99	89.74	0.08	34.192	0.42	8.22
	5D	75	2.79	2.52	1.96	100.60	4.96	73.64	7.75	78.12	0.08	34.507	0.38	8.24
	6S	200	2.79	3.64	2.24	105.94	5.58	71.68	8.37	77.56	0.08	34.496	0.32	8.23
	6D	200	2.48	1.54	2.24	64.63	5.58	73.22	8.06	77.00	0.08	34.546	0.29	8.24
DOH WATER QUALITY STANDARDS														
NOT TO EXCEED 10%				14.00	8.50				40.00	250.00	1.25		0.90	
NOT TO EXCEED 2%				25.00	15.00				60.00	350.00	2.00		1.75	

TABLE 3. Water chemistry composition in samples collected at locations where marine algae were collected for analysis of stable isotope (15N). For sampling locations see Figure 1.

SAMPLING LOCATION	PO4 (μM)	NO3 (μM)	NH4 (μM)	SI (μM)	DOP (μM)	DON (μM)	TP (μM)	TN (μM)	TURBIDITY (NTU)	SALINITY (o/oo)
KEPUHI POINT										
Tide pool	0.08	0.18	0.05	5.61	0.19	8.28	0.27	8.51	0.34	34.483
Bench	0.14	0.22	0.02	6.36	0.16	6.28	0.30	6.52	0.11	34.439
Bench	0.15	0.23	0.03	6.29	0.17	5.67	0.32	5.93	0.11	34.449
Shoreline	0.12	0.13	0.01	4.63	0.19	5.94	0.31	6.08	0.09	34.522
Shoreline	0.12	0.17	0.02	4.38	0.18	4.71	0.30	4.90	0.09	34.559
KAUHOLA POINT										
Offshore	0.10	0.06	0.03	2.37	0.19	6.73	0.29	6.82	0.15	34.570
Offshore	0.11	0.06	0.01	2.28	0.20	5.43	0.31	5.50	0.15	34.570
Offshore	0.11	0.06	0.02	2.33	0.23	5.69	0.34	5.77	0.17	34.566
KAUHOLA STREAM–KEAWAELI BAY										
Stream	0.39	17.60	0.02	329.57	0.18	5.75	0.57	23.37	4.10	0.186
Beach	0.52	16.55	0.00	311.85	0.19	7.71	0.71	24.26	4.20	0.788
Beach	0.46	14.00	0.17	266.11	0.22	9.21	0.68	23.38	3.60	5.845
Shoreline	0.16	1.12	0.08	23.06	0.18	5.38	0.34	6.58	0.44	32.392
KALALAE–AKOAKOA										
Seep	1.23	166.71	0.22	452.76	0.25	0.44	1.48	167.37	1.08	1.166
Beach	0.22	2.19	0.47	7.12	0.23	15.17	0.45	17.83	1.05	34.406

CORRECTION

THE PRECEDING DOCUMENT(S) HAS BEEN REPHOTOGRAPHED TO ASSURE LEGIBILITY
SEE FRAME(S)
IMMEDIATELY FOLLOWING

TABLE 3. Water chemistry composition in samples collected at locations where marine algae were collected for analysis of stable isotope (15N). For sampling locations see Figure 1.

SAMPLING LOCATION	PO4 (μM)	NO3 (μM)	NH4 (μM)	SI (μM)	DOP (μM)	DON (μM)	TP (μM)	TN (μM)	TURBIDITY (NTU)	SALINITY (o/oo)
KEPUHI POINT										
Tide pool	0.08	0.18	0.05	5.61	0.19	8.28	0.27	8.51	0.34	34.483
Bench	0.14	0.22	0.02	6.36	0.16	6.28	0.30	6.52	0.11	34.439
Bench	0.15	0.23	0.03	6.29	0.17	5.67	0.32	5.93	0.11	34.449
Shoreline	0.12	0.13	0.01	4.63	0.19	5.94	0.31	6.08	0.09	34.522
Shoreline	0.12	0.17	0.02	4.38	0.18	4.71	0.30	4.90	0.09	34.559
KAUHOLA POINT										
Offshore	0.10	0.06	0.03	2.37	0.19	6.73	0.29	6.82	0.15	34.570
Offshore	0.11	0.06	0.01	2.28	0.20	5.43	0.31	5.50	0.15	34.570
Offshore	0.11	0.06	0.02	2.33	0.23	5.69	0.34	5.77	0.17	34.566
KAUHOLA STREAM–KEAWAELI BAY										
Stream	0.39	17.60	0.02	329.57	0.18	5.75	0.57	23.37	4.10	0.186
Beach	0.52	16.55	0.00	311.65	0.19	7.71	0.71	24.26	4.20	0.788
Beach	0.46	14.00	0.17	266.11	0.22	9.21	0.68	23.38	3.60	5.845
Shoreline	0.16	1.12	0.08	23.06	0.18	5.38	0.34	6.58	0.44	32.392
KALALAE-AKOAKOA										
Seep	1.23	166.71	0.22	452.76	0.25	0.44	1.48	167.37	1.08	1.166
Beach	0.22	2.19	0.47	7.12	0.23	15.17	0.45	17.83	1.05	34.406

TABLE 5. Coral species percent cover, non-coral substrata cover, and coral community statistics from transect surveys off North Kohala. For transect station locations, see Figure 1.

CORAL SPECIES	KAPANA BAY 10'	KAPANA BAY 32'	KAUHOLA POINT 26'	KEAWAELI BAY 15'
Porites lobata	0.1	15.1	3.9	0.5
Pocillopora meandrina	5.6	21.2	4.2	0.3
Montipora verrucosa		1.2		
Pavona varians			0.1	
Cyphastrea ocellina	0.1			
TOTAL CORAL COVER	5.8	37.5	8.2	0.8
NUMBER OF SPECIES	3	3	3	2
CORAL COVER DIVERSITY	0.173	0.798	0.75	0.874
NON-CORAL SUBSTRATA				
Limestone		3.8	17.8	15.3
Sand		55.5	0.6	1.9
Sargassum				60.5
Basalt	94.2	62.5	91.8	21.5

TABLE 6. Coral species percent cover, non-coral substrata cover, and coral community statistics from transect surveys off South Kohala. For transect station locations, see Figure 2.

CORAL SPECIES	KAWAIHAE LIGHTHOUSE 10'	KAWAIHAE LIGHTHOUSE 20'	SPENCER PARK 10'	SPENCER PARK 15'
Porites lobata	27.6	23.6	0.1	28.4
Porites compressa			40.5	31.2
Pocillopora meandrina	15.1	10.4		0.2
Pocillopora eydouxi		3.4		
Montipora patula	0.4	2.2		
Montipora verrucosa	10.6	5.3		3.0
Pavona varians	0.1			
Leptastrea purpurea	2.4	0.8		
TOTAL CORAL COVER	56.2	45.7	40.6	62.8
NUMBER OF SPECIES	6	6	2	4
CORAL COVER DIVERSITY	1.198	1.338	0.02	0.87
NON-CORAL SUBSTRATA				
Limestone	5.6	4.3	28.4	30.5
Sand	1.4		2.7	1.2
Basalt	36.8	50.0		
Rubble			1.5	5.5
Calcareous algae			26.8	

CORAL SPECIES	PUAKO 6'	PUAKO 15'	HONOKAOPE 8'	HONOKAOPE 10'
Porites lobata	53.3	44.2	65.4	60.1
Porites compressa	1.7	10.3	0.2	3.4
Pocillopora meandrina	1.5	4.0	7.1	4.9
Montipora patula		0.9	2.6	
Montipora verrucosa				1.0
Montipora flabellata				2.1
Pavona varians	0.6	1.0	0.2	0.1
TOTAL CORAL COVER	57.1	60.4	75.5	71.6
NUMBER OF SPECIES	4	5	5	6
CORAL COVER DIVERSITY	0.312	0.84	0.49	0.647
NON-CORAL SUBSTRATA				
Limestone	42.9	39.6	18.5	16.9
Sand			5.9	1.9
Basalt				9.6

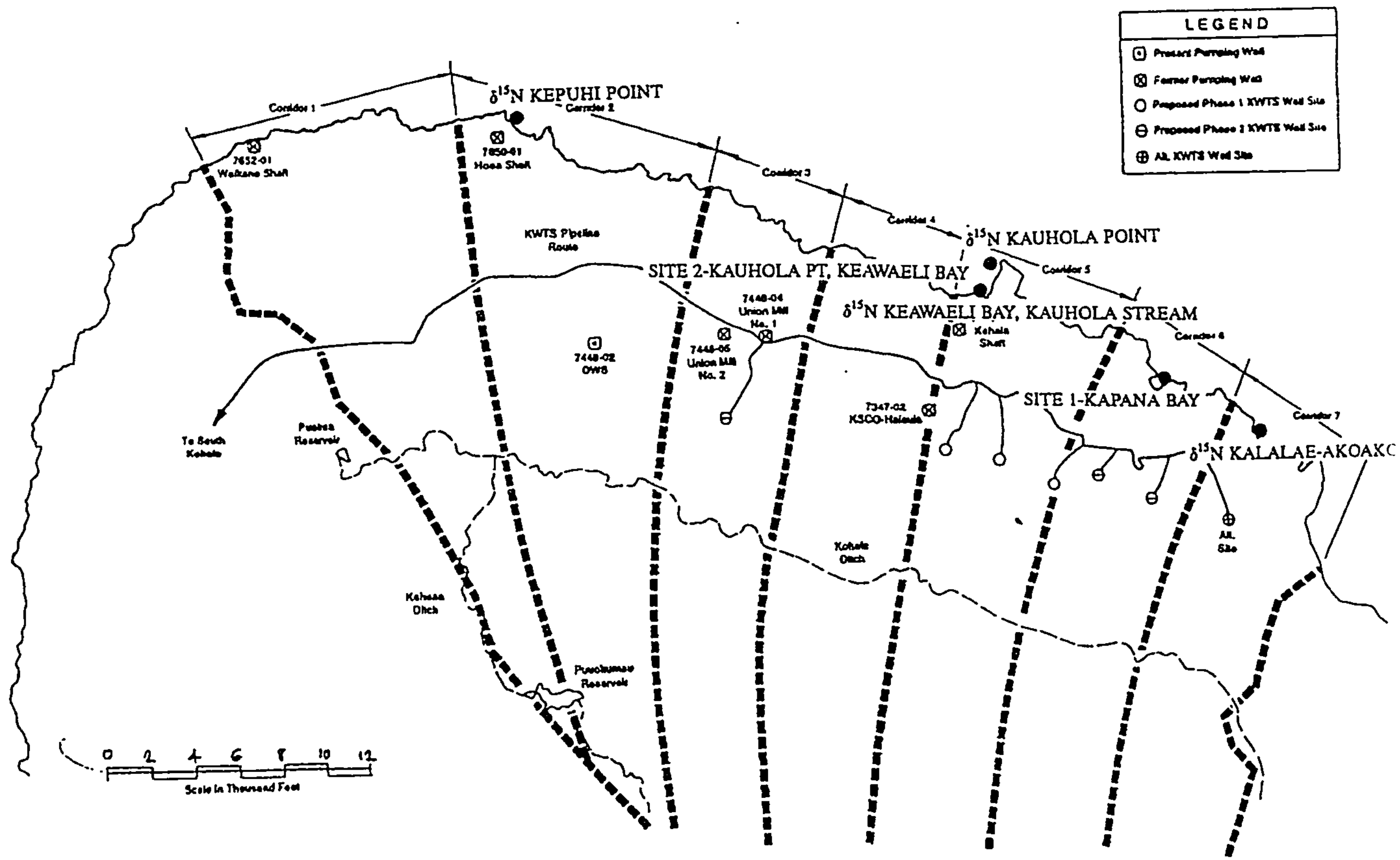

FIGURE 1. Map of North Kohala area showing seven mauka-makai groundwater flow corridors (from Nance) and proposed locations of Kohala Water Transmission System (KWTS) wells. Also shown are locations of water chemistry and coral community assessments (Sites 1 and 2), and locations where marine algae were collected for δ^{15}N analysis.

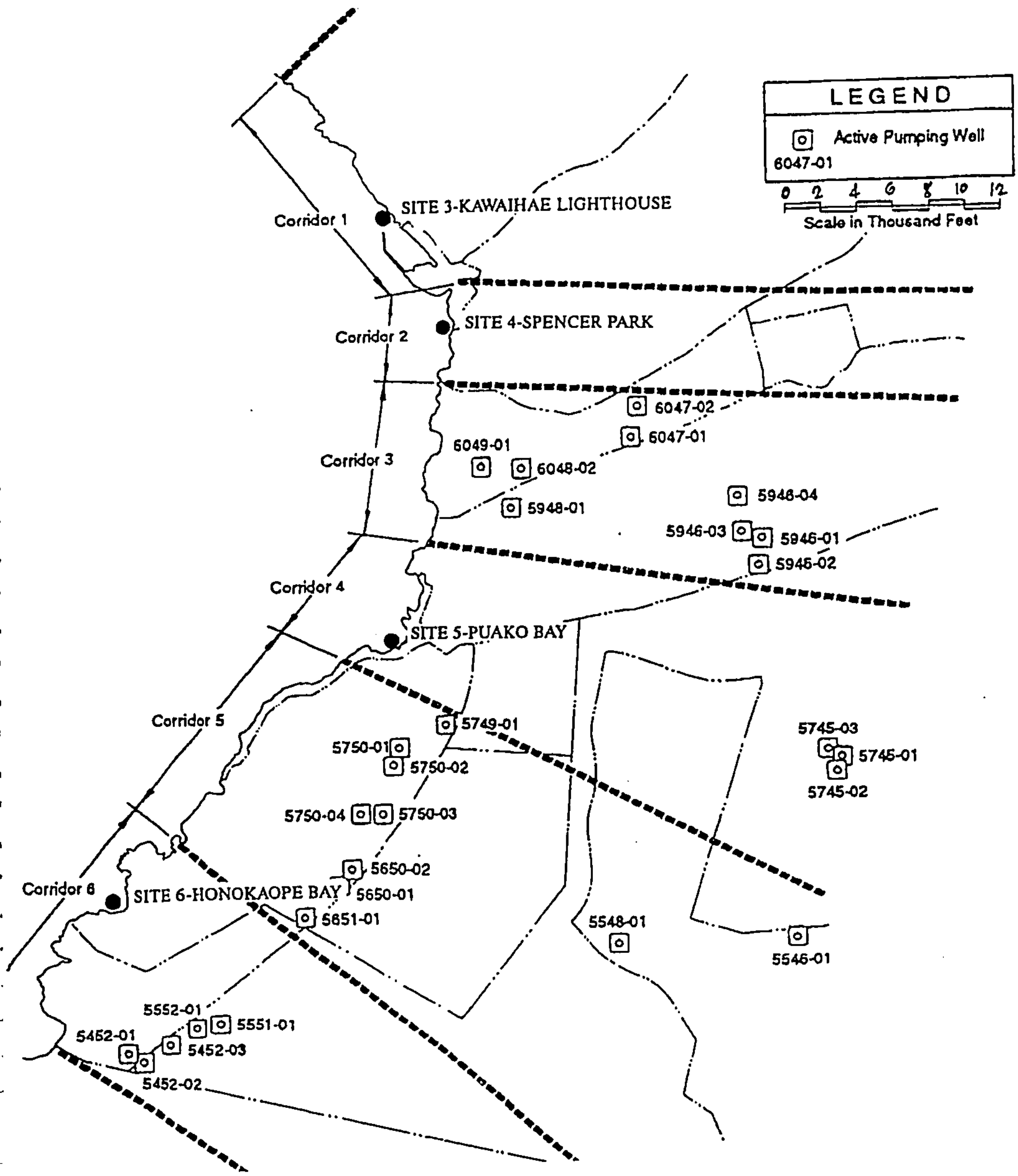

FIGURE 2. Map of South Kohala area showing six mauka-makai groundwater flow corridors (from Nance) and locations of active pumping wells. Also shown are locations of water chemistry and coral community assessments (Sites 3-6).

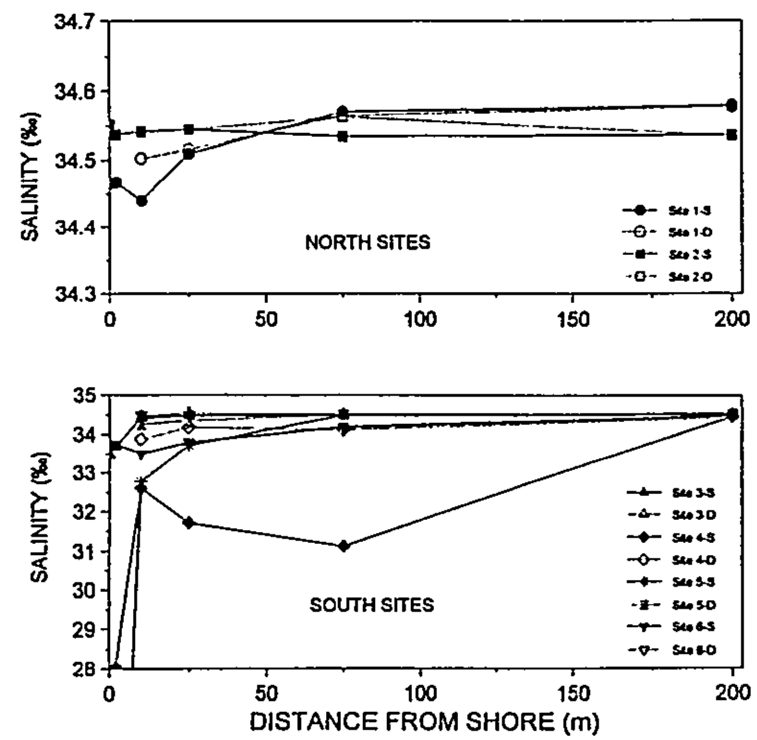

FIGURE 3. Plots of salinity collected from surface (S) and deep (D) water offshore of North and South Kohala as functions of distance from the shoreline. Note y-axis scales are different. For sampling site locations, see Figures 1 and 2.

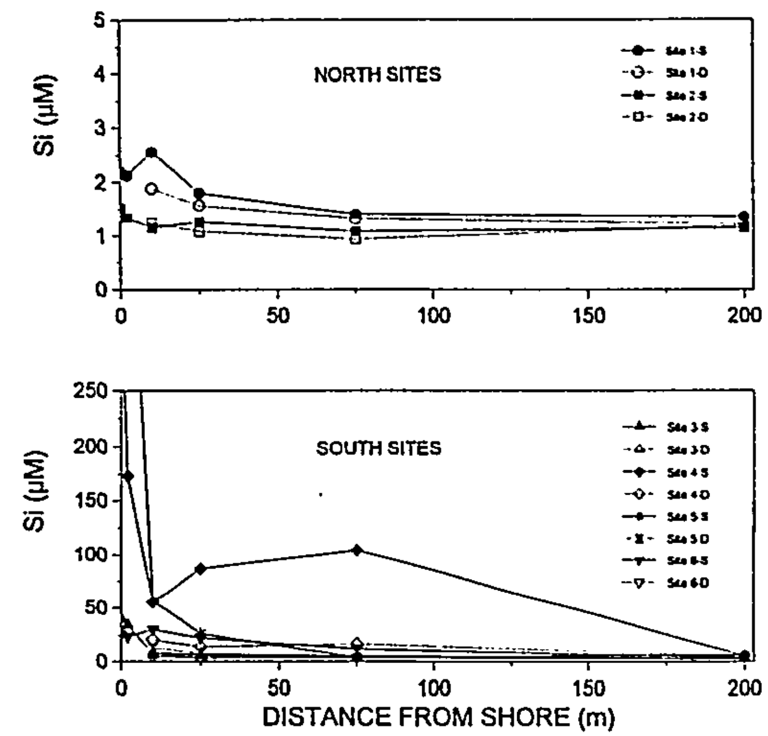

FIGURE 4. Plots of dissolved silica collected from surface (S) and deep (D) water offshore of North and South Kohala as functions of distance from the shoreline. Note y-axis scales are different. For sampling site locations, see Figures 1 and 2.

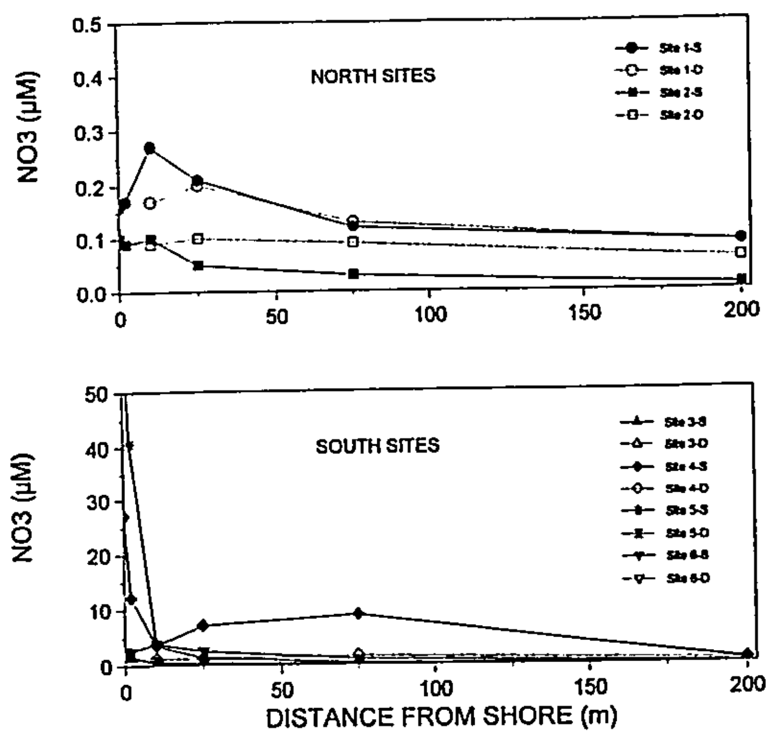

FIGURE 5. Plots of dissolved nitrate collected from surface (S) and deep (D) water offshore of North and South Kohala as functions of distance from the shoreline. Note y-axis scales are different. For sampling site locations, see Figures 1 and 2.

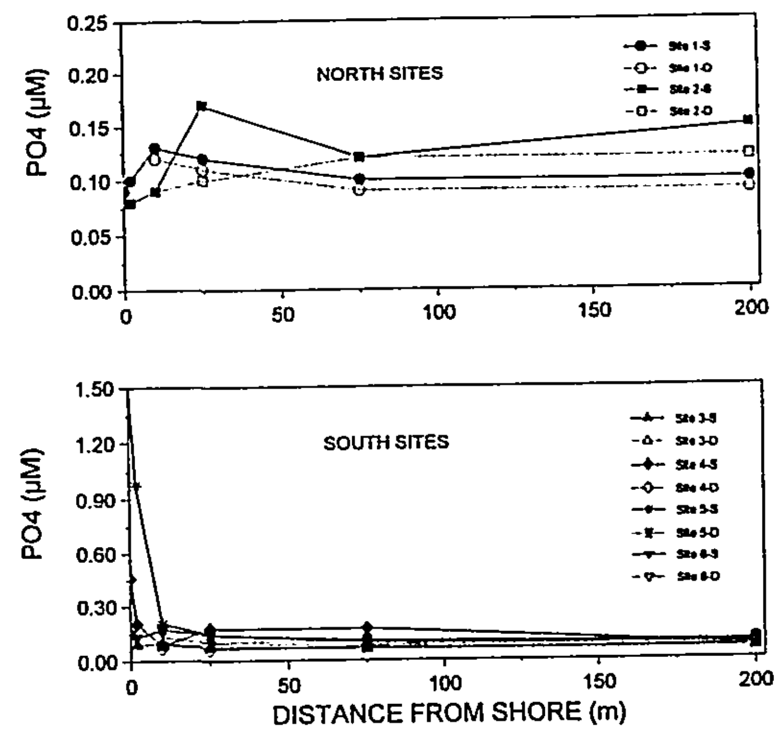

FIGURE 6. Plots of dissolved phosphate collected from surface (S) and deep (D) water offshore of North and South Kohala as functions of distance from the shoreline. Note y-axis scales are different. For sampling site locations, see Figures 1 and 2.

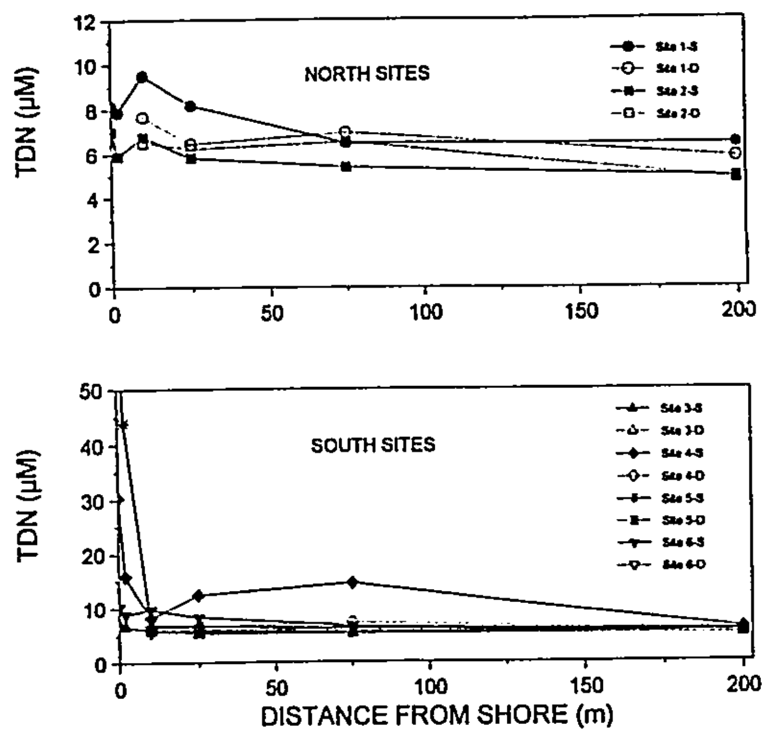

FIGURE 7. Plots of total dissolved nitrogen collected from surface (S) and deep (D) water offshore of North and South Kohala as functions of distance from the shoreline. Note y-axis scales are different. For sampling site locations, see Figures 1 and 2.

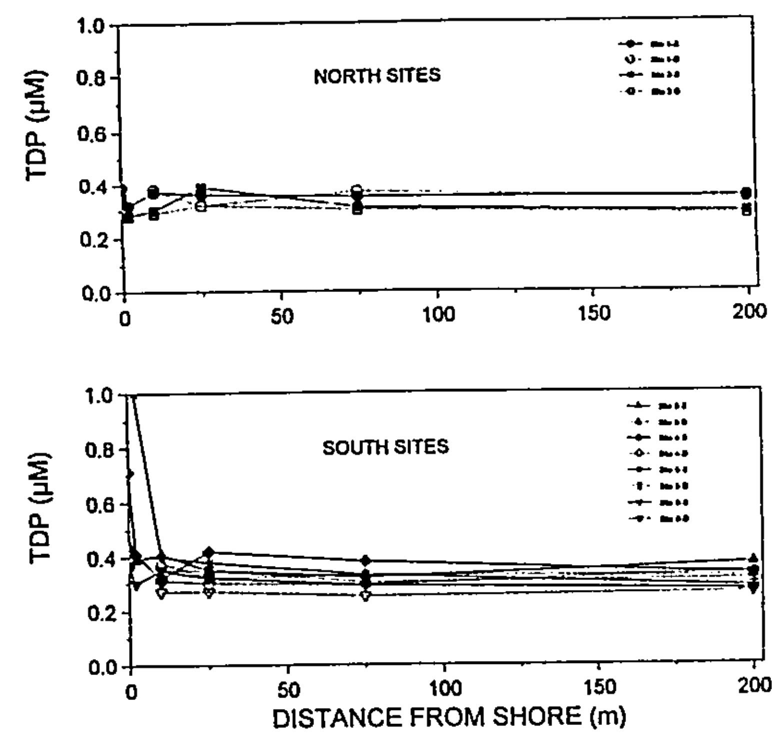

FIGURE 8. Plots of total dissolved phosphate collected from surface (S) and deep (D) water offshore of North and South Kohala as functions of distance from the shoreline. For sampling site locations, see Figures 1 and 2.

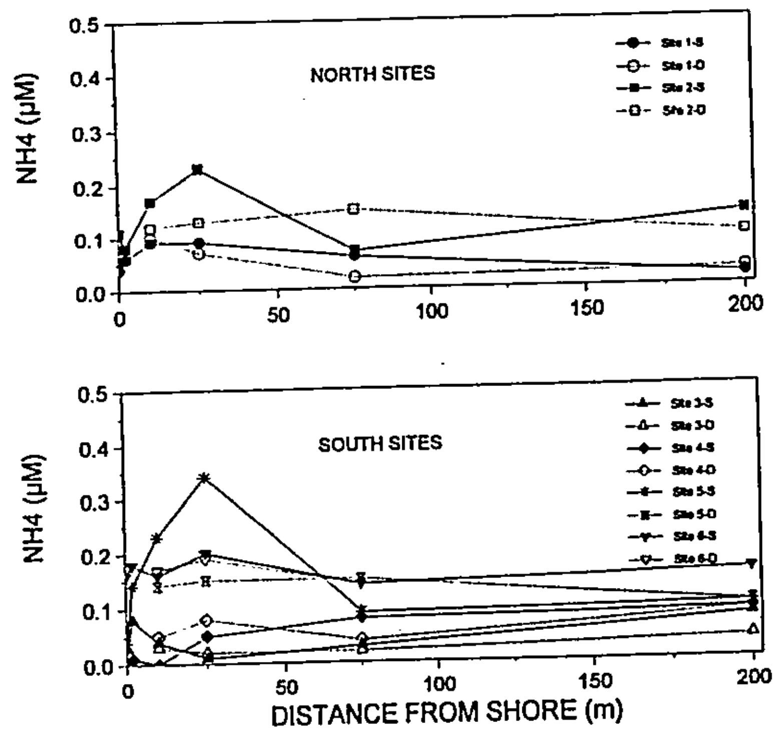

FIGURE 9. Plots of ammonium collected from surface (S) and deep (D) water offshore of North and South Kohala as functions of distance from the shoreline. For sampling site locations, see Figures 1 and 2.

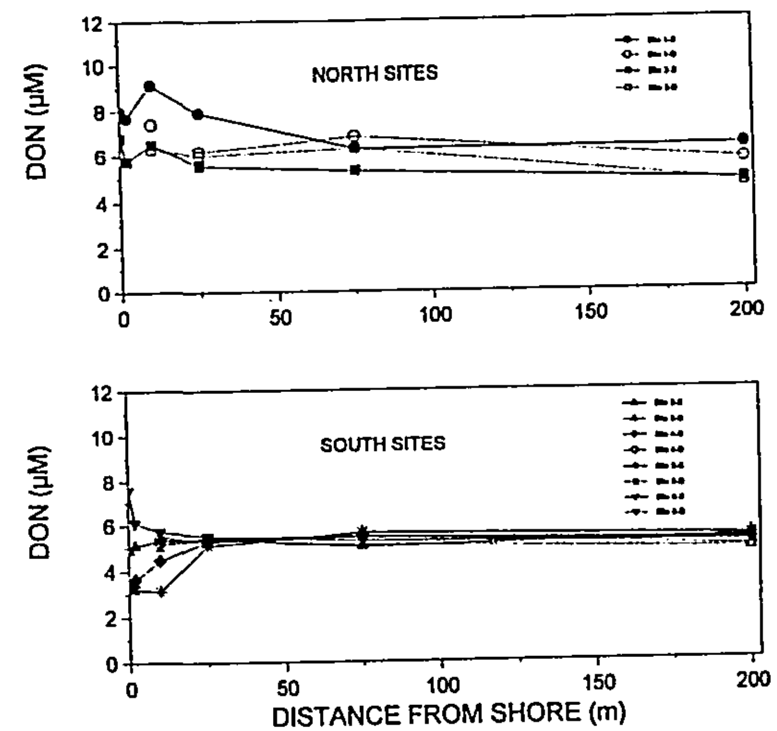

FIGURE 10. Plots of dissolved organic nitrogen collected from surface (S) and deep (D) water offshore of North and South Kohala as functions of distance from the shoreline. For sampling site locations, see Figures 1 and 2.

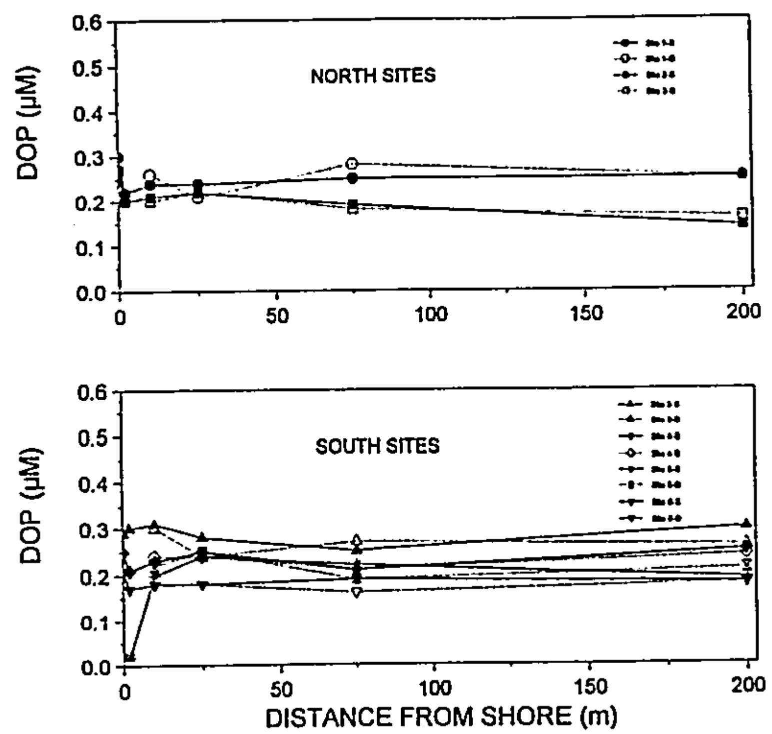

FIGURE 11. Plots of dissolved organic phosphate collected from surface (S) and deep (D) water offshore of North and South Kohala as functions of distance from the shoreline. For sampling site locations, see Figures 1 and 2.

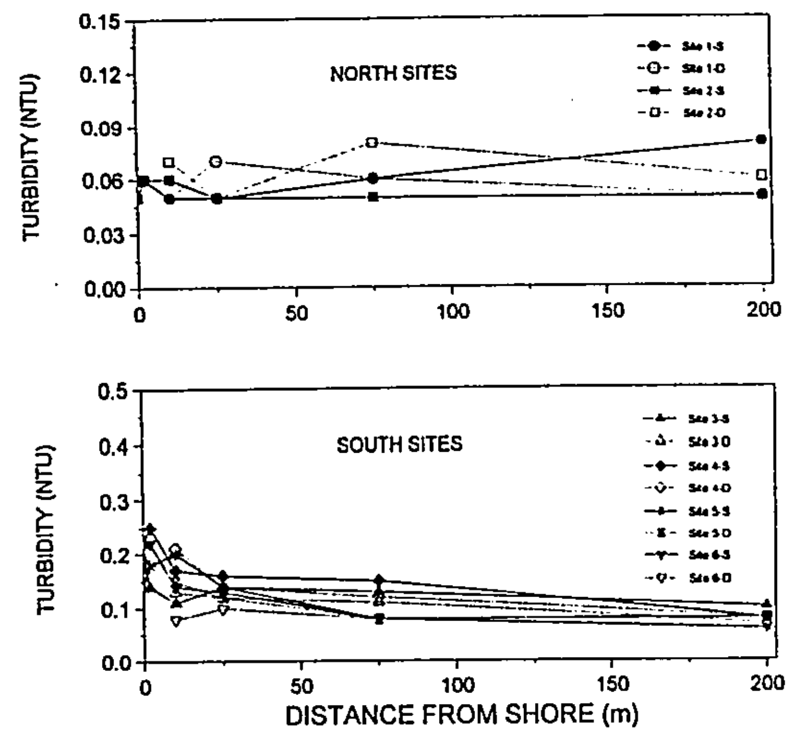

FIGURE 12. Plots of turbidity collected from surface (S) and deep (D) water offshore of North and South Kohala as functions of distance from the shoreline. Note y-axis scales are different. For sampling site locations, see Figures 1 and 2.

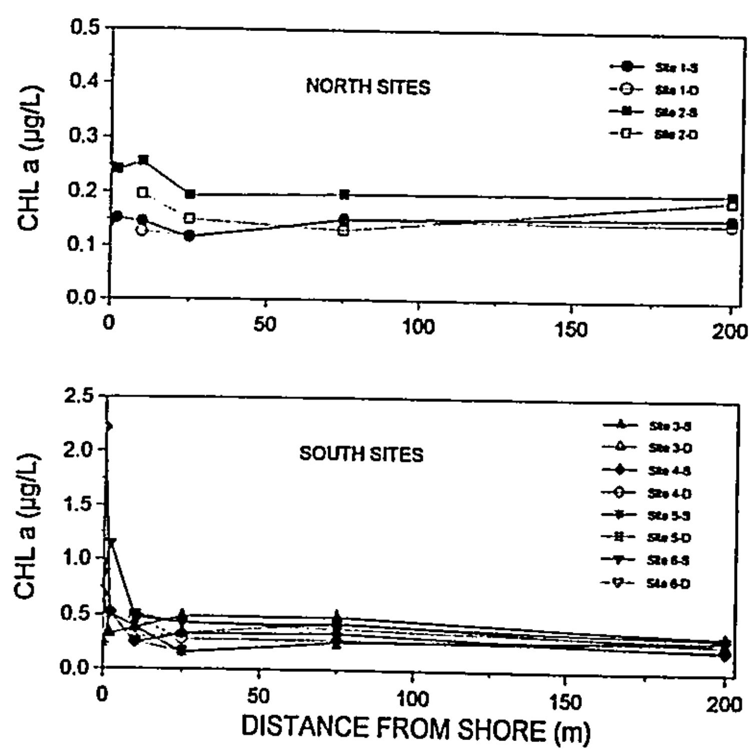

FIGURE 13. Plots of chlorophyll *a* collected from surface (S) and deep (D) water offshore of North and South Kohala as functions of distance from the shoreline. Note y-axis scales are different. For sampling site locations, see Figures 1 and 2.

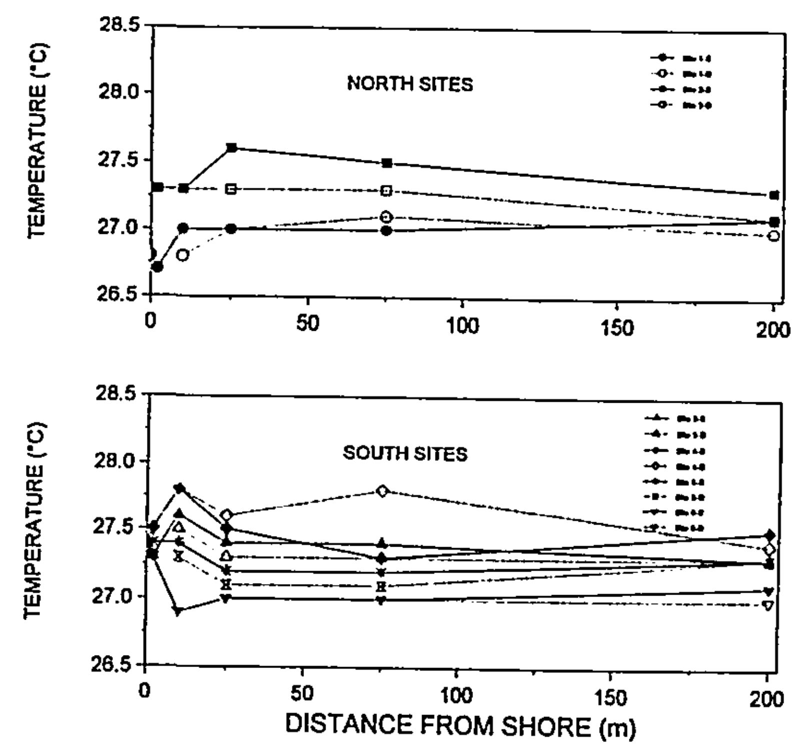

FIGURE 14. Plots of temperature collected from surface (S) and deep (D) water offshore of North and South Kohala as functions of distance from the shoreline. For sampling site locations, see Figures 1 and 2.

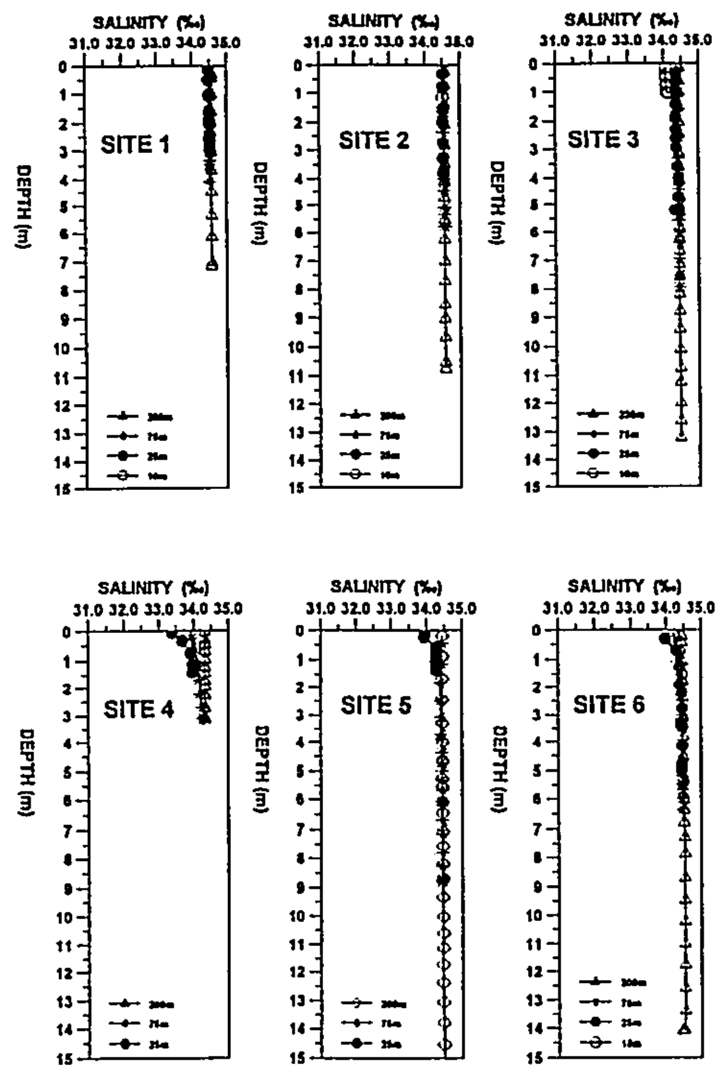

FIGURE 15 Vertical profiles of salinity at sampling stations 10 to 200 meters from shore at six sites located offshore of North and South Kohala. For sampling site locations, see Figures 1 and 2.

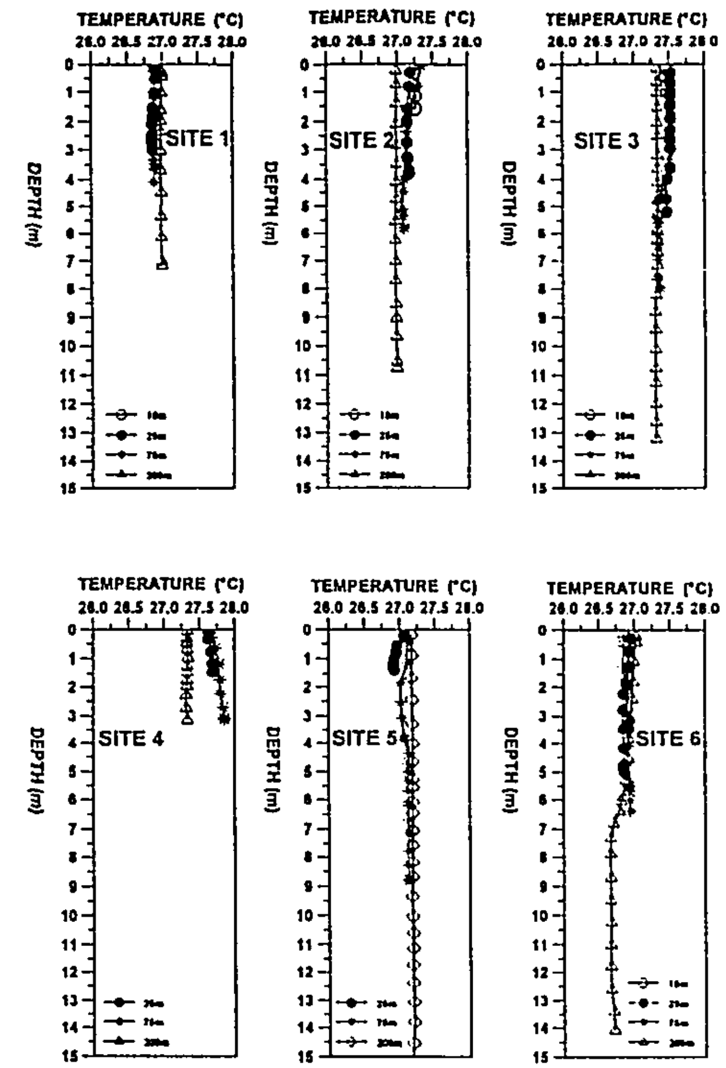

FIGURE 16 Vertical profiles of temperature at sampling stations 10 to 200 meters from shore at six sites located offshore of North and South Kohala. For sampling site locations, see Figures 1 and 2.

APPENDIX A.
NORTH KOHALA SITES

REEF CORAL TRANSECT DATA SHEET

TRANSECT SITE: KWTS-Site 1
TRANSECT ID #: KAPANA BAY (10')
DATE: 9/2/94

MEAN CORAL COVER 5.8 %
STD. DEV. 5.3
SPECIES COUNT 3
SPECIES DIVERSITY 0.173

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata								1			1.0
Pocillopora meandrina	8		6	3		12	13			14	56.0
Cyphastrea ocellina					1						1.0
QUAD CORAL TOTAL	8	0	6	3	1	12	13	1	0	14	58.0
Basalt	92	100	94	97	99	88	87	99	100	86	942.0

TRANSECT SITE: KWTS-Site 1
TRANSECT ID #: KAPANA BAY (30')
DATE: 9/2/94

MEAN CORAL COVER 37.5 %
STD. DEV. 10.7
SPECIES COUNT 3
SPECIES DIVERSITY 0.798

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	14	16	8	11	9	2	28	28	14	21	151.0
Pocillopora meandrina	16	35	11	18	36	35	14	16	10	21	212.0
Montipora verrucosa	2	7							2	1	12.0
QUAD CORAL TOTAL	32	58	19	29	45	37	42	44	26	43	375.0
Limestone	5		2	6			3	6	4	12	38.0
Basalt	31	42	79	65	55	63	55	50	70	45	555.0

TRANSECT SITE: KWTS-Site 2
TRANSECT ID #: KAUHOLA PT. (26')
DATE: 9/2/94

MEAN CORAL COVER 8.2 %
STD. DEV. 3.9
SPECIES COUNT 3
SPECIES DIVERSITY 0.749

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	5	3	5	3	4	2	8	4	3	2	39.0
Pocillopora meandrina	3	3	0	4	0	14	6	0	5	7	42.0
Pavona varians										1	1.0
QUAD CORAL TOTAL	8	6	5	7	4	16	14	4	8	10	82.0
Limestone	4	12	15	2	15	17	14	43	6	8	136.0
Basalt	86	82	80	76	81	55	72	53	86	82	753.0
Sand	2			15		12					29.0

TRANSECT SITE: KWTS-Site 2
TRANSECT ID #: KEAWAELI BAY (15')
DATE: 11/14/94

MEAN CORAL COVER 0.8 %
STD. DEV. 0.6
SPECIES COUNT 2
SPECIES DIVERSITY 0.661

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	1				1			1	1	1	5.0
Pocillopora meandrina		1		2							3.0
QUAD CORAL TOTAL	1	1	0	2	1	0	0	1	1	1	8.0
Sargassum	56	54	67	38	89	55	67	68	57	54	605.0
Sand	1		3		3		4	4		4	19.0
Limestone	18	40	7	21	3	20	10	16	10	8	153.0
Basalt	24	5	23	39	4	25	19	11	32	33	215.0

APPENDIX D

ARCHAEOLOGICAL INVENTORY SURVEY

BIOLOGICAL SURVEY

AN ARCHAEOLOGICAL INVENTORY SURVEY FOR THE KOHALA WATER TRANSMISSION SYSTEM PROJECT NORTH KOHALA AND SOUTH KOHALA DISTRICTS, ISLAND OF HAWAI'I

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ABSTRACT

At the request of Megumi Kon, Inc. an archaeological inventory survey was conducted in a project area consisting of a corridor of land passing through the northern section of South Kohala District and most of North Kohala District, Island of Hawai'i. A total of five sites (State Sites 50-10-5- 19,774, 19,775, and 19,776 in Waikoloa *ahupua'a* and Sites 50-10-11- 19,777, and 19,778 in Makiloa *ahupua'a*) were recorded within the project area. These sites include three marine shell midden scatters, one platform, and one habitation complex. All five sites are significant under Criterion D for the data they have yielded or are likely to yield. In addition, Sites 19,775 and 19,776 are significant under Criterion E because of their significance to an ethnic group. It is recommended that the access road to the Pressure Breaker Reservoir be realigned to miss Site 19,775, and that an archaeological monitor be present when the access roads are constructed to the Pressure Breaker Reservoir [TMK 5-9-03:Various] and the Kawaihae Terminal Reservoir [TMK 6-1-01:3].

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FIGURES

INTRODUCTION

At the request of Megumi Kon, Inc. an archaeological inventory survey was conducted for the Kohala Water System Transmission Project (County of Hawaii Department of Water Supply) by Scientific Consultant Services, Inc (SCS). This Kohala Coast Water Transmission System is intended to deliver water from the Hawi aquifer to the coastal region of South Kohala. In addition, the project will provide for the upgrade of the existing water system in North Kohala, which is currently dependent on a combination of surface and deep well sources.

The archaeological inventory survey consisted of documentary research, fieldwork, laboratory work, and the preparation of a report discussing this work.

A total of 10 person-days were expended in the field. At various times the crew consisted of Susan Cameron, B. A. (Field Assistant), David Chaffee, B. A. (Field Assistant), and Robert L. Spear, Ph.D. (Principal Investigator). Documentary research was conducted by Diane Guerriero.

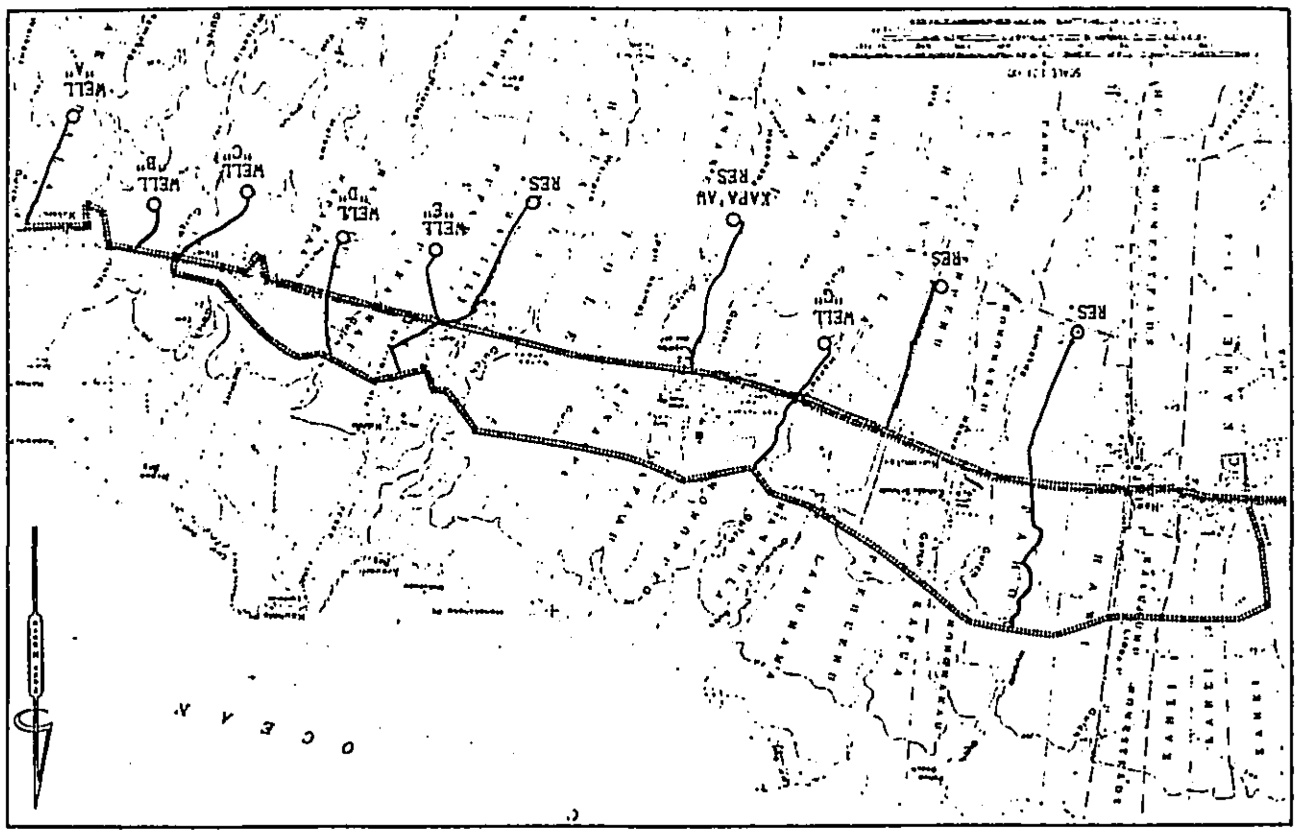
PROJECT LOCATION AND ENVIRONMENT

The project area consists of two possible pipeline routes (one following the existing main highway and an alternate route which utilizes an old cane haul road called Pratt Road), well and reservoir locations, and the access roads to those locations. The project area starts at Well Site "A" located at Tax Map Key (TMK) 5-2-05:1 near Makapala in North Kohala District, continues west and then south across North Kohala District, and on into South Kohala District. The project area corridor ends at the Lalamilo Terminal Reservoir Site (TMK 6-8-01:6) *mauka* of Puako Bay in West Hawai'i, South Kohala District (Figures 1 and 2).

As can be expected, a wide variety of environmental conditions were encountered over the entire length of the project area. From its beginning at well location "A" in the wet, windward portion of North Kohala near Makapala the environment in the project area becomes progressively dryer as one travels west.

RECEIVED AS FOLLOWS

FIGURE 2: USGS HAWI QUADRANGLE SHOWING PROJECT AREA CORRIDOR, ACCESS ROADS, WELL, AND RESERVOIR SITES.



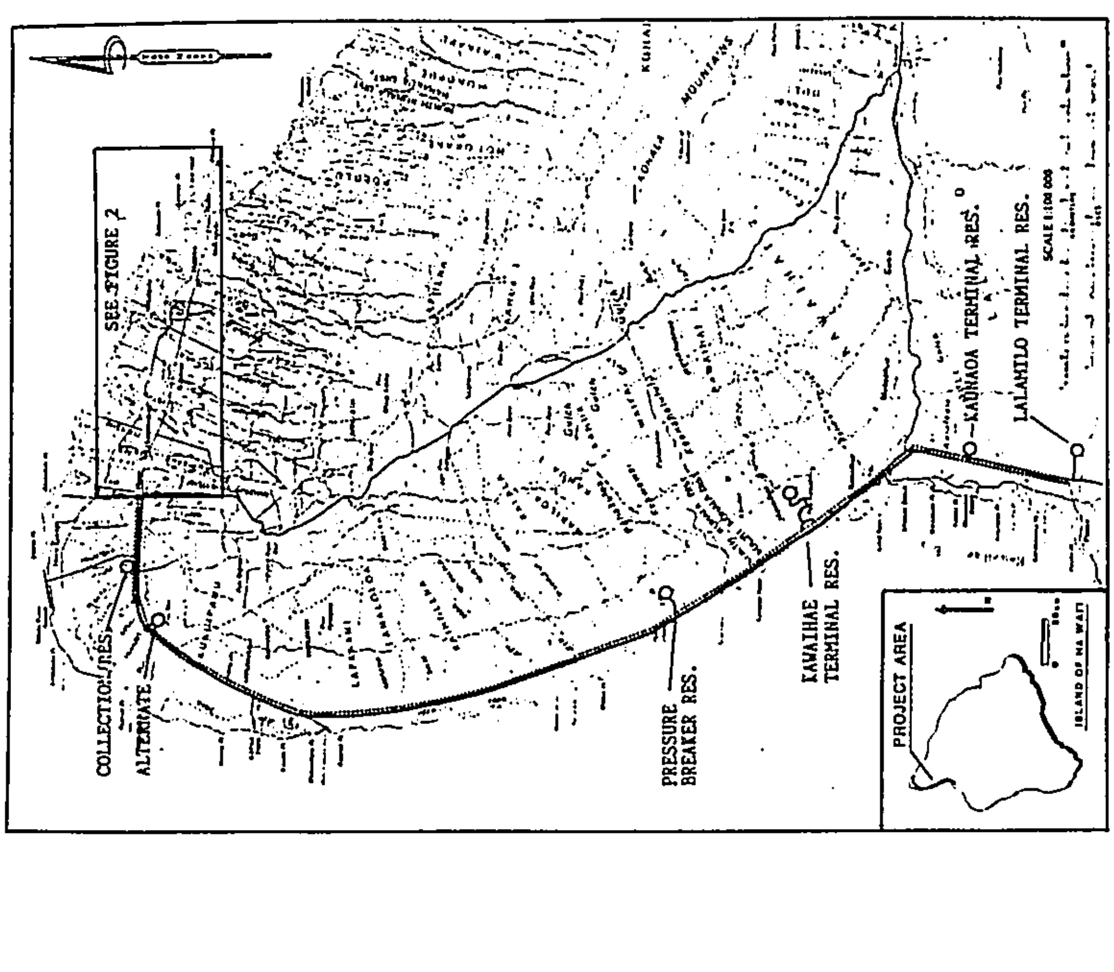


FIGURE 1: USGS HAWAII COUNTY TOPOGRAPHIC MAP SHOWING PROJECT AREA.

THE KOHALA ENVIRONMENT

North Kohala is separated into two major environmental zones, leeward and windward, by the 1675 m high ridge of the Kohala Mountain. The great variety of environments in the 1020 sq. mi. that make up North Kohala make this a unique district on the Big Island.

The Windward Zone

Tomonari-Tuggle (1988) provides an excellent model of the windward zone:

> The windward environmental zone extends from the boundary between North Kohala and Hamakua at 'Awini ahupua'a to Pu'uepa ahupua'a, and along the summit of the Kohala Mountain. Rainfall is considerably higher than on the leeward coast, highest in the windward valleys and decreasing toward the north. A strong swell system in deep offshore waters precludes as rich a marine ecosystem as on the more protected leeward side but near shore exploitation zones for shellfish and herbivores exist along sea cliffs and boulder beaches which alternate along a coastline dissected by valleys and gulches.
>
> -The windward zone can be divided into three sub-areas: The windward valleys, kula gulches, and kula slopes. Cut through Pololu Series lava flows, the valleys from 'Awini to Pololu are highly dissected, steep-sided, and flat-bottomed, separated by narrow ridges which end at 300 m (1000 ft) high sea cliffs. Gentle down-valley slopes on the valley floors are cut by perennial streams, except in Pololu whose intermittent stream flow is marked by alternating periods of drought and flood. Basalt sands appear periodically on the commonly boulder beach at Pololu.
>
> The kula gulches from Makanikahio to 'Iole ahupua'a are narrow, shallow, and geologically immature. Carved by perennial streams, the gulches are separated by broad kula areas with moderate, mauka-makai slopes and undulating topography. As at Pololu, a sand beach appears periodically at Kapanaia Bay.
>
> The kula slopes from 'Ainakea to Pu'uepa ahupua'a are characterized by smooth to undulating topography dissected by small gulches with intermittent to dry streams. Its boundaries with adjacent environmental zones are indistinct; the transition from the distinctively wet windward kula gulches to the dry leeward slopes is gradual through this area. The sea cliffs in this zone decrease in height to approximately 10 m high at the north point.

The environmental variations are generally accountable by the basic geologic foundation of the area, and by the subsequent influence on topography of rainfall, winds, and surface runoff. The land area which is now called the district of North Kohala was formed by two

runoff. The land area which is now called the district of North Kohala was formed by two eruption series of the Kohala volcano, approximately 450,000 years ago. The older Pololu Series, composed primarily of primitive basalts and olivine basalts, with ash forming the basic material of much of the present soils, was followed by an erosional period during which V-shaped valleys on the windward coast were carved and then alluvially filled by subsidence and emergence processes.

Volcanic activity in the second eruptive series, The Hawi Volcanic Series, occurred from 60,000 to 250,000 years ago. This followed the period of erosion and subsequent deposition in the Pololu Series and deposited primarily oligoclase andesites over portions of the original volcanic dome of the Pololu Series (Macdonald and Abbott 1970).

The younger Hawi Series lavas left uncovered a section of the windward coast which illustrates the difference in erosion between the two series. The original Pololu Series lavas formed what we see today as the deeply gouged, flat-bottomed valleys from Pololu to Waipi'o. The Hawi Series formed the smaller gulches and wide, rolling *kula* slopes of the northern windward area.

With the exception of the windward valleys, today's topography of North Kohala largely follows the surface of underlying lava flows resulting in smooth to undulating landscapes. Wind and water acting on the dissimilar lava types accounts for most of the erosional differences of these two environmental zones.

The long ridge of the Kohala Mountains works to block to the moisture-laden trade winds (predominantly from the northeast) pushing the trades upward, where the cooling results in condensation and much increased rainfall in the windward areas of North Kohala. The rainfall decreases rapidly on the leeward side as the air warms in its return to lower elevations.

The Kohala Mountain summit at 1675 m (5,260 ft) has an average annual rainfall of over 4000 mm. Rainfall declines steeply in the areas leeward of Kohala Mountain toward the Kawaihae minimum rainfall of less than 250 mm annually (Giambelluca 1986: 13,14). On the leeward side, median annual rainfall is approximately 60 inches at Pu'u Hue, which is 579 m (1900 ft) above sea level and approximately 13 inches at Mahukona at the coast (Taliaferro:1959 in Tomonari-Tuggle:1988).

Directed from the northeast, the ocean currents pound against the windward coast continuing the erosional processes which formed the distinctive sea cliffs. The leeward coast is sheltered by the land mass from the northeast trade wind swell system. The lava flows which formed the leeward slope continue offshore and are the predominant underwater substrate. There are localized sandy bottom areas but no sand beaches (Newman 1970: 30).

The Leeward Zone

The leeward zone exhibits a much more homogeneous environment characterized by dry conditions, low annual rainfall, plants and animals that have adapted to a harsher environment, and areas of subsistence farming and ocean exploitation for the populations that chose to settle there.

Rainfall in the dry leeward portion of North Kohala and the South Kohala portion of the project area corridor is under ten inches annually (Armstrong:1983).

Vegetation

The type and distribution of plants in any area closely follows climatic factors. The most important climatic factors governing plant distribution in Hawai`i seems to be average annual rainfall at elevations below about 5000 feet, and temperature and rainfall at higher elevations . Vegetation in the wet North Kohala portion of the project corridor characteristically consists of Guava (Psidium guajava), *koa haole* (Leucaena leucocephala), lantana (Lantana camara), Spanish clover, and Bermuda grass. To the west of the wet forest zone but not yet on the coast, plants such as lantana, *koa haole*, *klu* (Acacia farnesiana), *pānini* (Opuntia megacantha), `ilima (Sida fallax), and Natal redtop grass are typical. On the coast in both the North and South Kohala plants like *kiawe* (Prosopis pallida), *koa haole*, finger grass and *pili* grass (Heteropogon contortus) are characteristic (Armstrong 1983:70,71). *`Ilima*, and *pili* grass are native species.

With post-contact western settlement, sugarcane became king displacing much of the native vegetation. Vast tracts of land were given over for plantation purposes in Hamakua District as well as in North Kohala district. Figure 3 shows the field system for Kohala Sugar Company as late as 1966. Sugarcane is by far the most common vegetation found in the pro-

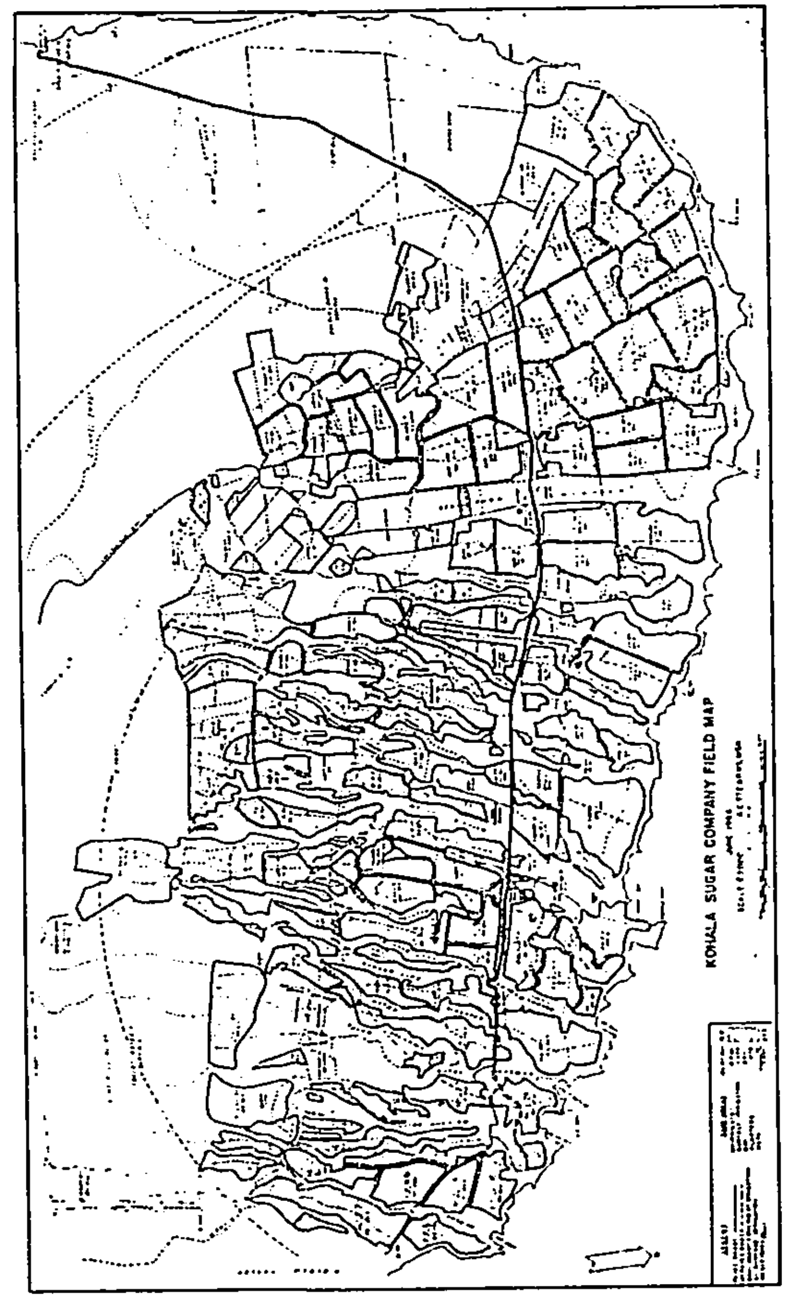


FIGURE 3: REPRODUCTION OF A 1966 KOHALA SUGAR COMPANY FIELD MAP SHOWING EXTENT OF SUGARCANE FIELDS IN NORTH KOHALA.

ject corridor's North Kohala section.

Soils

Soils types in the project corridor cover a wide range of depositional patterns, erosional characteristics, and use varieties. Soils in the vicinity of the five new archaeological sites identified in the current phase of work are as follows:

Soils in this area of Sites 19,777 and 19,778 are Kawaihae extremely stony, very fine, sandy loam with 6-12 percent slopes (KNC). This soil type in representative profile, shows the surface layer is a dark reddish-brown soil about 2 inches thick. Below this is a dark reddish-brown and dusky-red stony silt loam and loam. Hard pahoehoe lava bedrock is at a depth of about 33 inches. This soil is used mostly for pasture, wildlife habitat, and recreation areas. Small areas, less than an acre in size, have been cleared of stone and used for irrigated truck crops (Sato et al. 1973:26, Map 23)

Soils in this area of Sites 19,774, 19,775, and 19,776 are Kawaihae very rocky, very fine, sandy loam (KOC). This soil is very similar to extremely stony, very fine, sandy loam (KNC) with 6-12 percent slope described above except that rock outcrops occupy 10 to 20 percent of the surface. This soil is used for pasture (Sato et al. 1973:26, Map 10).

HISTORICAL FRAMEWORK

NORTH KOHALA

At the time of Captain Cook's arrival in 1778 Kohala was one of six major political districts on the island of Hawai'i. Although Cook's ship never landed in North Kohala, the area was visited by westerners some years later when William Ellis and his party of missionaries visited Kohala in 1823 on an around the island tour. In Ellis (1963:285) the missionaries are said to have stopped in Kapa'au, an inland village approximately two miles east of Hawi, and talked to a congregation of about fifty Hawaiians, principally women. From there they journeyed to "Owawarua", a "considerable village on the northeastern coast, inhabited mostly by fisherman". They were unable to preach in this village however, because nearly all of the

inhabitants had gone off to Waimea to gather sandalwood. Ellis and the other missionaries set to sea in canoes from the village of Hihiu and traveled some twenty miles to Kawaihae.

As with many localities in the Hawaiian Islands, depopulation in North Kohala had a direct impact on settlement and land use. An 1832 missionary census counted 8,014 people in the district. A couple of years later, in 1835, another missionary census listed the population of North Kohala as 6,175, a reduction of 23% in three years (Schmitt 1973:27). As the native Hawaiian population declined, there was a shift in settlement distribution away from the leeward coast and its fishing grounds, towards the windward side and the leeward uplands (Denham et al. 1993:7).

In October 1840 Elias Bond and his bride of one month sailed with the Ninth Company of American Missionaries for Hawai'i. Bond and his wife, and eventually, their ten children became some of the first foreign residents of the area when they were stationed at Kohala, Hawai'i. Bond was to labor unremittingly for fifty-five years. He founded the Select Boys' Boarding School in 1842, which was merged with the first government English school when it opened in 1854. He also founded the Kohala (Mauna Oliva) Girl's school in 1874. In 1861 he started the Kohala Sugar Plantation to provide employment for his congregation. He also erected Kahahikiola Church (Day 1984:14). The Bond Complex; homestead, church, and school in 'Iole *ahupua'a* are State Historic Site No. 7100.

Close to the Bond Homestead site is the Kamehameha Statue commemorating the birthplace of the Hawaiian King.

In the latter half of the nineteenth century, large scale sugar ventures came to dominate the economy of North Kohala. Kohala Sugar Company was incorporated in 1863. By 1896 five additional sugar mills had become established. The Hawi Mill and Plantation Company was set up in 1881 with two sugar growing subsidiaries, Puakea Plantation and Homestead Plantation. The Hawaiian Railroad Company built a line from Mahukona to Nuili'i. The Hawi Mill refused to use the railroad and instead used the landing at Honoipu until 1912. In 1883 Hawi produced 1,500 tons of sugar (Denham et al. 1993:10).

The town of Hawi became the nucleus for a commercial center during the boom years of North Kohala sugar expansion. In 1885, there were retail operations in both Hawi and

Honomakau. In 1904 and 1914 government lands opened for homesteading in Kahei and Ka`auhuhu creating new residential communities to the north of Hawi. In the early twentieth century Hawi, along with Niuali`i-Makapala and Kapa`au become the major settlement areas in North Kohala.

State Historic Site No. 7139 is the Hawi Commercial District. It includes the urbanized area which grew out of the Hawi Mill. The commercial center is characterized by rows of wooden, frontier style buildings with false fronts (Tomonari-Tuggle 1988:54).

Numerous plantation camps in North Kohala are considered historically significant because they had served as a source of identity to the workers who inhabited them, many of whom were immigrants. In Hawi, 136 houses in six camps served the cane workers habitation needs and included swimming pool, tennis courts, a boarding house, gymnasium, volleyball court, and a dispensary. Goods and services were readily available in Hawi Town. Thirty five plantation camps existed in North Kohala (ibid.)

State Historic Site No. 7105 is the Kohala sugar district. It includes seven mill sites, plantation houses, and offices of the companies. The mill at Hawi, like most of the others is an overgrown foundation. The mill's stack stands behind the present Kohala Corporation offices (now Chalon's) in Hawi Town.

As the sugar industry's financial fortunes began to turn downward in the last half of the twentieth century, so has the population in North Kohala. In the last few decades, the economy of North Kohala has shifted to residential development.

SOUTH KOHALA

Perhaps the most significant historic sites in South Kohala District are Pu`ukohola *Heiau* and the smaller associated *heiau*, Mailekini at Kawaihae. Kirch (1985:175) writes about the *heiau*:

> The port of Kawaihae, with its sheltered natural harbor, was an important calling point for many of the early European voyagers and traders. For about five years 1790-1794, it was the primary residence of Kamehameha I as he regrouped and prepared his forces for the ultimate conquest of Maui,

> he regrouped and prepared his forces for the ultimate conquest of Maui, Moloka`i, and O`ahu. Here at Kawaihae, on a prominent natural rise above the harbor, Kamehameha I constructed (or, most probably, rebuilt and expanded) a massive war temple (Luakini) named Pu`ukoholā. It was on the altar of Pu`ukoholā in 1791 that Kamehameha offered up the body of his arch-rival and cousin Keōua, as an offering to Kūkā`ilimoku, his personal war god.

Stokes (1991) writes of Mailekini *Heiau*, it is; "Located 170 feet to the west of Pu`ukohola *Heiau*, near the foot of the hill. This *heiau* is supposed to be older than the present *heiau* of Pu`ukohola and has suffered more internal changes. At one time, in the early part of the nineteenth century, it was planned to convert Mailekini *Heiau* into a fort". In addition, Stokes writes, "It may be added that an elderly local native stated that Keoua Kuahuula, for whose conquest Kamehameha I built Pu`ukohola *heiau*, was cooked in an underground oven, the site of which is on a ridge about 50 feet to the west of the northwest corner of Pu`ukohola".

"Also at Kawaihae," Kirch (1985:175) writes:

> ...not far from Pu`ukoholā, is the house site of John Young, the English seaman who served for many years as an advisor to Kamehameha. The site, with its stone and lime-plaster structures, reflects a merger of sorts between the British background of Young and his adopted Hawaiian culture. The Young house site is surely one of the most important archaeological sites of the historic period in Hawai`i.

Early foreign visitors to this area include Archibald Menzies, who visited Hawaii in 1792 with Captain Vancouver. Menzies stated that along the coast of North Kona and South Kohala the land was: " barren and rugged with volcanic dregs and fragments of black lava...in consequence of which the inhabitants were obliged to have recourse to fishing for their sustenance" (Menzies 1920:99).

Cattle were introduced on the west coast of Hawai`i Island by Vancouver in 1794 and were allowed to roam freely at first, by the order of Kamehameha I, in order to allow them to increase and multiply. Sometime around 1815, a wall was built between the King's land in Waikoloa and that owned by Isaac Davis, in order to keep the roaming cattle out of the King's cultivated lands. It was named after the King's *konohiki*, Kauliokamoa (Barrere 1983:30). By the time Rev. Ellis conducted his tour around the island in 1822 there were: "immense herds of them, they do not attempt to tame any; and the only advantage they derive is by employing persons, principally foreigners, to shoot them, salt the meat in the mountains, and bring it down

Barrera cited these "marauding cattle," as the reason for the abandonment of agricultural plots, construction of stone walls, and the deforestation of portions of Hawai'i Island. By 1846 most of the Waimea area had been converted to pasture for cattle, sheep, and horses (Barrere 1984:48,49). A Rev. Lyons reported that because of this, many people had moved away and that he was then living in a cattle pen (Lyons in Barrera 1983).

Parker Ranch in 1901 bought this area, known as Waikoloa Nui, and used it as grazing land (Jensen and Burgett 1991:7).

In his book, Hawaiian Planter, Handy describes the native agriculture in Puako and on the coast of North Kona and South Kohala:

> From Puako to Anaehoomalu at the southern end of Kohala and from Kapalaoa, at the northern extreme of Kona, to Kailua there are no streams whatever, and certainly there were no terraces. South Kohala protected much dry taro in the lower forest zone which formerly extended far down over what is now open pasture (Handy 1940:119).
>
> The coastal section of Waimea, now called South Kohala, has a number of small bays with sandy shores where fishermen used to live, and where they probably cultivated potatoes in small patches. Anaehoomalu, Waialua Honkaope, Kalahuipuaa and Pauoa all have sandy strips along the sea. There is an area of black cinder in the section where sweet potatoes might be grown in rainy seasons. Puako was a sizable fishing village at one time where there were undoubtedly many sweet potato patches (ibid:163).

In his survey of Paniau, Kennedy reinforces the fact that Puako was once a fishing village and comments:

> The abundance of marine edibles coupled with the apparent lack of agricultural features in the immediate area of Paniau leads to the unavoidable conclusion that the Paiau site was primarily a fishing village. Accordingly, it is reasonable to assume that the efforts of the people living there were directed towards earning a subsistence living from the sea. Whatever trade or redistribution systems that may have occurred then between Paniau and other parts of Lalamilo ahupua'a or other places, are unknown and remain to be investigated (Kennedy 1980:9-10).

In Beaches of the Big Island, Clark refers to various sites in the Puako area and includes a bit of the history of Lorenzo Lyons, a missionary who came to Hawaii in the mid-1800's, and who had a church in Puako:

> The residential community, which dates from the early 1850's, begins at Puako Bay and extends for 3 1/2 miles of shoreline along Puako road. A large wave-washed bench of rock fronts almost the entire length of this long stretch of low-lying coast, but the irregular beach contains many small points, inlets, coves, and tidal pools. Two sites of historical interest along Puako Road are a field of petroglyphs and Hokuloa Church. The extensive petroglyph field is thought to contain some of the oldest carvings on the Big Island. The other historic site is that of the Hokuloa Church, built and dedicated on March 12, 1859, and is one of fourteen churches built by Reverend Lorenzo Lyons. Lyons, [was] known to his Hawaiian congregations as Makua Laiana (Clark 1985:130).

In 1977, a book about the Kohala area was written by various residents of the area. The book indicates sugar cane was grown in the area. The writers note that the name Puako is said to mean "sugar cane flower" and the "Puako once supported an early attempt at a sugar plantation run by John Hind". The name however, is older than the Hind attempt at growing cane (Stephenson 1977:84).

Barrere names Waikoloa as one of three permanent settlements in this area in the early 1800's:

> On the rising ground above the seacoast settlements, several main trails led past occasionally cultivated ground to the uplands of Waimea, where there were, the early 1820's, three major settlements about two miles apart. One was at Kesaili, one at Waikoloa, and one at Pu'ukapu. All three were concentrated where a major stream emptied itself upon the plateau.

Kamehameha I figures in the early history of South and North Kohala. Barrere reports that he gave Waikoloa Nui to either John Young or Isaac Davis, his two *haole* chiefs. It was listed as one of John Young's lands at the time of the Mahele (Privy Council Records 1848 3:98-99). This same Privy Council also found George Hu'eu's son, Davis, to be the heir to Waikoloa and awarded it him with the Land Commission Award Number 8521-B:1, Royal Patent 5671 (Board of Commissioners 1929:59). Hu'eu's mother was Kaha'anapilo, whose father was one of the Waimea chiefs that had previously held Waimea land (Barrere 1983:25). It was determined by Supreme Court Justice Robertson that the land was rightfully Hu'ue's through direct inheritance from his father, Isaac.

Although we refer to Waikoloa as an *ahupua'a* today, older references classify it as an *'ili* of Waimea *ahupua'a*. The following is part of testimony given by natives of the area:

Waikoloa is an *'ili* of Waimea *ahupua'a*; Waimea is an *Okana* (Kanehailua) (Boundary Commission Book No. 1:6-12).

George Hu'eu Davis himself referred to Waikoloa as an *'ili*. Several maps at the State Survey Office agree with this description. An exception is Marion Kelly's description of Waikoloa as *'ili kupono* (a land division whose occupants paid tribute to the ruling chief). She writes, "The other of these *'ili* kupono, namely Waikoloa, was given by Kamehameha as a separate property to Isaac Davis...(Kelly 1956:119). It should be noted here that the *'ili* of Anaehoomalu and Kalahuipua'a were detached from Hu'ue's award of Waikoloa and were awarded to Queen Kalama (Boundary Commission Book 1:8) (Jensen 1991:6).

Barrere gives a complete review of Hu'eu's battle to settle the boundaries of his land (Barrere 1983:29). The dispute was due to the Crown having lands that were also known as "Waikoloa." The issue was resolved by an agreement to name those lands belonging to the crown "Lalamilo" and "Waikoloa-iki."

ARCHAEOLOGICAL SETTLEMENT MODEL

The project corridor covers an extensive linear distance extending from Makapala on the windward side of North Kohala District to Puako Bay in South Kohala District. The project corridor extends through two major environmental zones in North Kohala, leeward and windward, formed by the 1675 m (5500 ft.) high ridge of the Kohala Mountain summit. Within North Kohala there is a great deal of environmental variation in terms of topography and rainfall. The South Kohala portion of the project area is, in general, similar to the leeward portion of North Kohala. Because of these factors no single settlement pattern model is appropriate for the project corridor.

Discussion of the origins, early settlement, and expansion of Hawaiian culture can be found in many publications including Hommon (1976), Cordy (1981), and Kirch (1985). A more localized model for the early settlement and expansion in North Kohala is described in Tomonari-Tuggle (1988:9-15) (Figure 4).

Essentially Tomonari-Tuggle's model describes an initial occupation of the maximum

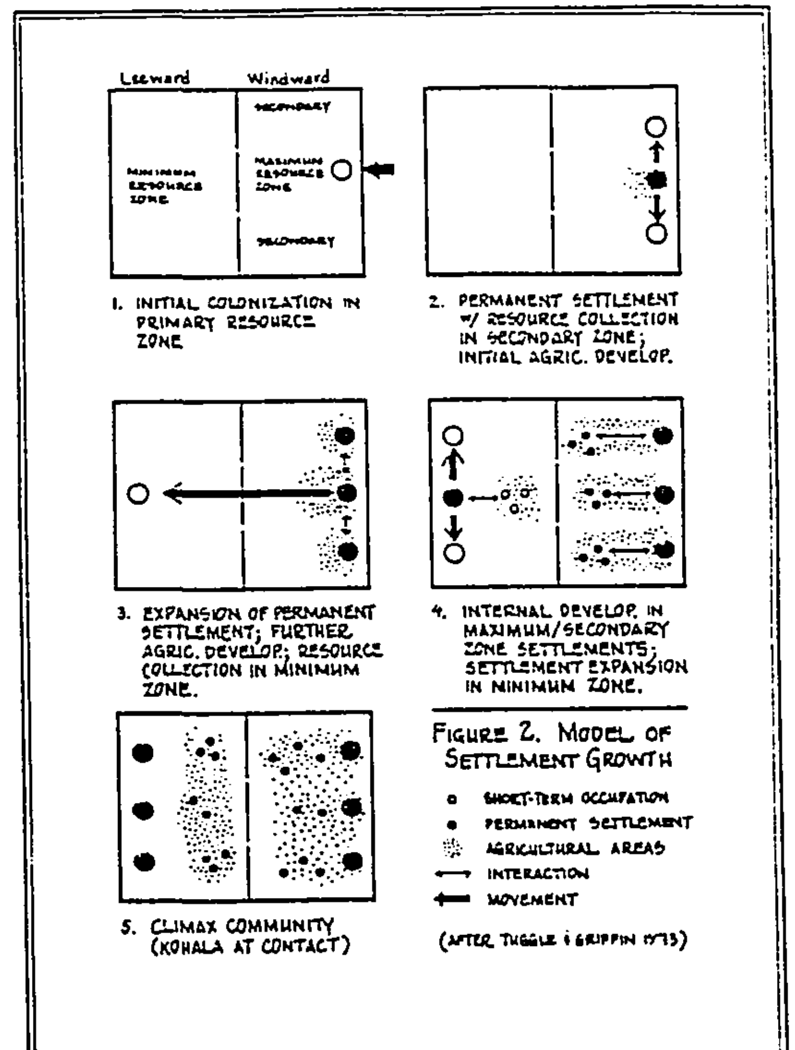


FIGURE 4: A MODEL FOR EARLY SETTLEMENT AND EXPANSION IN NORTH KOHALA. FROM TOMONARI-TUGGLE (1988).

resource zone in windward Kohala followed by the creation of permanent settlements, resource exploitation in the secondary zone, and initial agricultural development, all within the windward area. This is followed, in the windward area, by expansion of permanent settlement and further agriculture development, and resource collection in the leeward minimum zone. In turn, this is followed by internal development in the windward maximum and secondary zone settlements, and settlement expansion in the leeward minimum zone. Finally, the climax community at European contact reflected highly developed settlements in both the leeward and windward areas.

In North Kohala the maximum resource zone was probably the windward *kula* gulches of the Kohala Mountains. These gulches are characterized by optimum rainfall, permanent water, and relatively easy access to the ocean. In addition, the extensive inter-gulch *kula* slopes may have been covered in forest which would have provided a range of natural resources. It is hypothesized that it is from this area that the leeward, minimum resource zone, was first utilized and then occupied (Tomonari-Tuggle 1988:12-13).

At the time of European contact the cultural landscape was the product of hundreds of years of internal development with its end point being the *ahupua`a* system. On the windward side of North Kohala District rainfall allowed cultivation to be successfully carried out from the coast up to elevations of 2,000 to 3,000 ft., with forest products exploited above that (Figure 5).

Within windward North Kohala dryland taro was apparently planted fairly continuously across the *kula* lands from Pololu to Hawi. Also, as in Kona, the upland forest was developed in clearings in the forest zone. Besides the intensive cultivation of dryland taro there was cultivation of plantains, sugarcane, and sweet potato (Handy and Handy 1972:528-531).

This region also contained a number of gullies (the *kula* gulches) with permanent streams in which wet taro was cultivated and "nearly every *ahupua`a* within this zone included such a stream" (Tomonari-Tuggle 1988:11). Gulches which were developed into terraces, both seaward and inland wherever topography permitted, were Niuli`i, Waikani, Puwaiole, A`amakao, Walaohia, Halawa, Wainaea, and Akamoa (Handy and Handy 1972:530-531).

On the leeward side of North Kohala District a different type of *ahupua`a* settlement

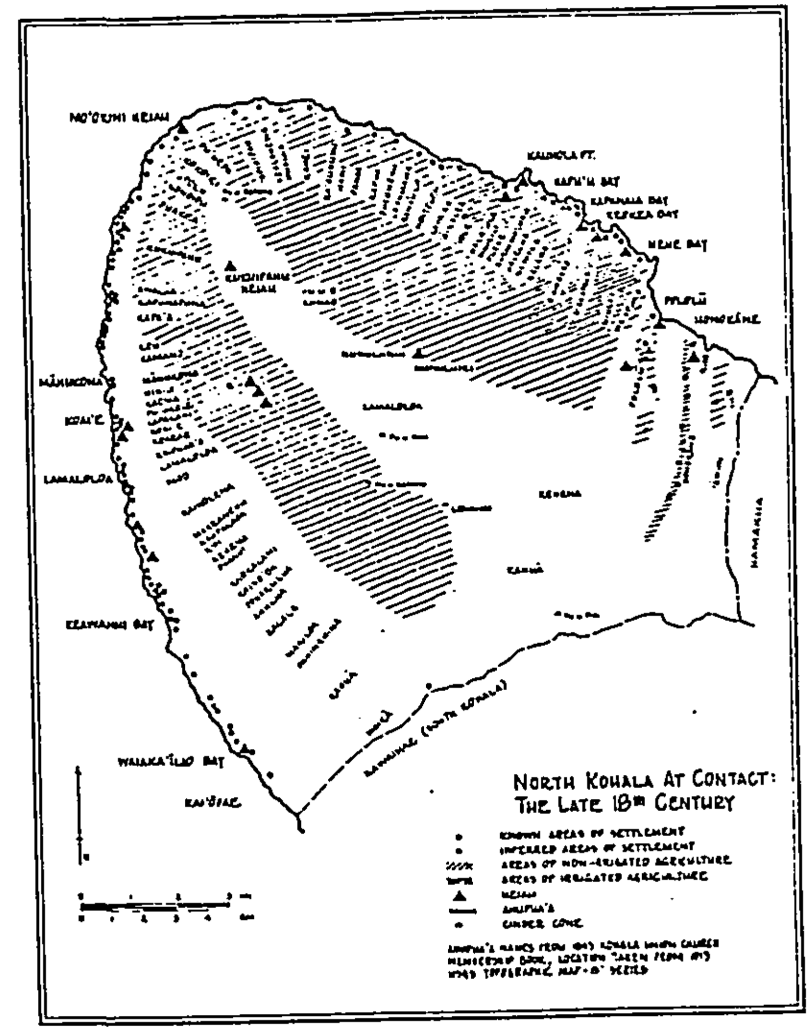


FIGURE 5: RAINFALL AND AGRICULTURE IN NORTH KOHALA AT CONTACT: THE LATE 18TH CENTURY. FROM TOMONARI-TUGGLE (1988).

On the leeward side of North Kohala District a different type of *ahupua'a* settlement pattern existed at the time of European contact primarily due to much reduced rainfall. Work done in Lapakahi *ahupua'a* was some of the first work done which helped delineate a three zone settlement model (Pearson 1969, Rosendahl 1972, and Tuggle and Griffin 1973). Numerous other archaeological projects including, but not limited to, Adams and Athens (1994), Barrera (1984, 1992), Bonk (1968), Burgett and Rosendahl (1993), Neller (1986), Rosendahl (1989), and Soehren (1964, 1969) have discussed various parts of these three settlement pattern zones as they were found in various *ahupua'a*.

The settlement pattern identified in leeward North Kohala consisted of three major zones (Kirch 1985:282). The first zone formed a narrow band of sites which are concentrated within the first 100 to 200 m inland of the shoreline. Figure 4, as well as showing the extent of the probable windward agricultural area, also shows the extensive coastal occupation of the leeward North Kohala District at the time of contact.

In contrast, the second zone, sometimes called a barren zone, started immediately inland of the coastal zone and extended inland for roughly 2.5 kilometers. Because rainfall is not adequate for agriculture in this region few sites were located here.

The third zone was an upland agricultural zone consisting of dry-land fields. In North Kohala this leeward upland agricultural zone has been termed the Kohala Field System. The Kohala Field System encompasses approximately 57 sq. kilometers along the leeward slopes of the Kohala Mountains between about 150 to 760 meters above sea level (Kirch 1985:230).

Below Kawaihae, in the South Kohala District, the coastal zone does not show the extensive high density occupation found in the North Kohala District. Instead, sites tend to cluster around embayments and fishponds that were situated along the coast. Examples of such habitation loci include 'Anaeho'omalu (Barrera 1972), Kalahuipua'a (Kirch 1979), Puako (Cox and Stasack 1970, Smart 1964), and the area around, or near, Kawaihae Harbor (Soehren 1964, Clark and Kirch 1983, Allen 1987, and Carlson and Rosendahl 1990.

The barren zone inland of these habitation loci has been described above. The inland agriculture zone, which lies beyond the barren zone, is situated on the slopes of the saddle between Mauna Kea and the Kohala Mountains in the vicinity of the town of Waimea (Clark

(Kirch 1985:231) is similar to the more widely studied Kona Filed System.

Archaeological Expectations Within the Project Area

Based on the previous discussions of history and archaeological settlement models what archaeological features might be expected in the project area? Within the windward section of North Kohala the *kula* gulches might be expected to contain agricultural features such as *lo'i* terraces and the remains of agricultural soil horizons, while the *kula* slopes would contain such agricultural features as rock alignments, low stacked walls, and rock mounds.

Habitation features would probably have been scattered throughout the field areas, perhaps being somewhat more concentrated around the gulches. Habitation features might include enclosures, platforms, and C-shapes. Burials, both subsurface and within architectural features, and various religious features would also be expected.

However, due to the extensive impact of sugarcane production on the landscape in windward North Kohala few pre-Contact architectural features probably remain. Only in gulches which were not heavily impacted by sugarcane agriculture is it likely that such significant sites remain. An example of this is Kumakua Gulch where four significant sites were identified (Denham et. al 1993).

On the leeward side of North Kohala dense concentrations of architectural features can be expected in the coastal settlement zone where it has not extensively been impacted by sugarcane cultivation, ranching, or other modern activities. Within the coastal settlement zone features such as permanent residential structures (enclosures and platforms), burial platforms, fishing shrines, canoe houses, and other structures are possible.

In the coastal zone below Kawaihae, in the South Kohala District, the habitation loci situated around bays and fishponds include various features. These features consist of habitation structures, such as platforms and enclosures, other walled structures, habitation and burial caves, cairns, trails, fishponds, shrines, petroglyphs, and *papamu*.

The second settlement zone, the barren zone, is expected to contain few architectural features. Expected features include trails, temporary shelter walls of various shapes (e.g. C, L, and U-shapes), rock cairns, alignments, and shell midden scatters (Clark and Kirch 1983). Although not common, favorable environmental microniches might contain agricultural features like mounds or terraces. The interfaces between the barren zone and the other two settlement zones might also show a somewhat higher number of features.

The upland agricultural zone, including the Kohala Field System and the Waimea-Lalamilo field complex, were quite extensive. This settlement zone includes features such as long walls and mounds which form field boundaries, mounds, alignments, planting circles, small clearings, simple terraces, and animal enclosures or pens. Also present were habitation features, primarily C- and L-shaped walls. In addition, in the Waimea-Lalamilo complex, an extensive system of irrigation ditches is present.

The leeward project area corridor consists of the main highway, access roads to the proposed reservoirs, and the reservoirs themselves. Few, if any, archaeological features are expected along the main highway because the corridor actually lays within the area destroyed by the construction of the highway itself. The only possible exception to this is where the highway crosses large gullies which might still retain some intact architectural features.

The Alternate Collection Reservoir and its associated access road appear to be located in an area that was once part of the Kohala Field System. However, this location has been extensively impacted by ranching activities and the presence of significant pre-Contact architectural features is highly unlikely.

South of the Alternate Collection Reservoir the possibility increases that the locations of the four remaining reservoirs and access roads may have been subjected to less post-Contact or modern disturbance. All four of these reservoir and access road locations fall on, or near the edge of, the coastal settlement zone and extend into the barren settlement zone. In general, features expected for these locations include temporary habitation structures, cairns, trails, and scatters of marine shell.

METHODOLOGY

Research on the historic use of sections of the project area was conducted at Chalon International of Hawaii, Inc., Kohala, Island of Hawaii. Several maps and air photos were consulted concerning land-use and Mr. Michael Gomes, Vice-President and Director of Projects, was interviewed because he is a life long resident of the North Kohala area.

Field inspection was conducted on all portions of the transmission system including proposed wells, pipeline routes, all reservoir locations, and all access roads. Much of the project area is situated in abandoned sugar cane fields, along old sugar cane roads, or along the existing main highway. The extensively disturbed nature of these portions of the project area were confirmed by the use of vehicular survey.

Areas that were considered to have the potential of being undisturbed were subjected to a surface reconnaissance conducted on foot. These areas included large gullies along the main highway, the access roads and construction locations of the alternate Collection Reservoir, the Pressure Breaker Reservoir, the Kawaihae Terminal Reservoir, and the Lalamilo Terminal Reservoir.

Along the proposed access roads crew members walked transects that paralleled the length of the route. Within the areas where reservoirs are to be built transects were also walked to insure 100% ground coverage. Spacing between the field crew varied from five to ten meters depending on the vegetation and topography. Ground exposure varied from good to excellent.

All identified sites were marked with Blue-and-White flagging tape labeled with a temporary site number beginning with SS-1 through SS-5. Project records included site and feature forms, scaled sketch maps, and a photographic record. Recovered cultural material was limited to a small amount of marine shell which was weighed and identified. All project materials are stored at the office of SCS, Kaneohe, Hawaii.

FIELDWORK RESULTS

Although several known historic sites are located near the project corridor none of them will be significantly impacted by the proposed project. Some of these sites include the Bond complex, Kamehameha Statue, Kohala Sugar District, Hawi Commercial District, Pu'ukohola and Mailekini *Heiau*, and John Young's home.

A total of five archaeological sites were identified during the fieldwork. Three of the site were small scatters of marine shell (Sites 50-10-5-19,774, 50-10-11-19,777, and 50-10-11-19,778), one site was a platform (Site 50-10-5-19,775), and one site was a complex of features comprised of at least three enclosures and a small paved area (Site 50-10-5-19,776).

Site 50-10-5-19,774 (Temporary Site SS-2)

Site 19,774 was located in Makiloa *ahupua'a* and consisted of a light shell midden scatter located along the access road to the proposed Pressure Breaker Reservoir at approximately 240 ft. above mean sea level (Figures 6 and 7). The site was situated approximately 0.26 km *mauka* from the main highway on a ridge that slopes to the west. A small gully was located approximately 20.0 to 30.0 m to the south of the site. The site measures 11.50 east/west by 6.80 m north/south.

The midden at the site consisted of a very small amount of shell comprised of 11.5 gm of Purpura aperta, 2.7 gm of Cypraea caputserpentis, and 1.8 gm Drupa ricina. All of the observed midden was collected. No other cultural material was observed at the site and no excavations were conducted.

This site is interpreted as a pre-Contact temporary habitation or rest stop utilized by travelers who were moving between the coastal habitation zone and the upland agricultural zone. The site was significant under Criterion D for the information it contained. Sufficient information has been gathered from the site that it can no be considered no longer significant.

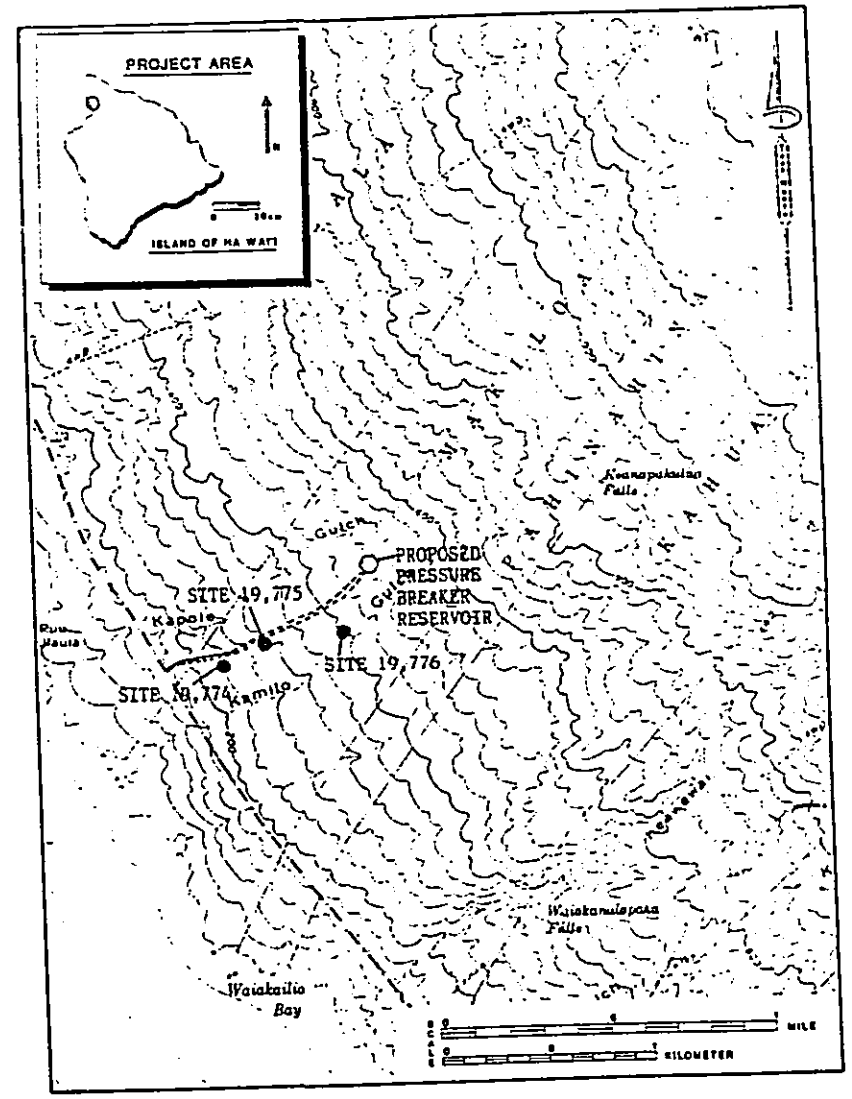


FIGURE 6: USGS KAWAIHAE QUADRANGLE SHOWING SITES 50-10-5-19,774, 19,775 AND 19,776 IN MAKILOA AHUPUA'A.

FIGURE 7: VIEW OF OCEAN FROM SITE 19,774. VIEW TO SOUTH

Site 50-10-5-19,775 (Temporary Site SS-4)

Site 19,775, located in Makiloa *ahupua'a*, was a stone platform located along the proposed access road to the Pressure Breaker Reservoir Site approximately 0.48 km *mauka* of the main highway (see Figure 6). The platform was situated at an elevation of approximately 320.0 ft. above mean sea level on the edge of a ridge which sloped to the northwest.

The platform measured 3.60 m by 2.20 m, with the long axis oriented along a northwest/southeast line (Figure 8). The exterior height of the platform varied from one cobble high to 0.30 m along the northeast edge. The platform was constructed of angular to subangular small to large cobbles and small boulders. The east corner of the structure was based on a bedrock outcrop and some slumping had occurred on the south corner of the platform. At least 12 pieces of small cobble sized, rounded coral were situated across the surface of the platform and on the ground surface nearby.

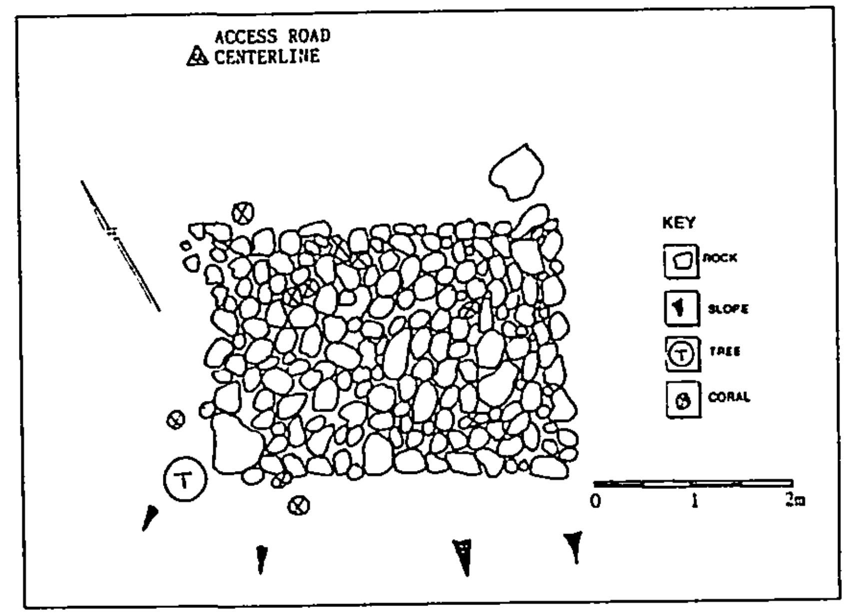


FIGURE 8: PLANVIEW OF SITE 19,776.

No excavations were conducted at this site and no cultural material collected.

The site is interpreted as a possible pre-Contact burial because of the architectural style of the platform and the presence of the numerous pieces of coral. The site is significant under Criterion D because of the information it has yielded and is likely to yield. In addition, if the platform feature is a burial it is significant under Criterion E because of the cultural significance it has to an ethnic group. Figures 9 and 10 show Site 50-10-5-19,775.

FIGURE 9: SITE 19,775 PLATFORM WITH VIEW OF OCEAN. VIEW TO SOUTH

FIGURE 10: SITE 19,775 PLATFORM SHOWING CORAL. VIEW TO SOUTH.

Site 50-10-5-19,776 (Temporary Site SS-5)

Situated in Makiloa *ahupua'a*, this site was observed approximately 50 to 75 m south of the proposed access road which will lead to the Pressure Breaker Reservoir (see Figure 6). Because the site was located so far from the access road corridor its location is only approximately known, as is true for the constituent architectural features. The site is estimated to be situated 0.80 km from the highway at the 400 ft. elevation, just north of a branch of Kamilo Gulch.

The identified architectural features of the site included at least three enclosures and a possible paved area. The enclosure closest to the access road included a large piece of branch coral (over 60 cm in length) and a large waterworn basalt upright.

Based on the limited data collected, the site is interpreted as a permanent habitation complex including a shrine. While the age of the site is not known, the architectural features and the apparent absence of historic materials suggest that the site is pre-Contact in age. The site is significant under Criterion D for the information it contains. In addition, the site is significant under Criterion E because of the cultural significance of the shrine.

Site 50-10-11-19,777 (Temporary Site SS-1)

This site was located in Waikoloa *ahupua'a* (Figures 11 and 12). The site consisted of a light scatter of marine shell located approximately 0.60 km *mauka* of the main highway along the south side of the existing access road to the Lalamilo Terminal Reservoir Site. This midden scatter measured 40.00 m east/west by 15.00 m north/south and was situated at an approximate elevation of 270 to 280 ft. above mean sea level on a ridge that slopes down to the northeast.

The midden consisted of 11.9 gm of Cypraea caputserpentis, 0.1 gm of Nerita picea, and 1.1 gm of unidentified shell. All of the observed midden was collected.

A single shovel probe was excavated at this site. The probe measured 0.20 by 0.20 m, and was excavated to a depth of 0.20 m. Only a single soil layer was encountered in this probe. The soil layer was dark brown (7.5 YR 3/4, d) very fine, silty loam. No cultural material was observed in the excavation unit.

RECEIVED AS FOLLOWS

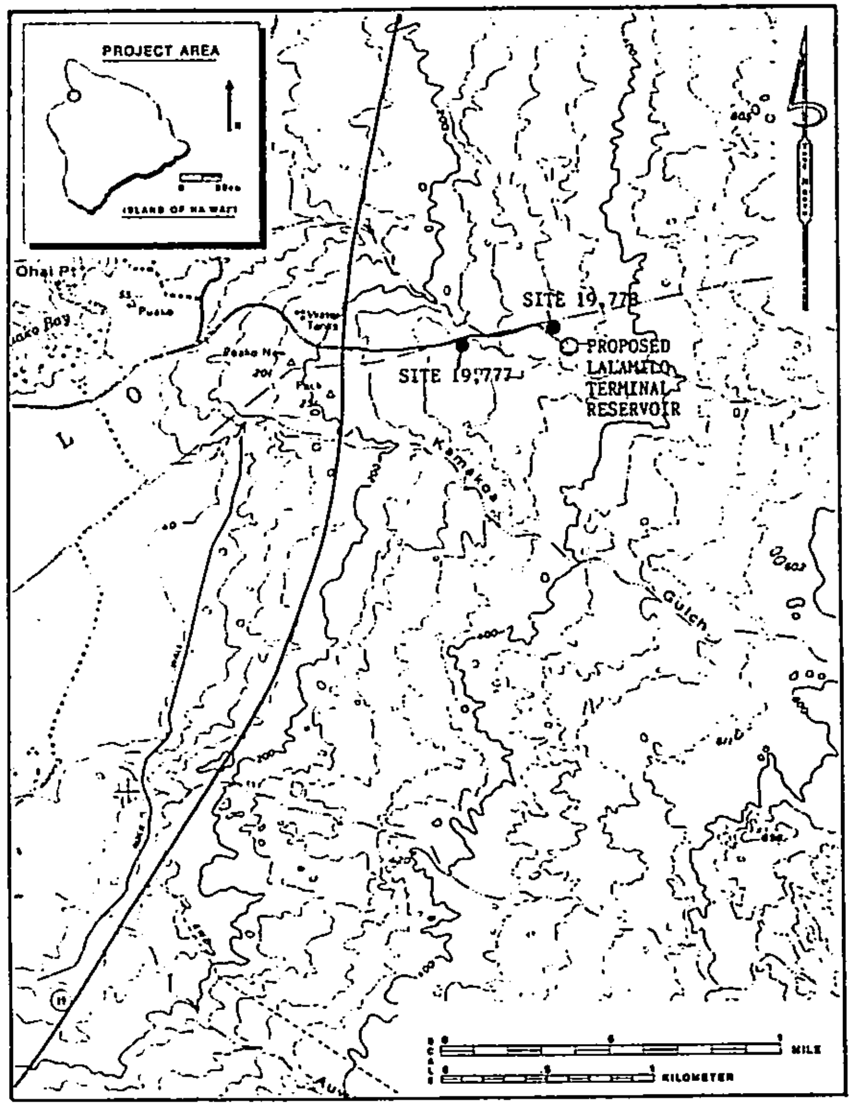


FIGURE 11: USGS PUU HINAI QUADRANGLE SHOWING SITES 50-10-11-19,777 AND 19,778 IN WAIKOLOA AHUPUA'A.

FIGURE 12: VIEW OF SITE 19,777. VIEW TO NORTH

Site 19,777 is interpreted as a pre-Contact temporary habitation or rest stop utilized by travelers between the coastal settlement zone and the agricultural zone located at higher elevations. The site was significant under Criterion D for the information it contained. Sufficient data has been gathered from this site so that it may be considered no longer significant.

Site 50-10-11-19,778 (Temporary Site SS-3)

This site was situated in Waikola *ahupua'a* and consisted of a small shell midden scatter situated in the route of the access road leading to the Lalamilo Terminal Reservoir Site (see Figure 11). The site was located 1.00 km *mauka* from the main highway at an elevation of approximately 300 ft. above mean sea level. The site covered an area of 6.10 m east/west by 5.80 m north/south and was located on a level area the foot of a ridge (Figure 13).

FIGURE 13: VIEW OF SITE 19,778. VIEW TO NORTHEAST

The shell midden at this site consisted of 6.2 gm of Cypraea caputserpentis. No other cultural material was observed at this site and no excavations were deemed necessary.

This site is interpreted as a pre-Contact temporary habitation or rest stop use by travelers in transit between the coastal zone and the upland agricultural zone. The site was significant under Criterion D, because of the information it contained. Sufficient information was gathered from this site so that it is no longer significant.

DISCUSSION

The research conducted at Chalon International, the interview with Mr. Gomes, and the field checks confirmed that all of the well locations and their associated access roads were located in areas highly disturbed by sugar cane production. This is also true of the Collection Reservoir Site, the Kapa'au Booster Pump Station, the Kapa'au Reservoir Site, the Kynnersley Booster Pump Station, the Hawi Booster Pump Station, and the alternate pipeline route which follows the cane haul road known as Pratt Road. South of the Alternate Collection Reservoir sugarcane agriculture appears to have played a lesser role in modifying the landscape within the project area.

Similar results have obtained by other researchers. Neller found that the region from Upolu Airport to the U.S. Coast Guard Loran Station had been virtually destroyed by sugarcane cultivation (Neller 1986:2). Denham et. al. surveyed portions of Hawi, Pahoa, and Honomakau *ahupua'a* and found no sites in the flat areas impacted by sugarcane (Denham et. al. 1993: 1). Erkelens and Athens surveyed 122 acres in the *ahupua'a* of Waiapuka and Makanikahio 1 and 2 and confirmed their expectation that their project area was extensively disturbed by sugarcane agriculture (Erkelens and Athens 1994:iii).

The pipeline route located along Akoni Pule Highway has also been highly disturbed by the construction of that highway. The only areas along the highway that were closely inspected were the gullies that the highway crossed. No significant cultural remains were found in these gullies which were generally quite disturbed by the highway construction.

Three sites were identified along the access road to the Pressure Breaker Reservoir. Site 19,774 was a midden scatter not associated with any surface architecture or recognized trail. Such a midden scatter was expected in the barren settlement zone.

The presence of the platform (site 19,775) and the habitation complex (site 19,776) were somewhat surprising. The location of site 19,776 on the edge of a gully suggests that sufficient water may have been present in the gulch to support the residence. Insufficient work has been carried out at this site to allow this to be more than conjecture at this point.

The two sites (sites 19,777 and 19,778) identified along the access road to Lalamilo Terminal Reservoir were both midden scatters. Again, such scatters were expected in the barren zone and fit the settlement model. No surface architecture or trails were associated with either site.

RECOMMENDATIONS

Sufficient work has been completed at sites 19,774, 19,777, and 19,778 that they can be considered no longer significant. Site 19,775, a probable burial platform, should be preserved by slightly realigning the access road to the north to avoid impacting the feature. Site 19,776 is situated outside of the proposed access road corridor and should not be in any danger from project activities.

It is also recommended that an archaeological monitor be present when the access roads to the Pressure Breaker Reservoir and the Kawaihae Terminal Reservoir are constructed. Because access roads of this nature are sometimes realigned during construction the presence of a monitor would facilitate the construction. This is especially important along the access road for the Kawaihae Terminal Reservoir since several features (Allen 1987) are recorded near, but not in, the proposed access road.

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Final Draft

BIOLOGICAL SURVEY

KOHALA COAST WATER TRANSMISSION SYSTEM

WELL SITES, RESERVOIRS, ACCESS ROADS & PIPELINE ROUTE

KOHALA TO PUAKO, HAWAI'I

Prepared by:
Lani Stemmermann and Rexford Palmer

December 1994

BIOLOGICAL SURVEY

KOHALA COAST WATER TRANSMISSION SYSTEM

WELL SITES, RESERVOIRS, ACCESS ROADS & PIPELINE ROUTES

KOHALA TO PUAKO, HAWAI'I

SUMMARY

A biological survey of the proposed Kohala Coast Water Transmission System located no endangered, or candidate endangered species that legally require planning consideration. The proposed well field is situated on land once in sugar cultivation, and the proposed pipeline is located on the road shoulder or in the road for much of the route. Thus, prior to the project, most of the native biological communities that would be affected have already been disturbed. An early version of the project configuration shows the Phase II 6.0 MG Terminal Reservoir situated in the vicinity of patches of the native grass, *Eragrostis variabilis*. While this species does not legally require planning consideration, it is very rare to find weed-free patches of native grassland in the lowlands of the Hawaiian Islands. A recommendation was made in the draft report, to locate the reservoir in such a manner as to protect the nearby patches of native grassland. In a later, revised version of the the proposed project features, the terminal reservoir is located on the south side of the exisitng reservoir and thereby avoids the native grass area.

INTRODUCTION

A biological survey was conducted in the spring and fall of 1994 as part of an EIS for the Kohala Coast Water Transmission System. This survey includes plants and terrestrial vertebrates which are found along the project route. The project purpose is to transport water from the well field site located between Hawi and Niuli'i in windward North Kohala, to Hawaiian Homes lands at Kawaihae, and to a terminal reservoir situated upslope of Puako in leeward South Kohala.

METHODS

A walk-through survey was conducted of the project sites during February 1994. Notes were taken of plant species presence and abundance, and community structure and composition. A portion of the project was resurveyed in March 1994, six weeks following the heavy rains in early February, to account for short lived plant species that grow following seasonal rains. Following a revision of certain proposed project features the project area was resurveyed in October 1994, and revisited again in November 1994, following another period of heavy rains. Bird and mammal sign and occurrence were recorded during the surveys. The survey was conducted mid-day, and used no animal trapping methods. Standard references on the Hawaiian biota were consulted for species identification (Wagner, Herbst and Sohmer 1990, St. John 1973, Neal 1965, Pratt and Bruner 1987, Tomich 1969, Hawai'i Audubon Society 1993).

RESULTS

Plant species: Roughly 260 plant species were identified in the project area (Table 1). The species diversity was highest in the relatively wet northern portion of the project. However, native species were proportionally greater in the less disturbed and drier southern part of the project. We located no endangered or candidate endangered plant species. Further, we consulted the Nature Conservancy's Heritage Program maps for the presence of endangered plants near the project and none were indicated. Patches of a native grass, identified as *Eragrostis variabilis* (Hitchcock 1922), grow at the terminal reservoir site near Puako, and near (but off) the pipeline route on the makai side of the Akoni Pule Hwy just south of the ten mile marker. While this species is not legally protected, relativley intact patches of native plants in the Hawaiian lowlands are rare. This grass is scattered among buffel grass throughout the Puako site, and concentrated in level areas. A brief survey of surrounding areas indicated that there are other stands of grass nearby, but the extent of these over this dry leeward slope is not known. We flagged two patches of grass in the project area with red and white dotted ribbon. One patch is located 120 m at an uncorrected compass heading of 14 deg. from the NW corner of the fence around the existing reservoir. The western end of a larger patch is 52 m due north of the first patch. The revised project configuration surveyed in October and November 1994 places the Puako terminal reservoir on the south side of the exisitng reservoir, avoiding the patches of native grassland.

Plant communities and geographical units with which specific plants are associated are noted in the species list. Plant communities located in specific project areas are listed in Table 2. In the table the community designations for the pipeline route between Niuli'i and Hawi include both the original project configuration along the highway and the revised project configuration showing the pipeline following Pratt Rd. Well sites in the table represent the revised project configuration with the exception of well site "F" which is deleted in the new revision. The plant communities recognized in the table include:

Ruderal vegetation is the vegetation occurring in fequently disturbed sites such as that along roads. Ruderal species are indicated as "R" in the species list. The pipeline is situated along roadsides over much of its route. The plants in this community will quickly revegetate sites disturbed by project construction. The species composition for this community differs between the wet windward section of the project, and the leeward section.

Kiawe savanna vegetation is the open canopied dry forest vegetation dominated by short kiawe (*Prosopis*) trees 2-5 m tall, with an understory of buffel grass (*Pennisetum ciliaris*) to 50 cm tall. This vegetation, indicated as "KS" in the species list, occurs throughout much of the project--from Puako to north of Mahukona. Periodic fires, such as recent ones north of Kawaihae, are typical of this vegetation. In the relatively moister northern range of this vegetation type, buffel grass comprises 90% cover. In the drier Kawaihae to Puako area, there is more exposed ground, with buffel grass cover estimated at 25%-50%. At the Puako terminal reservoir area, buffel grass is the dominant ground cover throughout the area, but some sites are occupied by virtually pure stands of the native grass *Eragrostis variabilis*.

Closed canopy kiawe forest vegetation ("KF" in the species list) occurs where kiawe utilizes ground water resources such as just inland of Kawaihae harbor. The trees grow 8-10 m tall, and the understory is comprised of weedy non-native species. A short section of the proposed pipeline passes through this vegetation.

Pasture and Guava Scrub vegetation is found throughout the well field site. Species associated with Pasture and Guava scrub are indicated "P" in the species list. The well field site was once in planted sugar. When unmanaged these old fields become guava thickets, or pastures if they are managed for grazing. The species in both these plant communities are similar--with a greater cover of the more palatable grasses in the best managed pastures.

Commercial Macadamia forest is affected at three well sites and one of the booster stations. Wells "D" and "E", and the Kapa'au booster station are situated in macadamia orchards of small (less than 3 m) trees. These plantations are not yet in production. Ground cover at these sites consists of the same species found in the managed pasture vegetation. Producing commercial Macadamia forest is found at well site "F" (deleted in the revised project configuration). Typical pasture species form the understory in Macadamia orchards.

Stream and gulch vegetation--Some plants characteristically occur in gulches which are relatively wetter than surrounding areas. These are indicated as "S" in the species list. The pipeline adjacent to the road crosses numerous dry gulches between Mahukona and Puako. Most of these are intermittent streams, flowing only during or after heavy rain. Following rains these dry gulches are often lushly vegetated. Waiulaula Stream just north of the Mauna Kea Hotel complex, has a broad stream bed and is mapped as intermittent. However, it frequently has flowing or standing water and also has some common obligate wetland plant species associated with it in the project area (*Ludwigia, Polygonum*). Waiulaula has been modified in the past and flows through two culverts beneath Ka'ahumanu Hwy. The proposed pipeline would be situated in the highway roadbed above the stream and would not directly affect the streambed. Recently, intermittent leeward streams have been recognized as valuable habitat for native fish and this stream should be evaluated by an expert in that field if any affects of pipeline construction are anticipated.

The species associated with relatively moister gulches in the northern portion of the project are different from those in the dry leeward gulches. These gulches were not actively cultivated in sugar, and differ from surrounding pasture by having taller trees and many other species. Construction plans indicate they will not be affected by the project since the pipeline is situated in the already disturbed roadbed in the gulch areas. It should be noted that this document does not constitute an official Army Corp. of Engineers Wetland Determination. However, due to the location of the pipeline in the road there should be no direct affects on potential wetlands.

Ornamental vegetation is planted near dwellings, businesses, and along some roadways. Species listed as "O" in the species list have been planted. Several native Hawaiian species have been planted in the project area, and are indicated as ornamentals, rather than as associates of specific communities.

Bird Species detected in the project area, or known to occur there are listed in Table 3. Species not actually detected but noted in the literature as common in the S. Kohala region are also included (Hawaii Audubon Society 1993, Pratt and Bruner 1987). The native species detected include the 'Io which is common in the N. Kohala region; the plover, and ruddy turnstone which are common annual migrant species, and the pueo. The 'Io is an endangered species widespread on the island of Hawai'i, but it is highly unlikely that there could be any direct impact of this project on any of the native birds since the project is largely restricted to pastures and the already modified edges of existing roads.

Other Vertebrate Species seen during the survey include mongoose, domestic and feral cats, dogs, livestock, and poultry. Geckos, skinks, toads, rats, mice, and feral goats also occur in the project area. None of these species require planning consideration. The Hawaiian bat may fly over the project area, but Kohala roadsides and pastures are not considered the prime habitat for this endangered species.

ADEQUACY OF SURVEY

We believe there was adequate time and coverage allocated to this project to satisfactorily characterize the biota to be affected by the Kohala Coast Water Transmission Project, with the exception that this survey team does not have the expertise to fully evaluate stream fauna which may be associated with Waiulaula or any of the dry intermittent streams of South Kohala. Mosquito fish, red dragon flies, and tadpoles were seen at Waiulaula. Because the pipeline will be located in the road fill well above the streambed, the Waiulaula Stream will not be directly affected. It is our judgement that wetlands will not be affected by the proposed project because of the location of the pipeline in the roadbed. Although the present survey does not constitute an Army Corps of Engineers wetland determination, it is not anticipated that there will be any direct project affects on wetlands.

RECOMMENDATIONS

No attempt was made to adequately characterize the stream fauna. Intermittent streams in dry regions have only recently been recognized as potentially important wildlife habitat. Thus they would need to be surveyed by a specialist in that field if direct affects from pipeline construction are expected.

In our draft report we recommended that the location for the terminal reservoir at Puako be changed to avoid the patches of native grassland in the area. In the revised project configuration the reservoir is sited away from the native grassland. We recommend that this revised location be used rather than the originally designated site. Further we recommend that care should be taken not to damage these native grassland areas during construction, and that seed be gathered and scattered on bulldozed ground in the construction area for landscaping purposes.

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Table 1.-- Plants associated with various plant communities in four geographic units. Communities are: R- Ruderal, plants typically found along roadsides; KS-Kiawe Savannah vegetation; KF-Closed canopy Kiawe forest; P-Pasture and Guava scrub; S-Plants more or less restricted to gulches or streams within the delineated areas; O-Ornamental planting; X-present in area, but not necessarily associated with a specific community.

PLANTS Family, Species and Common Name		Life Form[1]	Status[2]	Niuli'i to Upolu	Upolu to Mahu-kona	Mahu-kona to Kawaihae	Kawaihae to Puako
FERNS							
Adiantum capillus-veneris	maiden hair fern	F	X				X
Dryopteris dentata	oak fern	F	X	S, P			
Nephrolepis exaltata	sword fern	F	X	S			
Phlebodium aureum		F	X	O			
Pityrogramma calomelanos	silver fern	F	X	S			
Polypodium scolopendria	laua'e	F	X	S			
Pteris sp.		F	X				S
Thelipteris sp.		F	X				S
GYMNOSPERMS							
Araucaria heterophylla	Norfolk Pine	T	X	O			
Cycas sp.	Sago palm	S	X	O			
MONOCOTYLEDONS							
Agavaceae--Agave family							
Agave sisalana	sisal	S	X		KS		S
Cordyline fruticosa	Ti	S	P	O			
Pleomele marginata	dracena	S	X	O			
Araceae--Taro family							
Alocasia cucullata	Chinese taro	H	X	S			
Epipremnum pinnatum	Taro vine	V	X	S			
Monstera deliciosa		S	X	O			
Syngonium sp.		V	X	O			
Xanthosoma sp.		H	X	S			
Cannaceae--Canna family							
Canna indica	li'ipoe	S	X	O, S			
Commelinaceae--Spiderwort family							
Commelina diffusa	honohono	H	X	X	R		
Cyperaceae--Sedge family							
Cyperus gracilis	McCoy grass	G	X	R			
Fimbristylis dichotoma			I				S
Kyllinga brevifolia	kili'o'opu	G	X	R,P			S
Kyllinga nemoralis	kili'o'opu	G	X	R			

PLANTS Family, Species and Common Name		Life Form[1]	Status[2]	Niuli'i to Upolu	Upolu to Mahukona	Mahukona to Kawaihae	Kawaihae to Puako
Dioscoreaceae--Yam family							
Dioscorea sp.	hoi	V	P	G			
Gramineae--Grass family							
Agrostis avenacea	he'upueo	G	X	R	R		
Andropogon virginicus	broomsedge	G	X	P			
Axonopus fissifolius	carpetgass	G	X	R,O,P	R		
Bamboo sp.		G	X	O			
Bothriochloa pertusa	pitted beard grass	G	X	R,P	R	R	
Brachiaria mutica	California grass	G	X	X	P		
Cenchrus ciliaris	buffel grass	G	X		KS,R	KS	KS
Cenchrus echinatus	sand bur	G	X	R	R	R	R
Chloris barbata	swollen finger grass	G	X		R	R	R
Chloris gayana	Rhodes grass	G	X	P	R	R	
Coix lachryma-jobi	Job's tears	G	X	S			
Cynodon dactylon	manienie	G	X	R	R	R	
Digitaria fuscescens	creeping crabgrass	G	X	R	R		
Digitaria insularis	sour grass	G	X	P,R			
Digitaria pentzii	pangola grass	G	X	P			
Digitaria violascens	crab grass	G	X	R			
Echinochloa colona		G	X	S			
Eleusine indica	goose grass	G	X	P,R	R		
Eragrostis variabilis	kawelu	G	E			KS	KS
Eragrostis sp.		G	X	R	R		
Heteropogon contortus	pili	G	I			KS	
Hyparrhenia rufa		G	X		R		
Melinus minutiflora	molasses grass	G	X	P,R			
Panicum maximum	Guinea grass	G	X	P	P,R		S
Paspalum conjugatum	Hilo grass	G	X	P,R			
Paspalum dilatatum	Dallis grass	G	X	R			
Paspalum urvillei	Vasey grass	G	X	R			
Pennisetum clandestinum	Kikuyu grass	G	X		R, P		
Pennisetum purpureum	napier grass	G	X	P,R,S	R,P		
Pennisetum setaceum	fountain grass	G	X		R	R	R
Rhynchelytrum repens	Natal red top	G	X	R	R	R	R
Saccharum sp.	sugar cane	G	X	P			
Setaria gracilis	yellow foxtail	G	X	R,P			
Setaria palmifolia	palmgrass	G	X	S			
Sorghum halpense		G	X	R	R		
Sporobolus indicus	smutgrass	G	X	R,P	R	R	
Stenotaphrum secundatum	St. Agustine grass	G	X		R		
Vulpia		G	X			R	

PLANTS Family, Species and Common Name		Life Form[1]	Status[2]	Niuli'i to Upolu	Upolu to Mahukona	Mahukona to Kawaihae	Kawaihae to Puako
Iridaceae--Iris family							
Neomarica caerulea		G	X	O			
Liliaceae--Lily family							
Aloe sp.		H	X				O
Hippeastrum vittatum	Barbados lily	H	X	O			
Musaceae--Banana Family							
Heliconia sp.		H	X	O			
Musa sp.	banana	T	X, P	O,G			
Strelitzia reginae	bird of paradise	S	X	O			
Palmae--Palm family							
Cocos nucifera	coconut	T	P	O			
Livistona chinensis	Chinese fan palm	T	X	G			
Phoenix sp.	datepalm	T	X	O			
Ptychosperma macarthuri	Macarthur palm	T	X	O			
Roystonea sp.	Royal palm	T	X	O			
Palm sp.		T	X				O
Pandanaceae--Pandanus family							
Pandanus tectorius	hala	T	I	X			
Zingiberaceae--Ginger family							
Alpinia speciosum	shell ginger	S	X	R			
DICOTYLEDONS							
Acanthaceae--Acanthus family							
Asystasia gangetica		H	X	X	R		R,S
Justicia betonica	white shrimp plant	S	X	X	X		
Thunbergia fragrans	white thunbergia	V	X	X			
Aizoaceae--Carpetweed family							
Sesuvium sp.		H	I?			R	
Amaranthaceae--Amaranth family							
Alternantera pungens	khaki weed	H	X			R	
Amaranthus lividus		H	X			R,S	S
Amaranthus spinosus	pig weed	H	X	X	R		S
Anacardiaceae--Mango family							
Mangifera indica	mango	T	X	X			
Schinus terebinthifolius	Christmas berry	T	X	P			

PLANTS Family, Species and Common Name		Life Form[1]	Status[2]	Niuli'i to Upolu	Upolu to Mahukona	Mahukona to Kawaihae	Kawaihae to Puako
Apocynaceae--Plumeria family							
Catharanthus roseus	periwinkle	H	X	O			O
Nerium oleander	oleander	S	X	O			O
Plumeria rubra		T	X	O			O
Thevetia peruviana	be-still tree	S	X				O
Asclepiadaceae--Milkweed family							
Asclepias physocarpa	balloon plant	H	X	R,P			
Calotropis gigantea	crown flower	X	S			O	O
Arailiaceae--Ivy family							
Polyscias guilfoylei	panax	S	T	O			
Schefflera actinophylla	octopus tree	T	X	X			
Balsaminaceae--Impatiens family							
Impatiens wallerana	impatiens	H	X	X			
Bignoniaceae--Catalpa family							
Kigelia africana	sausage tree	T	X	O			
Pyrostegia ignea	orange trumpet vine	V	X	S			
Spathodea campanulata	African tulip tree	T	X	S			
Boraginaceae--Borage family							
Cordia subcordata	kou	T	I				O
Heliotropium amplexicaule		H	X	R	R		
Heliotropium procumbens ?		H	X				R
Cactaceae--Cactus family							
Hylocereus undatus	night blooming cereus	V	X				O
Opuntia ficus-indica	panini	S	X		KS		
Cappparaceae--Caper family							
Gynandropsis gynandra	wild spider flower	H	X			KS	KS
Caricaceae--Papaya family							
Carica papaya	papaya	T	X	X			
Caryophylaceae--Pink family							
Drymaria cordata	pilipili	H	X	X			
Casuarinaceae--Casuarina family							
Casuarina equisetifolia	ironwood	T	X	X	X		O

PLANTS Family, Species and Common Name		Life Form[1]	Status[2]	Niuli'i to Upolu	Upolu to Mahukona	Mahukona to Kawaihae	Kawaihae to Puako
Chenopodiaceae--Goosefoot family							
Atriplex sp.	Kawaihae Harbor atriplex	H	X				R
Atriplex semibaccata	Australian saltbush	H	X			X	X
Chenopodium ambrosioides	Mexican tea	H	X			X	
Chenopodium carinatum		H	X				S
Chenopodium murale	'aheahea	H	X			X	X
Chenopodium oahuense	'aheahea	S	E				S
Compositae--Daisy family							
Ageratina riparia	Hamakua pamakani	H	X	S			
Ageratum conyzoides	maile hohono	H	X	P,R	R		
Artemesia vulgaris	wormwood	H	X	P,R			
Bidens alba		H	X	X	R		
Bidens cynapiifolia		H	X			S	
Bidens pilosa		H	X	X	R	S	R
Cirsium vulgare	thistle	H	X		R		
Conyza canadensis	horseweed	H	X	X	R	R	
Crassocephalum crepidioides		H	X	R			
Emilia sonchifolia	Flora's paintbrush	H	X	R	R	R	
Erechtites valerianifolia		H	X	R			
Galinsoga parviflora		H	X	R,S	R		
Gnaphalium sp.		H	X		R		
Lapsana communis		H	X	R			
Montanoa hibiscifolia		S	X	S			
Osteospermum calendulaceum		H	X				S
Pluchea symphytifolia	sourbush	S	X	X	R	R,S	S
Senecio madagascariensis		H	X	R,P	R		
Sigesbeckia orientalis		H	X	X			
Sonchus oleraceus	pualele	H	X	R	R	R	
Synedrella nodiflora		H	X	X	R		
Taraxacum officinale	dandelion	H	X	R			
Tridax procumbens		H	X	R	R	R	R
Verbesina encelioides		H	X		R	R	
Vernonia cinerea	ironweed	H	X	P,R	R	R	
Wedelia trilobata		H	X	X	R		O
Zinnia sp.		H	X		X		

PLANTS Family, Species and Common Name		Life Form[1]	Status[2]	Niuli'i to Upolu	Upolu to Mahu-kona	Mahu-kona to Kawaihae	Kawaihae to Puako
Convolvulaceae--Morning Glory family							
Ipomoea	moon flower	V	X	S			
Ipomoea	blue morning glory	V	X	X	X		
Ipomoea	yellow morning glory	V	X	X			
Ipomoea cairica	koali 'ai	V	I?			S,KS	
Ipomoea triloba		V	X			R	
Jacquemontia ovalifolia	pa'u o hi'iaka	H	I			KS	KS
Merremia aegyptia	koali kua hulu	V	X			KS,R	KS,R
Merremia tuberosa	wood rose	V	X	X			
Crassulaceae--Sedum family							
Kalanchoe pinnata	air plant	H	X	X			
Cruciferae--Mustard family							
Cardamine flexuosa		H	X	S			
Lepidium sp.		H	X		R	S,R	
sp.		H	X			R	
Cucurbitaceae--Melon family							
Cucurbita sp.	pumpkin	V	X	O			
Cucumis dipsaceus	teasel gourd	V	X			S,KF	
Momordica charantia	bitter melon	V	X	X			R
Euphorbiaceae--Spurge family							
Acalypha wilkesiana		S	X	O			
Aleurites moluccana	kukui	T	P	S			
Chamaesyce hirta	garden spurge	H	X	R	R	R	R
Chamaesyce hyssopifolia		H	X		R	R	R
Chamaesyce prostrata	prostrate spurge	H	X	R	R		S
Codiaeum variegatum	croton	S	X	O			
Euphorbia heterophylla	kaliko	H	X	X	R	R	
Phyllanthus debilis		H	X	X	R		S
Ricinus communis	Castor bean	S	X	S			S
Goodeniaceae							
Scaevola sericea	naupaka	S	I			O	O
Labiatae--Mint family							
Hyptis pectinata		S	X	R,P		R	
Leonotis nepetifolia	Lion's ear	H	X		X	S,R	

PLANTS Family, Species and Common Name		Life Form[1]	Status[2]	Niuli'i to Upolu	Upolu to Mahu-kona	Mahu-kona to Kawaihae	Kawaihae to Puako
Lauraceae--Laurel family							
Cinamomum verum	cinnamon	S	X	P			
Persea americana	avocado	T	X	X			
Leguminosae--Bean family							
Acacia confusa	Formosan koa	T	X	X			O
Acacia koaia	koaia	T	E		O		
Cajanus cajan	pigeon pea	S	X	O			
Calliandra inaequilatera	Lehua-haole	S	X	O			
Canavalia cathartica	maunaloa	V	X	X			
Cassia sp.	shower tree	T	X	O			
Chamaecrista nictitans	lauki	H	X	X	R	R	R
Crotalaria sp.	rattlepod	H	X	X			
Crotalaria pallida		H	X	X	R		
Desmanthus virgatus		S	X	R,P	R,P		
Desmodium cajanifolium		S	X	R			
Desmodium sandwicense	pua pilipili	H	X	P,R	R		
Desmodium tortuosum	beggarweed	H	X	R			R
Desmodium triflorum		H	X	R,P	R		
Desmodium sp.		V	X	X			
Erythrina sp.		T	X	O			
Erythrina sp.		T	X				O
Glycine wightii		V	X	P,R	P		
Indigofera suffruticosa	indigo	S	I	P,R	R,P		
Leucaena leucocephala	koa haole	S	X	P,R,S	X	S	S
Macroptilium lathyroides		H	X	R,P	R	R	
Medicago lupulina		H	X		R,P		
Mimosa pudica	sleeping grass	H	X	R,P			S
Paraserianthes falcataria	albizia	T	X	X			
Prosopis pallida	kiawe	T	X	X		KF,KS	KF,KS
Pueraria lobata	kudzu	V	X	P			
Senna surattensis	kolomona	S	X	R			
Trifolium repens	white clover	H	X	R,P	P,R		

PLANTS Family, Species and Common Name		Life Form[1]	Status[2]	Niuli'i to Upolu	Upolu to Mahukona	Mahukona to Kawaihae	Kawaihae to Puako
Malvaceae--Hibiscus Family							
Abutilon grandifolium	ma'o	S	X	X	X	S,KF	S, KF
Gossipium barbadense	cotton	S	X				O
Hibiscus tiliaceus	hau	T	I	S			
Hibiscus sp.		S	X	O			O
Malva parviflora	cheeseweed	H	X		R	R,S	
Malvastrum coromandelianum		H	X	R	R		S
Malvaviscus penduliflorus	Turk's cap	S	X	S			
Sida acuta		H	X	P			
Sida fallax	'ilima	S	I		R,P	KS	KS
Sida rhombifolia		S	I?	P,R	P,R	R	R
Thespesia populnea	milo	T	I		O	X	X
Meliaceae--Mahogany family							
Melia azedarach	Pride of India	T	X	P			
Molluginaceae--Carpetweed family							
Mollugo cerviana		H	X			S	S
Moraceae--Fig family							
Artocarpus altilis	'ulu	T	P	X			
Ficus microcarpa	banyan	T	X	X			
Ficus sp.	banyan	T	X	O			
Moringaceae							
Moringa oleifera	horseradish tree	T	X				O
Myrtaceae--Myrtle Family							
Eucalyptus sp.		T	X	X			
Metrosideros polymorpha	'ohi'a	S	E	O			
Psidium guajava	common guava	T	X	P			
Syzigium aromaticum	clove	T	X	O			
Syzygium cumini	Java plum	T	X	P			
Nyctaginaceae--Four-o-clock family							
Boerhavia coccinea		H	X			R	R
Boerhavia repens		H	I				S
Bougainvillea sp.		S	X	O			O

PLANTS Family, Species and Common Name		Life Form[1]	Status[2]	Niuli'i to Upolu	Upolu to Mahukona	Mahukona to Kawaihae	Kawaihae to Puako
Onagraceae--Evening Primrose family							
Ludwigia octovalvis	kamole	H	X				S
Oxalidaceae--Sorrel Family							
Oxalis corniculata	wood sorrel	H	I	P,R			
Oxalis corymbosa	pink wood sorrel	H	X	P			
Papaveraceae--Poppy family							
Argemone glauca		H	E				KS,R
Passifloraceae--Passion Fruit family							
Passiflora edulis	passion fruit	V	X	X			
Passiflora pulchella		V	X	P,G			
Phytolaccaceae--Pokeweed family							
Rivina humilis		S	X	G			
Plantaginaceae--Plantain family							
Plantago lanceolata		H	X	R			
Plantago major	laukahi	H	X	R	R		
Plumbaginaceae--Leadwort family							
Plumbago auriculata	blue plumbago	S	X	O			O
Primulaceae--Primrose family							
Anagallis arvensis	pimpernel	H	X	R			
Proteaceae--Protea family							
Macadamia ternifolia	macadamia nut	T	X	crop			
Polygalaceae							
Polygala paniculata		H	X	R			
Polygonaceae--Buckwheat family							
Polygonum punctatum		H	X				S
Portulacaceae--Portulaca family							
Portulaca oleracea	'ihi	H	X			S	S
Portulaca pilosa		H	X		X	X	X

PLANTS Family, Species and Common Name		Life Form[1]	Status[2]	Niuli'i to Upolu	Upolu to Mahu-kona	Mahu-kona to Kawaihae	Kawaihae to Puako
Rosaceae--Rose family							
Osteomeles anthyllidifolia	'ulei	S	E		O		
Rosa sp.	rose	S	X	O			
Rubiaceae--Coffee family							
Hedyotis corymbosa		H	X		R		
Paederia scandens	Maile pilau	V	X	X			
Spermacoce assurgens		H	X	R,P			S
Spermacoce mauritiana		H	X	R			
Rutaceae--Citrus family							
Murraya paniculata	mock orange	S	X	O			
Sapindaceae							
Litchi chinensis	litchi	T	X	O			
Solanaceae--Tomato family							
Solanum americanum	popolo	S	I?	X			
Solanum linnaeanum	apple of Sodom	S	X				S
Sterculiaceae--Chocolate family							
Waltheria indica	hi'aloa	S	S	X	X	R,KS	R,KS
Umbelliferae--Parsley family							
Centella asiatica	asiatic pennywort	H	X	X			
Ciclospermum leptophyllum	fir-leaved celery	H	X	R			
Foeniculum vulgare	fennel	H	X		X		
Hydrocotyle sibthorpioides							S
Verbenaceae--Verbena family							
Clerodendrum philippinum	pikake hohono	S	X	O			
Lantana camara	lantana	S	X	P		KS	
Phyla nodiflora		H	X				O
Stachytarpheta sp.	owi	H	X	P,R	R		
Verbena litoralis	owi	H	X	P	R		
Zygophyllaceae--Caltrop family							
Tribulus terrestris	puncture weed	H	X				R

1 G-Grass; S-Shrub (0.5-2 m tall); H-Herb (0-0.5 m tall); T-Tree (>2 m tall); V-Vine.

2 X-Not native to Hawai'i, P-Polynesian introduction, E-Endemic to Hawai'i (native to Hawai'i and found nowhere else), I-Indigenous to Hawai'i (native to Hawai'i and elsewhere.)

Table 2.-- Distribution of plant communities in the various project units. Communities are: R-Ruderal, plants typically found along roadsides; KS-Kiawe Savannah vegetation; KF-Closed canopy Kiawe forest; P-Pasture and Guava scrub; M-Commercial macadamia plantation; S-Plants more or less restricted to gulches or streams within the delineated areas; O-Ornamental plantings.

	PLANT COMMUNITIES						
Project Unit	R	KS	KF	P	M	S	O
Well site A				x	•		
Well site B				x			
Well site C				x			
Well site D					x		
Well site E					x		
Well site F					x		
Well site G				x			
Upolu Road Collection Reservoir	Pasture, but not surveyed per instructions						
Breaker Reservoir and accesss road	Kiawe savannah, but not surveyed per instructions						
Terminal Reservoir and access road		x					
Hawi Booster Station				x			x
Kynnersley Booster Station				x			
Upper Kapa'au Booster Station				x			
Lower Kapa'au Booster Station					x		
Halaula Booster Station				x			
Makapala booster station				x			
Pipeline route: Niuli'i to Upolu Road, including access roads to wells and booster stations	x			x		x	x
Pipeline route: Upolu to Mahukona	x	x		x			x
Pipeline route: Mahukona to Kawaihae	x	x	x			x	x
Pipeline route: Kawaihae to Puako	x	x	x			x	x

Table 3.--Birds seen, or known to frequent the project area of the Kokala Coast Water Transmission System. For the purposes of noting avifauna distribution, the project is subdivided into four areas. Listed species without a checked distribution are noted in Hawaii's Birds as common in the South Kohala District, but were not seen at the time of the survey. The absence of a check for any species in a given area does not preclude its presence there--only that it was not detected during the survey. * indicates native species, ** indicates naturally occurring migrant species

BIRDS Family, Species and Common Name		Niulii to Upolu Rd	Upolu Rd to Mahukona	Mahukona to Kawaihae	Kawaihae to Puako
Accipitridae--Eagles and Hawks					
**Buteo solitarius*	'io	x			
Alaudidae--Larks					
Alauda arvensis	skylark	x	x	x	
Charadriidae--Plovers					
***Pluvialis dominica*	Golden Plover	x	x		x
Columbidae--Pigeons and doves					
Columba livia	Rock dove	x			x
Geopelia striata	Zebra dove	x	x	x	x
Streptopelia chinensis	Spotted dove	x	x		
Emberizidae--Emberizine finches					
Cardinalis cardinalis	Northern cardinal	x	x	x	
Paroaria capitata	Yellow billed cardinal	x	x	x	x
Sicalis flaveola	Saffron finch				
Estrildidae--Waxbills and Mannikins					
Lonchura malabarica	Warbling silverbill		x		x
Lonchura punctulata	Nutmeg mannikin	x			
Fringillidae--Cardueline finches					
Carpodacus mexicanus	house finch	x	x	x	
Mimidae--Mockingbirds					
Mimus polyglottos	Northern Mockingbird		x	x	

BIRDS Family, Species and Common Name		Niulii to Upolu Rd	Upolu Rd to Mahukona	Mahukona to Kawaihae	Kawaihae to Puako
Muscicapidae--Insect eaters					
Garrulax canorus	hwamei	x			
Passeridae--Sparrow family					
Passer domesticus	sparrow	x	x	x	x
Phasianidae--Gallinaceous birds					
Francolinus francolinus	Black francolin	x	x	x	x
Francolinus pondicerianus	Gray francolin		x		x
Pteroclididae--Sandgrouse family					
Pterocles exustus	chesnut-bellied sandgrouse				x
Scolopacidae--Shorebirds					
***Arenaria interpres*	ruddy turnstone	x			
Strigidae--Typical owls					
**Asio flammeus*	pueo		x		
Sturnidae--Starlings & Mynas					
Acridotheres tristis	Common myna	x	x	x	x
Tytonidae--Barn owls					
Tyto alba	barn owl	x			
Zosteropidae--White-eyes					
Zosterops japonicus	Japanese white eye	x	x	x	

APPENDIX E

EVALUATION OF DIESEL GENERATOR NOISE LEVELS

AIR QUALITY STUDY

Y. Ebisu & Associates
Acoustical and Electronic Engineers
1126 12th Avenue
Room 305
Honolulu, Hawaii 96816
(808) 735-1634

YEA Job #32.049
January 5, 1995

Department of Water Supply
County of Hawaii
15 Aupuni Street
Hilo, Hawaii 96720

Attention: Mr. William Sewake, P.E.

Subject: Evaluation of Diesel Generator Noise Levels
Kohala Water Transmission System DEIS

Dear Mr. Sewake:

The following letter report contains my evaluations regarding potential noise impacts from the proposed diesel generators:

Purpose. The potential noise levels from diesel generators located at proposed Well Sites "C", "D", and "E" of the Kohala Water Transmission System (see ENCLOSURE 1) were evaluated and compared with existing background ambient noise levels. The 800 kw generators were all assumed to be installed in quiet suites, with estimated noise levels of 72 dBA at 50 FT distance. The nearest existing residences to the three well sites are located at distances ranging from 1,200 to 1,400 FT from the well sites where the generators are planned to be located. The following report provides the predicted noise levels from the generators at the nearest existing residences, compares the generator noise levels with measured daytime and nighttime background ambient noise levels, and describes the potential risks of adverse noise impacts from the generator noise at these residences. General recommendations for minimizing these risks were provided.

Noise Descriptors. The noise descriptor currently used by federal agencies to assess environmental noise is the Day-Night Average Sound Level (Ldn). This descriptor incorporates a 24-hour average of instantaneous A-Weighted Sound Levels as read on a standard Sound Level Meter. The minimum averaging period for the Ldn descriptor is 24 hours (by definition). Additionally, sound levels which occur during the nighttime hours of 10:00 PM to 7:00 AM are increased by 10 decibels (dB) prior to computing the 24-hour average by the Ldn descriptor.

ENCLOSURE 2 provides a matrix of land uses which are considered to be compatible with various levels of exterior noise as measured by the Ldn descriptor system. An exterior noise level of 55 Ldn is considered to be the "Compatible, or Unconditionally

Acceptable" level of exterior noise for low-density, residential areas. The existing State Department of Health (DOH) property line noise limits (which are applicable only on the island of Oahu) for single family residences limit daytime noise levels to 55 dBA during the hours of 7:00 AM to 10:00 PM, and limit night-time noise levels to 45 dBA during the hours of 10:00 PM to 7:00 AM. ENCLOSURE 3 presents the typical range of common sounds using the dBA meter scale. These DOH limits for residential properties are essentially equivalent to the 55 Ldn level. They are currently not applicable on the island of Hawaii, but may be applied to the outer islands of the state in the near future.

Existing Background Noise Levels. Existing average background ambient noise levels were measured at the locations indicated in ENCLOSURE 1 near the proposed Well Sites "C" thru "E" during the afternoon of December 16, 1994 and during the early morning hours of December 17, 1994. Average background ambient noise levels during the late afternoon hours of 5:00 to 6:00 PM ranged from 42 to 46 dBA, and was controlled by the natural sounds of birds, farm animals, and foliage movenent with the wind. During the early morning hours of 4:00 to 5:00 AM the next day, measured average background ambient noise levels were similar at 43 to 45 dBA, primarily due to foliage movement with the wind. Minimum background ambient noise level measured during periods of calm winds was 37 dBA. Based on these measurements, the existing natural (not man-made) background ambient noise levels at the existing residences near the three well sites were estimated to range from approximately 40 to 45 Ldn.

Predicted Generator Noise Levels. The noise level of a quieted diesel generator will decrease to levels below 72 dBA with increasing distance beyond 50 FT from the generator. Meteorological factors, temperature gradient and wind conditions, as well as local shielding effects will affect the degree of reduction of the generator noise level with increasing distance. ENCLOSURE 4 provides the predicted range of generator noise levels with increasing distance from the generator as the shaded area. During the daytime period, when ground and air temperatures near the ground tend to be higher than the air temperatures at the higher altitudes, the lower range (bottom of shaded area) of generator noise levels can be expected. During the late night or early morning period, when cool drainage winds from the upper slopes tend to produce lower air temperatures near the ground than at higher altitudes, the upper range (top of the shaded area) of generator noise levels can occur.

The nearest existing residences to the three proposed well sites with operating diesel generators are located between 1,200 to 1,400 FT from the well sites. At these distances, predicted generator noise levels range between 32 to 46 dBA, with the lower levels near 32 dBA expected to occur during the daylight hours, and the higher levels near 46 dBA expected to occur during the early morning hours before sunrise. With daytime background ambient noise levels in the mid-40 dBA range, the generators may not be audible, and risks of adverse noise impacts are expected to be relatively low during the daytime hours.

The worst case conditions are expected to occur during the early morning hours before sunrise when background ambient noise levels are typically at their lowest levels and when generator noise levels may be at their highest levels due to meteorological factors. Under worst case conditions, generator noise levels may exceed the State DOH nighttime limit of 45 dBA for residences on Oahu, and will probably be audible above the lower nighttime background ambient noise levels of 37 to 45 dBA. Approximately 5 to 10 dB of additional quieting (or sound attenuation) will be required at the three generator powered well sites to minimize risks of adverse noise impacts or complaints at the nearest residences.

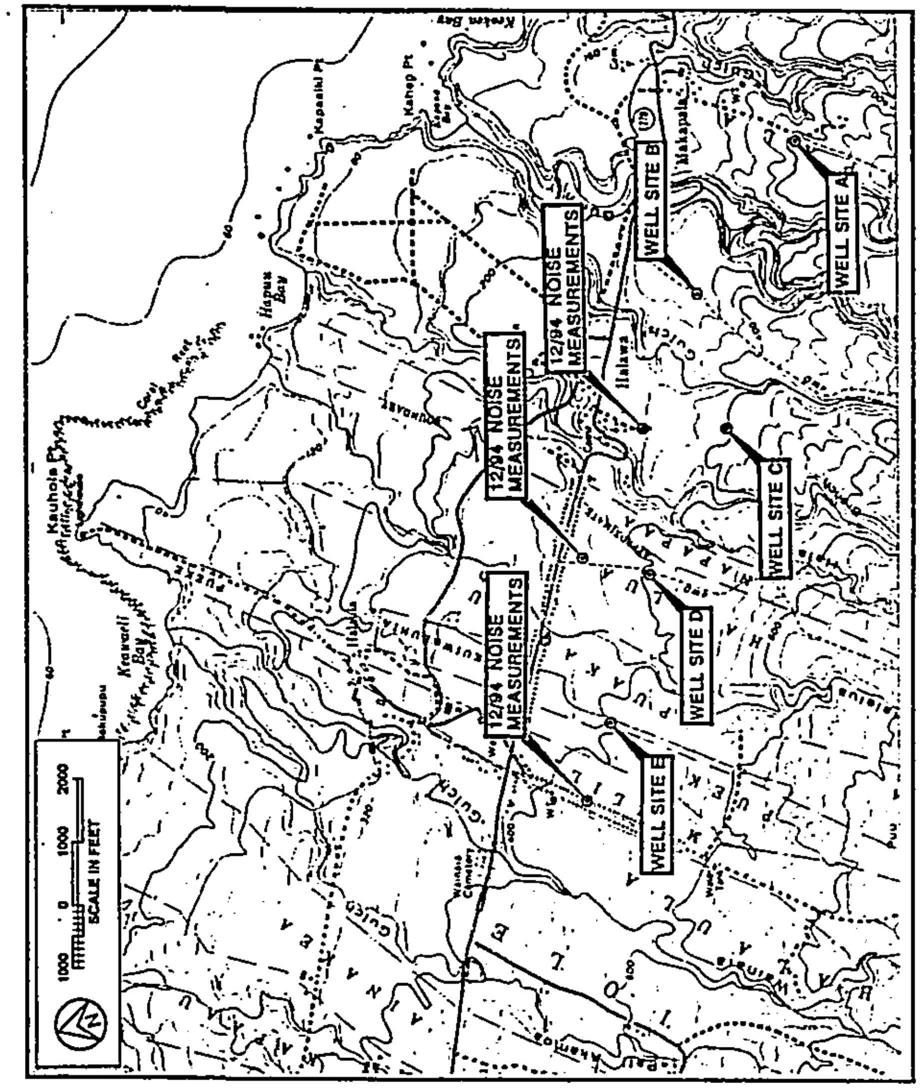
<u>Possible Noise Mitigation Measures</u>. The use of additional sound attenuation measures at the diesel generators or the construction of sound attenuation berms or walls at the well sites are possible means of obtaining the 5 to 10 dBA of additional noise reduction required to minimize risks of adverse noise impacts or complaints from the operation of the diesel generators at night. The required height of the walls or berms will be in the order of 14 to 16 FT above the base of the generator due to the 12.5 FT height of the generator housing.

Sincerely,

Yoichi Ebisu, P.E.

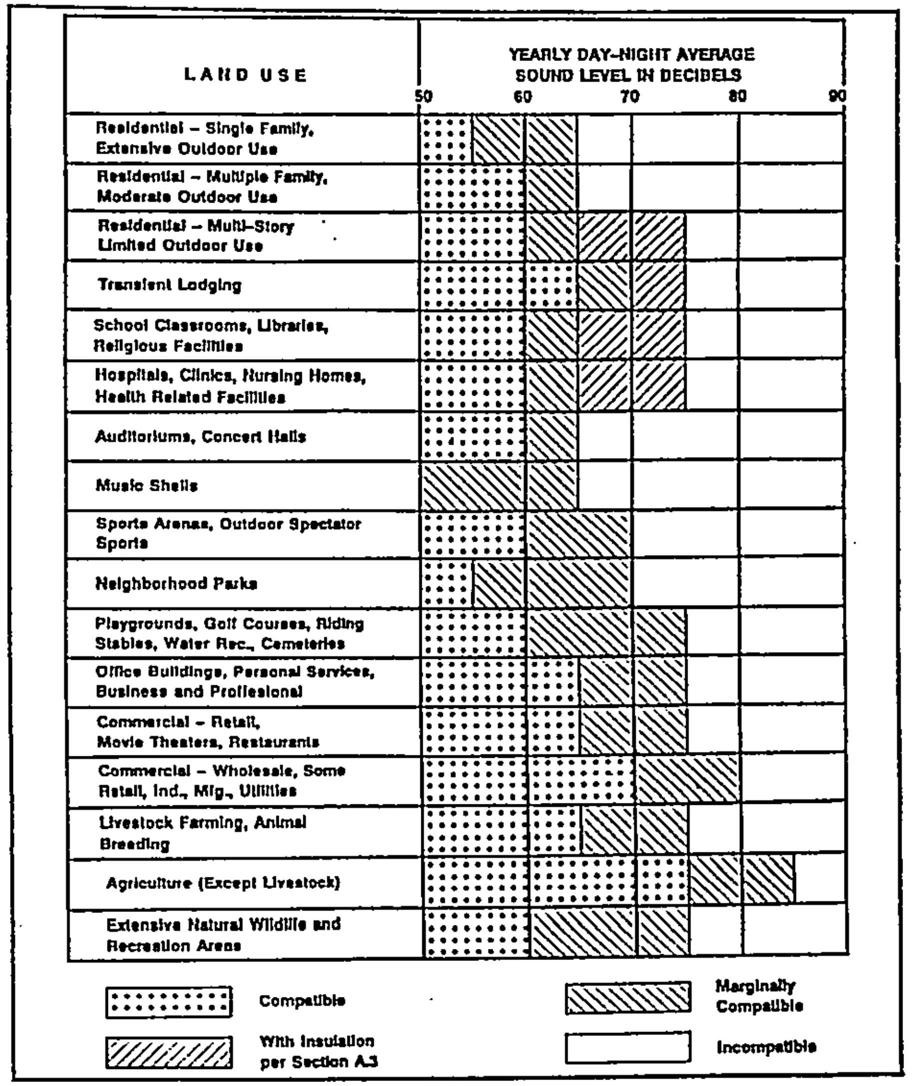
encl.

cc: Megumi Kon, P.E.



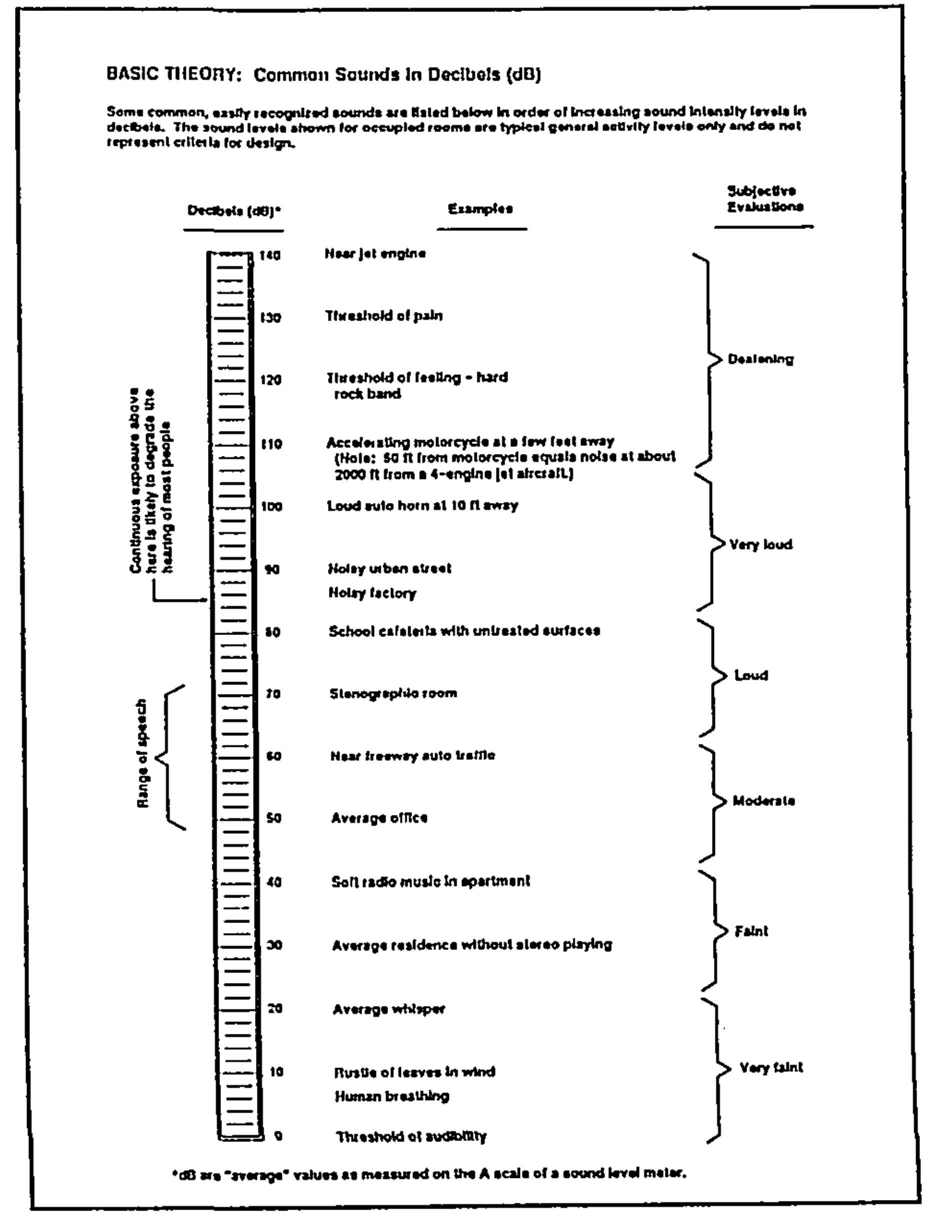
LOCATIONS OF PROPOSED WELL SITES

ENCLOSURE 1



LAND USE COMPATIBILITY
WITH YEARLY DAY-NIGHT AVERAGE SOUND LEVEL
AT A SITE FOR BUILDINGS AS COMMONLY CONSTRUCTED
(Source: American National Standards Institute S3.23-1980)

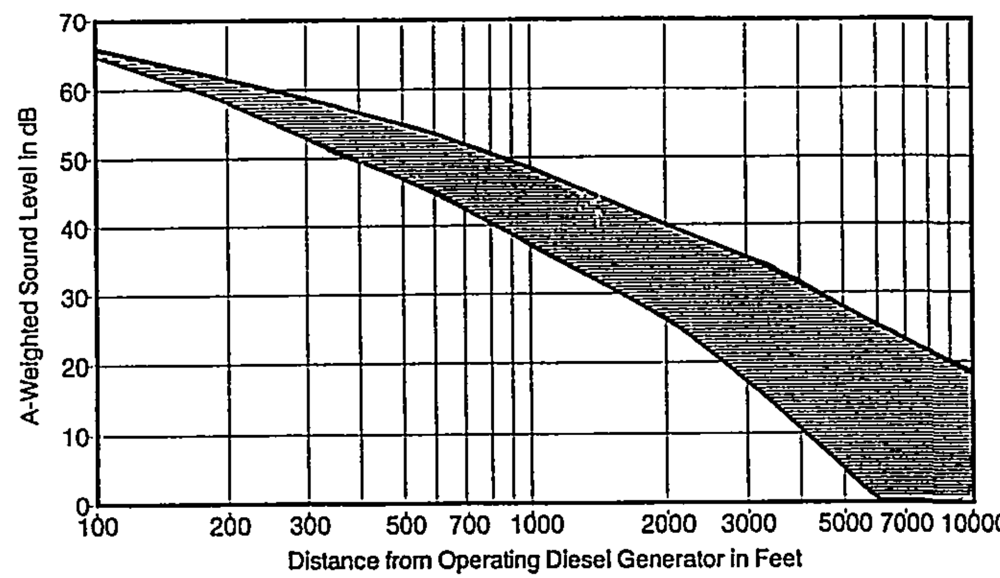
ENCLOSURE 2



ENCLOSURE 3

ENCLOSURE 4

ANTICIPATED RANGE OF QUIET 800 KW GENERATOR NOISE LEVELS VS. DISTANCE



AIR QUALITY STUDY
FOR THE PROPOSED
KOHALA WATER TRANSMISSION SYSTEM

NORTH AND SOUTH KOHALA, HAWAII

Prepared for:

Hawaii County Department of Water Supply

February 1995

B. D. NEAL & ASSOCIATES

Applied Meteorology • Air Quality • Computer Science

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FIGURES

TABLES

TABLES (cont.)

1.0 SUMMARY

The Hawaii County Department of Water Supply is proposing to develop a water transmission system along the north and west coasts of the North and South Kohala Districts on the island of Hawaii. Major elements of the project include a total of 12 wells, a water transmission pipeline and several water reservoirs along the pipeline route. Phase I of the project will provide 10 million gallons per day capacity. Phase II of the project will double the system capacity to 20 million gallons per day. Due to the anticipated lack of available commercial power during Phase I of the project, the Department of Water Supply plans to provide an 820 kW diesel generator unit at each of three well sites located near Halawa in North Kohala. This study examines the potential air quality impacts that could occur as a result of air pollution emissions emanating from the diesel generator units. Mitigative measures to lessen project impacts are suggested where possible and appropriate.

Both federal and state standards have been established to maintain ambient air quality. At the present time, six parameters are regulated including: particulate matter, sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone and lead. Hawaii state air quality standards are more stringent than the comparable national limits except for the standards for sulfur dioxide and particulate matter, which are set at the same levels.

Regional and local climate together with the amount and type of human activity generally dictate the air quality of a given location. The climate of the project area is very much affected by its windward and coastal situation. The predominant trade winds can be expected to approach the project area from the southeast, being deviated somewhat by the terrain. When the trade winds are

weak or absent, small scale landbreeze-seabreeze and/or mountain-induced circulations may develop. Mean wind speeds can be expected to vary between about 5 and 20 miles per hour, although there are likely prolonged periods of higher or lower velocities. Based on temperature data for the area, temperatures at the project site likely range between about 50°F and 95°F. Average annual rainfall at the elevation of the project site is probably about 55 to 60 inches based on rainfall data for the area.

Although there no air quality monitoring data are available from the State Department of Health for the project area, it appears likely that both state and national ambient air quality standards are currently being met. This can be surmised due to the lack of air pollution sources and the prevailing upwind location with respect to Kilauea Volcano.

Potential emissions from individual generator units were estimated and compared to the significant emission rates defined by the State Department of Health. All of the air pollutants emitted were found to have emission rates that were less than significant except for nitrogen oxides, which indicated that an ambient air quality impact analysis was warranted for this constituent. This was accomplished using a computerized atmospheric dispersion model developed by the U.S. Environmental Protection Agency (EPA). Due to the relatively small size of the project sources and the lack of detailed meteorological data for the project area, a "screening-level" analysis was performed which provided conservatively high estimates of air quality impacts.

Three generator exhaust designs were examined in the air quality impact analysis. These included an exhaust plenum, a rooftop stack and a "good engineering practice" stack. A good engineering practice stack is typically 2.5 times the height of any nearby buildings or structures to avoid plume downwash. The results of this analysis indicated that the ambient air quality standards for nitrogen dioxide could potentially be exceeded if the generator units are configured with either the exhaust plenum or the rooftop stack. With a good engineering practice stack, maximum concentrations from an individual unit would only reach about 7 percent of the national limit and 10 percent of the state limit. Cumulative impacts from all three generator units, if they occur, would remain well within both state and national standards if the stack heights conform with good engineering practice.

In addition to examining the potential air quality impacts due to nitrogen oxides emissions, nuisance from odorous emissions was also investigated. The odor assessment was performed by identifying and quantifying the probable odorous compounds in the generator exhaust gas, performing worst-case dispersion calculations and comparing the results to published odor detection levels. The results of this investigation showed that diesel exhaust odors would not occur at or beyond the well site boundaries for any of the three exhaust configurations.

Based on the results of this study, it is recommended that the generator units be equipped with stacks that are at least 2.5 times the height of the generator enclosure to avoid plume downwash. To ensure that odor problems from unburned hydrocarbons are avoided, a routine maintenance program with scheduled engine tuneups should be established. It is further recommended that the generator enclosures be situated at the well sites so that the sides that represent the width (i.e., the minimum horizontal dimension) face toward the southeast and northwest. This will help to minimize the aerodynamic wake created by the enclosure during tradewind conditions and thus reduce plume downwash potential. If practical,

it would also be desirable to locate the three generator sites so that they are not aligned with the prevailing winds, i.e., so that the three sites are not located along a southeast/northwest line. This will help to avoid cumulative effects.

2.0 INTRODUCTION AND PROJECT DESCRIPTION

The Hawaii County Department of Water Supply (DWS) is proposing for development the Kohala Water Transmission System. As indicated in Figure 1, the proposed project consists of a pumped water transmission pipeline that would originate near Kauhola Point in the North Kohala District, follow along the Hawi-Niulii, Akoni Pule and Queen Kaahumanu Highway corridors and terminate in the Lalamilo area mauka of Puako Bay in the South Kohala District. Current plans call for the system to be built in two phases. In Phase I the system will have the capacity to recover and transport 10 million gallons per day (mgd). Phase II will supplement the system with additional wells and reservoirs to increase capacity to 20 mgd.

The major project components comprising Phase I will include six wells at three sites located mauka of the Hawi-Niulii Highway near Halawa, a diesel generator and associated fuel storage facilities at each of the three sites, the main water transmission pipeline varying in size from 16 inches to 36 inches, three booster pump stations and water reservoirs at Puakea Ranch, Kawaihae, Hapuna and Puako. The Phase I well sites are designated as C, D and E in Figure 1 and are depicted in more detail in Figures 2, 3 and 4. Phase II will include six additional wells at the three sites designated as A, B and F in Figure 1 and reservoirs at Puakea Ranch and at Puako. It is anticipated that power for the Phase II wells will be provided by the electric utility.

The purpose of this study was to evaluate the potential air quality impacts of emissions from the proposed diesel generator units included in Phase I and recommend mitigative measures, if possible and appropriate, to reduce or eliminate any degradation of air quality in the area. Before examining the potential impacts of the proposed facilities, a discussion of ambient air quality standards is presented and background information concerning the regional and local climatology and the present air quality of the project area is provided.

3.0 AMBIENT AIR QUALITY STANDARDS

Ambient concentrations of air pollution are regulated by both national and state ambient air quality standards (AAQS). National AAQS are specified in Section 40, Part 50 of the Code of Federal Regulations (CFR), while State of Hawaii AAQS are defined in Chapter 11-59 of the Hawaii Administrative Rules. Table 1 summarizes both the national and the state AAQS that are specified in the cited documents. As indicated in the table, AAQS have been established for six air pollutants. These regulated air pollutants include: particulate matter, sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone and lead. National AAQS are stated in terms of primary and secondary standards. National primary standards are designed to protect the public health with an "adequate margin of safety". National secondary standards, on the other hand, define levels of air quality necessary to protect the public welfare from "any known or anticipated adverse effects of a pollutant". Secondary public welfare impacts may include such effects as decreased visibility, diminished comfort levels, or other potential injury to the natural or man-made environment, e.g., soiling of materials, damage to vegetation or other economic damage. In contrast to the national AAQS, Hawaii State AAQS are given in terms of a single standard that is designed "to protect public health and

welfare and to prevent the significant deterioration of air quality".

Each of the regulated air pollutants has the potential to create or exacerbate some form of adverse health effect or to produce environmental degradation when present in sufficiently high concentration for prolonged periods of time. The AAQS specify a maximum allowable concentration for a given air pollutant for one or more averaging times to prevent harmful effects. Averaging times vary from one hour to one year depending on the pollutant and type of exposure necessary to cause adverse effects. In the case of the short-term (i.e., 1- to 24-hour) AAQS, both national and state standards allow one exceedance per year.

State of Hawaii AAQS are in some cases considerably more stringent than comparable national AAQS. In particular, the State of Hawaii 1-hour AAQS for carbon monoxide is four times more stringent than the comparable national limit, and the state 1-hour limit for ozone is more than two times as stringent as the federal standard.

Hawaii AAQS for sulfur dioxide were relaxed in 1986 to make the state standards essentially the same as the national limits. In 1993, the state also revised its particulate standards to follow those set by the federal government. It has been proposed in various forums that the state also relax its carbon monoxide standards to the national levels, but at present there are no indications that such a change is being considered.

4.0 REGIONAL AND LOCAL CLIMATOLOGY

Regional and local climatology significantly affect the air quality of a given location. Wind, temperature, atmospheric turbulence, mixing height and rainfall all influence air quality. Although the climate of Hawaii is relatively moderate throughout most of the state and most of the year, significant differences in these parameters may occur from one location to another. Most differences in regional and local climates within the state are caused by the mountainous topography.

The sites of the proposed Phase I wells and diesel generator units are located within the North Kohala District on the northern coast of the island of Hawaii. The topography of Hawaii Island is dominated by the great volcanic masses of Mauna Loa (13,653 feet), Mauna Kea (13,796 feet), and of Hualalai, the Kohala Mountains and Kilauea. The island consists entirely of the slopes of these mountains and of the broad saddles between them, and many of the weather and climate features for a given location can be attributed to the local topography. The sites of the proposed diesel generator units are situated at about the 400-foot level on the lower northeastern slope of the Kohala Mountains. The topography in this area rises steadily to the southwest reaching an elevation of about 1000 feet within about one-half mile and then rises more steeply to the south eventually reaching an elevation of about 5000 feet within about 12 miles.

The winds at any given location obviously play a major role in the transport and dispersion of air pollution. The Hawaiian Islands lie well within the belt of northeasterly trade winds generated by the semi-permanent Pacific high pressure cell to the north and east. The trade winds are a very persistent phenomenon and occur about 65 percent of the time on the average. Northern and eastern

facing areas of the islands typically experience winds from the northeast or east a high percentage of the time. The northeastern coast of the island of Hawaii where the proposed project sites are located is well exposed to the trade winds. Although there are no published wind data available for the area, it can be ascertained that the trade winds are deviated to a somewhat more easterly or southeasterly direction by the local topography. The topography of the northern area of the island combined with its situation with respect to the Alenuihaha Channel serves to accentuate tradewind speeds in the area. Mean tradewind speeds likely range between about 15 and 20 mph, while during strong tradewind days, mean speeds may reach 30 to 40 mph.

In winter, the passage of storms can bring very strong "Kona" winds for brief periods from the south or southwest to areas of the islands that face in these directions. The Halawa area is largely sheltered from Kona winds by the Kohala Mountains.

When the trade winds are absent or weak, local winds such as land/sea breezes and/or upslope/downslope winds tend to dominate the wind pattern for the area. During such times, winds typically move onshore from the northeast or east during the daytime because of seabreeze and/or upslope effects. At night and during the early morning hours, drainage winds occur which move downslope from the southwest and out to sea.

Plume rise from air pollution sources depends in part on air temperature. Colder temperatures tend to result in higher emissions of contaminants from automobiles but lower concentrations of photochemical smog and ground-level concentrations of air pollution from elevated plumes. In Hawaii, the annual and daily variation of temperature depends to a large degree on elevation above sea level, distance inland and exposure to the trade winds. Average temperatures at locations near sea level generally are warmer than those at higher elevations. Areas exposed to the trade wind tend to have the least temperature variation, while inland and leeward areas often have the most. Long-term temperature data have been published for several locations in the project area. Data for Kapaau are probably reasonably representative of the project site. Mean annual temperature for Kapaau is 73°F, and average annual daily minimum and maximum temperatures are 66°F and 79°F, respectively [Ref. 1]. The temperature extremes reported at this location range from 51°F to 94°F.

Small scale, random motions in the atmosphere (turbulence) cause air pollutants to be dispersed as a function of distance or time from the point of emission. Turbulence is caused by both mechanical and thermal forces in the atmosphere. It is oftentimes measured and described in terms of Pasquill-Gifford stability class. Stability class 1 is the most turbulent and class 6 the least. Thus, air pollution dissipates the best during stability class 1 conditions and the worst when stability class 6 prevails. In the North Kohala area, stability class 5 or 6 is generally the highest stability class that occurs, developing during clear, calm nighttime or early morning hours when temperature inversions form either due to radiational cooling or to downslope winds that push warmer air aloft. Stability classes 1 through 4 occur during the daytime, depending mainly on the amount of cloud cover and incoming solar radiation and the onset and extent of the sea breeze.

Mixing height is defined as the height above the surface through which relatively vigorous vertical mixing occurs. Low mixing heights can result in high ground-level air pollution concentrations because contaminants emitted from or near the surface can become trapped within the mixing layer. In Hawaii, minimum mixing

heights tend to be high because of mechanical mixing caused by the trade winds and because of the temperature moderating effect of the surrounding ocean. Low mixing heights may sometimes occur, however, at inland locations and even at times along coastal areas early in the morning following a clear, cool, windless night. Coastal areas may also experience low mixing levels during sea breeze conditions when cooler ocean air rushes in over warmer land. Although there are no mixing height data for the North Kohala area, mixing heights elsewhere in the state typically are above 3000 feet (1000 meters). Mixing heights in the North Kohala area probably tend to be somewhat lower during periods of light winds and also during periods when sea breeze conditions develop during the daytime.

Rainfall can have a beneficial effect on the air quality of an area in that it helps to suppress fugitive dust emissions, and it may also "washout" gaseous contaminants that are water soluble. Rainfall in Hawaii is highly variable depending primarily on elevation and on location with respect to the trade wind. Being a trade wind exposed area at a lower elevation, the Halawa area normally receives relatively moderate rainfall. At nearby Kapaau, annual rainfall averages about 57 inches [Ref. 1]. Although September is the driest month on the average, rainfall tends to be spread fairly evenly throughout the year

5.0 PRESENT AIR QUALITY

Present air quality in the project area is mostly affected by air pollutants from natural and/or vehicular sources. Agricultural and small industrial sources may also affect the present air quality but probably only to a minor degree. Natural sources of air pollution emissions which may affect the project area include the ocean, vegetation, wind-blown dust and volcanoes. Of these natural sources of air pollution, volcanoes are probably the most significant, although the project area is impacted much less than the leeward areas of the island. Volcanic emissions have chronically plagued large portions of the Kona and leeward Kohala Coast areas since the latest eruption phase of Kilauea Volcano began in 1983. Air pollution emissions from Kilauea Volcano consist primarily of sulfur dioxide. After entering the atmosphere, these sulfur dioxide emissions are carried away by the wind and either washed out as acid rain or gradually transformed into particulate sulfates. The resulting particulate sulfate emissions can be seen as volcanic haze (vog) which persistently hangs over the leeward areas of the island. The American Lung Association recently studied the character and concentrations of volcanic air pollution at several locations around the island. The results indicated that sulfate levels are up to five times higher in the West Hawaii area compared to locations near Hilo. Potential impacts on human health from the vog are still inconclusive and remain under study. Federally-funded programs to better research its effects are currently underway. The Halawa area is upwind of Kilauea Volcano most of the time and is located outside of the recirculation zone that causes the volcanic emissions to impact the Kona and leeward Kohala Coast areas.

The Hawi-Niulii Highway, which is located less than one-half mile to the north of the project well sites, provides the only route for motor vehicle traffic going to and from the Hawi-Niulii area. Exhaust gases and fugitive dust from motor vehicles traversing this roadway will tend to be carried over the project sites during periods of northerly winds. Any high levels of air pollution presently occurring in the area due to motor vehicle emissions are likely confined to short periods and limited areas near intersections where and when traffic congestion occurs during poor dispersion conditions.

The State Department of Health operates a network of air quality monitoring stations at various locations around the state. Unfortunately, very little data are available for the island of Hawaii, and none are available for the North Kohala area specifically. It may be inferred, however, that due to the lack of major sources of air pollution in the area and the relatively uncongested traffic conditions that the current air quality is relatively good. Vog may occasionally affect the area during Kona wind conditions.

6.0 PROJECT AIR POLLUTION EMISSIONS

Emission estimates were prepared for all air pollution sources that would be associated with the project. For the Kohala Water Transmission System, it is expected that the only air pollution sources will be the diesel generator units and associated fuel storage facilities which will be needed at well sites C, D and E. To ascertain the potential significance of these emissions, the estimates were then compared to the "significant" emission rates as defined by the State Department of Health [Ref. 2]. If estimated emissions are below the significant levels for a given source, the source is generally considered to be insignificant, and it is unlikely that emissions from the source will have any significant impacts on air quality. If emissions exceed the significant levels, it does not necessarily indicate that there would be significant impacts, but it does suggest that a more detailed analysis of the potential impacts may be warranted.

Project pumping requirements indicate that an 800 kW generator unit will be needed at each of the three well sites in lieu of commercial power. For the purposes of this study, it was assumed that the generator unit provided at each location will be a sound-attenuated Caterpillar Model 3508/820 kW or equivalent. Each of the three well sites was also assumed to be provided with two fixed-roof above ground fuel storage tanks with a capacity of 5,200 gallons each.

Table 2 is a summary of the estimated "potential" emissions for the project. As indicated in the table, potential emissions were calculated based on emission data provided by the generator manufacturer and assume 100 percent load and continuous operation. Actually, during the early and later stages of the project, it is expected that load factors will be less than 100 percent. Emission estimates are given in the table for each of the major (regulated) air pollutants that would be emitted including: total suspended particulate (TSP), and particulate matter less than 10 microns diameter (PM-10), carbon monoxide, sulfur dioxide, nitrogen oxides and volatile organic compounds (VOC). As indicated in the table, estimates are given in terms of tons of air pollution emitted per year.

The emission calculations indicated that fuel storage and handling operations would emit only negligible amounts of VOC emissions due to the relatively non-volatile nature of diesel fuel at ambient temperatures. Thus, air pollution emissions at the well sites would be limited primarily to the diesel generator units. Each diesel generator unit was estimated to potentially emit on an annual basis: 2.5 tons of TSP/PM-10, 22.6 tons of carbon monoxide, 7.9 tons of sulfur dioxide, 112.4 tons of nitrogen oxides and 1.9 tons of VOC.

Table 3 shows the state-defined significant emission rates (in tons per year) for carbon monoxide, nitrogen oxides, volatile organic compounds (hydrocarbons), sulfur dioxide and particulate matter. These values can be used to assess the significance of the estimated emission rates. Emissions (or changes in emissions)

below the significant emission rates are considered minor enough that any air quality impacts will likely be small. Emissions above the significant levels generally indicate that an air quality analysis or a more detailed examination of those emissions may be warranted to determine what impact significance the project might have. Because the well sites are not located on contiguous or adjoining properties, it would generally be considered appropriate to make comparisons to the emissions from individual locations and not to the total emissions from all three sites.

Comparing the significant emission rates to the estimated emissions given in Table 2 for each well site, it can be seen that the estimated emission levels are less than the significant emission rates for all of the regulated pollutants except for nitrogen oxides. Thus, this suggests that an assessment of the potential air quality impacts from the nitrogen oxides emissions at each well site may be warranted.

7.0 AIR QUALITY IMPACT ASSESSMENT

Based on the results of the air pollution emission inventory for the project and the comparison of the estimated emissions with the state-defined significant emission rates, an air quality impact assessment was prepared for project-related nitrogen oxides emissions. As discussed in Section 3, state and national ambient air quality standards have been established for annual average concentrations of nitrogen dioxide. Thus, to assess the potential impacts on air quality from project-related nitrogen oxides emissions, the maximum annual average nitrogen dioxide concentration was estimated in the vicinity of the Phase I well sites and compared to the state and national standards.

Due to the relatively small size of the generator units and the lack of detailed meteorological data available for the project area, a screening-level air quality impact analysis was performed to assess the project impact. Screening analyses are designed to provide conservatively high estimates of maximum air quality impacts. The screening analysis for the subject project was accomplished using the U.S. EPA's SCREEN2 air quality model [Ref. 3]. SCREEN2 is a computerized atmospheric dispersion model that predicts maximum ground-level concentrations for point, area or volume sources of air pollution. Emission and source data together with a standard range of possible meteorological conditions were input to the computer model. The computer model then calculated plume rise and plume dilution and dispersion with distance from the source for each meteorological scenario to determine the location and magnitude of maximum 1-hour ground-level concentrations.

After obtaining the calculated maximum 1-hour average concentrations from SCREEN2, estimates of annual average concentration were derived using a 1-hour to annual conversion factor of 5 percent. This is a standard technique for obtaining conservatively high estimates of annual average concentrations when detailed annual meteorological data are not available. Typically, the maximum mean annual concentration for a given location is observed to range from about 3 to 5 percent of the peak-hour concentration. Based on the expected persistent tradewind conditions in the project area, the upper end of this range was used to estimate maximum annual concentrations.

Source data used in the air quality impact assessment are given in Table 4. As noted in the table, source data used in the assessment pertain to a Caterpillar Model 3508/820 kW sound-attenuated generator set or equivalent. Note that three exhaust configura-

tions were examined: discharge plenum, rooftop stack and Good Engineering Practice (GEP) stack. In the air quality modeling analysis, all three exhaust configurations were represented as point sources. It was also assumed that in all three configurations the generator set would be housed within an enclosure measuring 3.8 m in height, 2.3 m in width and 12.2 m in length.

The discharge plenum configuration assumed that the radiator discharge would be combined with the engine exhaust, and the combined effluent would be discharged to the atmosphere through a large duct at roof level. This configuration contributes to sound attenuation and allows for placement of the generator set next to a building or other obstruction that may restrict air flow to the radiator. The Caterpillar Model 3508/820 kW discharge plenum has a flow rate of 32.7 m^3/s and a temperature of 346°K (based on an average ambient temperature of 73°F).

The rooftop stack configuration assumed that the engine exhaust would exit at roof level through a separate outlet, i.e., it would not be mixed with the radiator discharge. In the Caterpillar Model 3508/820 kW design, the exhaust outlet is 10 inches (0.25 m) in diameter, and the outlet temperature and flow rate are 825°K and 3.48 m^3/s, respectively.

The GEP stack alternative assumed that all stack parameters would be the same as the rooftop stack configuration except that the height of the engine exhaust would conform with GEP stack height guidelines. GEP stack height guidelines [Ref. 4] recommend that to avoid aerodynamic downwash due to adjacent structures stack heights should be equal to the structure height plus 1.5 times the lesser of the height or maximum projected structure width. In this case, this is equivalent to 2.5 times the enclosure height or 9.5 m.

In modeling the three exhaust configurations, it should be noted that the main difference occurs with respect to the estimated plume rise and final plume height due to the differences in exhaust height, flow rate, exit velocity and exit temperature. No specific allowance was made for the increased dilution at the source provided by the exhaust plenum design. All three exhaust options were assumed to be point sources, and the point source model only considers mass emission rate and not initial concentration. In some cases, this may result in over estimates of concentrations very close to the emission source, but for the longer downwind distances that usually are of most concern, the over estimate is probably small. In concept, it might be expected that the initial dilution of the exhaust plenum would yield lower ambient concentrations. In practice, however, this may not be so. This is partly because, as indicated in Table 4, the exhaust velocity for the discharge plenum is much lower than for the stack exhaust options. The higher exit velocity for the stack designs will basically serve the same function as the exhaust plenum, but instead of diluting the exhaust gases with the radiator discharge, it will dilute the gases with entrained ambient air.

Meteorological inputs required by SCREEN2 include: temperature, wind speed and atmospheric stability. For a given temperature, SCREEN2 examines a range of coincident wind speed and stability conditions which include both the expected mean and extreme conditions. In a screening analysis, it is generally assumed that any wind direction may occur for each set of wind speed and stability conditions. A temperature of 73°F was used for all calculations. As indicated in Section 4, this is the mean temperature in the Halawa area.

Impacts of Individual Generator Units

Table 5 shows the resulting estimated maximum nitrogen dioxide ground-level concentrations resulting from nitrogen oxides emissions from an individual project generator unit. As noted in the table, these are the projected incremental concentrations only, i.e., the concentrations attributable to each generator unit, without background concentration and without contribution from any other sources in the area. In preparing these estimates, 100 percent conversion of nitrogen oxides to nitrogen dioxide was assumed. This is a standard assumption used in a screening analysis involving nitrogen oxides emissions. In this case, due to short distances involved between the source and the locations of maximum concentration, this likely results in overestimates of the actual maximum nitrogen dioxide concentrations.

As indicated in the table, the discharge plenum and rooftop stack configurations were predicted to result in maximum concencentrations that are more than ten times higher than the GEP stack alternative. This is due primarily to the predicted building downwash caused by the generator unit enclosure during high wind conditions. One-hour maximum concentrations for the discharge plenum and rooftop stack were estimated to reach 3857 and 3323 $\mu g/m^3$, respectively, while the GEP stack resulted in a maximum estimated concentration of 134 $\mu g/m^3$. The distances indicated in the table refer to the distance from the source to the location of maximum concentration. In the case of the discharge plenum and rooftop stack, maximum 1-hour concentrations were predicted to occur at 30 m, which is the estimated distance to the site boundary. For the GEP stack, the 1-hour maximum concentration was projected to occur at a distance of 180 m.

As indicated above, maximum annual average concentrations were estimated as 5 percent of the 1-hour maximum concentrations predicted by SCREEN2. The estimated maximum annual concentrations for the discharge plenum, rooftop stack and GEP stack were 193, 166 and 6.7 $\mu g/m^3$, respectively. The distances to the annual maximum concentrations cannot be predicted without having access to more detailed meteorological data for the project site, but it is likely that the annual maxima for all three exhaust alternatives will occur within about 500 m from the generator unit. Due to the anticipated wind pattern for the area, it is likely that the direction of the annual maximum concentration for all three exhaust options would occur to the west or northwest of the generator unit.

As discussed previously and shown in Table 1, both the national and the state AAQS for nitrogen dioxide concentrations pertain to annual averaging times. The national standard is set at 100 $\mu g/m^3$, while the state standard is set at 70 $\mu g/m^3$. Thus, based on the results of the screening analysis, emissions from an individual generator unit for both the discharge plenum and the rooftop stack would potentially exceed both the national and the state AAQS, while the maximum concentration from an individual unit with a GEP stack would remain well within both standards.

Cumulative Impact

Due to the relative nearness and the alignment of the three proposed generator sites, it is conceivable that the emissions exhausted from the units could interact and cause a cumulative impact. As indicated in Figure 1, the three sites will be spaced approximately one-half mile apart and aligned approximately along a southeast/northwest axis. Thus, the potential for plume interaction will occur when winds are from the southeast or northwest.

As indicated previously, the expected prevailing wind direction is from the east or southeast. Hence, areas to the northwest of well site E, located on the northwest end of the line connecting the generator sites, could be expected to have the maximum cumulative impact. The screening analysis performed for this study cannot predict cumulative impacts from multiple sources; however, maximum cumulative impacts from the three generator units would obviously be less than three times the impact of an individual generator unit. In all probability, the maximum cumulative impact would be less than twice the maximum impact of a single generator unit.

Based on the predicted impacts for the individual generator units given in Table 5, cumulative impacts from generator units with either discharge plenums or rooftop stacks would further increase the potential exceedance of both the state and the national AAQS. Cumulative impacts from generator units with GEP stacks would remain well within the allowable limits even if cumulative impacts are two to three times the level predicted for an individual unit.

8.0 ODOR IMPACT ASSESSMENT

The national and state ambient air quality standards are primarily designed to protect human health and thus may not guard against some of the annoyance aspects of air pollution such as nuisance odor problems. Diesel engines are known to emit odorous compounds which are usually characterized as having either an oily-kerosene characteristic or a smoky-burnt quality. Most studies have identified the odor-producing compounds as being either unburned or partially burned hydrocarbons.

More than a hundred different species of hydrocarbon compounds have been found to exist in the exhaust of large diesel engines [Ref. 5]. Many of the odor-producing compounds occur at very low concentrations and have correspondingly low odor thresholds. The oily-kerosene odor from diesel engines is generally attributed to alkyl-substituted benzene and napthalene type compounds, while oxygenated aromatic structures (aldehydes) have been related to the smoky-burnt smell. Hydrocarbon species in the latter group of compounds that have been identified in diesel engine exhaust streams include: acetaldehyde, benzaldehyde, crotonaldehyde, formaldehyde, proprionaldehyde and acrolein.

Table 6 lists the odor-causing compounds that would likely be present in the generator exhaust gas and the estimated emission rate and odor threshold for each compound. Except for acrolein, the emission estimates are based on the total hydrocarbon emission rate specification given for the Caterpillar Model 3508/820 kW generator unit operating at 100 percent load and the species weight fractions reported by the California Air Resources Board for large bore diesel engines [Ref. 5]. Acrolein emission estimates were calculated based on generator fuel usage at 100 percent load and the U.S. EPA acrolein emission factor for large bore diesel engines [Ref. 6].

Data in the literature on odor threshold concentrations for any particular compound often vary by 10-fold or more. This is usually due to the imprecise methods of testing and because of the somewhat subjective nature of odor detection. For some compounds, as indicated in Table 6, no odor threshold information is readily available. Of the eight odorous compounds that will likely be present in the generator exhaust gas, only four could be assigned odor threshold values.

As indicated in Table 6, all of the probable odorous compounds would have very small mass emission rates. Of the eight compounds listed in the table, formaldehyde would have the highest emission rate, and acetaldehyde and proprionaldehyde the next highest. Of the four compounds that were assigned odor thresholds, proprionaldehyde has the lowest detection level. Based on the ratios of the emission rates to the available odor threshold levels, it appears that either the proprionaldehyde or the acetaldehyde emissions may have the greatest odor-causing potential.

Proprionaldehyde is usually described as having a "suffocating odor". It has a boiling point of 49°C and thus will be emitted as a gas but will change phase to a liquid vapor at ambient temperature. Acetaldehyde has a pungent odor and exists as either a gas or a liquid at ambient conditions.

To evaluate the potential odor impacts from the diesel exhaust emissions, the SCREEN2 model was used with the same source data given in Table 4 except that the acetaldehyde emission rate was input instead of the nitrogen oxides emission rate. It was assumed that the acetaldehyde emissions would remain stable in the atmosphere over the relatively short distances involved. To allow for the fact that concentrations predicted by SCREEN2 pertain to hourly averaging times and that odor impacts may occur over shorter time periods, concentrations predicted by SCREEN2 were multiplied by a factor of two. The resulting estimated maximum acetaldehyde concentrations indicate that even if the odor threshold for acetaldehyde is an order of magnitude lower, the diesel generator emissions should not be detectable as an odor at or beyond the well site boundaries for any of the three exhaust configurations.

9.0 CONCLUSIONS AND RECOMMENDATIONS

Although there are no air quality data available for the project area, it may be surmised that current air quality conditions are relatively pristine. This is due to the absence of air pollution sources and the prevailing upwind location of the project area with respect to Kilauea Volcano.

The diesel generator units at each of the three Phase I well sites will be relatively small sources of air pollution. Based on Department of Health definitions, only nitrogen oxides emissions from an individual generator unit would be considered significant enough to warrant an ambient air quality impact assessment.

Atmospheric dispersion modeling results indicate that nitrogen oxides emissions from an individual generator unit could potentially exceed ambient air quality standards if a discharge plenum or rooftop stack is used. This is due primarily to plume downwash caused by a building wake effect that the generator enclosure would create in moderate to high wind speeds. On the other hand, the dispersion modeling results show that maximum impacts would be well within ambient air quality standards if the generator stack height conforms with good engineering practice. This would be so even if there are cumulative impacts due to the relative nearness of the three generator sites. Thus, it is recommended that a separate stack be used to exhaust combustion gases from each generator unit and that the stack be extended to good engineering practice stack height. In the case of the proposed generator units, this means that the generator stack height should be at least 2.5 times the enclosure height.

Several odorous compounds will likely be present in the generator exhaust gases at low concentrations, but these should not be detectable at or beyond the well site boundaries. To ensure that odor problems are avoided, a routine maintenance program should established to keep the generator engines well-tuned so as to minimize unburned hydrocarbon emissions.

Due to the expected southeast prevailing winds in the project area, it would be advisable to orient the generator enclosures so that the sides that represent the width (i.e., the minimum horizontal dimension) face toward the southeast and northwest. This will help to minimize the aerodynamic wake created by the enclosure and thus reduce plume downwash potential. If practical, it would also be desirable to locate the three generator sites so that they are not aligned with the prevailing winds, i.e., so that the three sites are not located along a southeast/northwest line. This will help to avoid cumulative effects.

REFERENCES

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4. Guideline for Determination of Good Engineering Practice Stack Height (Technical Support Document for the Stack Height Regulations), Revised, U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA-450/4-80-023R, June 1985.

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6. Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, Fourth Edition Including Supplements A-D, AP-42, U.S. Environmental Protection Agency, Research Triangle Park, NC, September 1991.

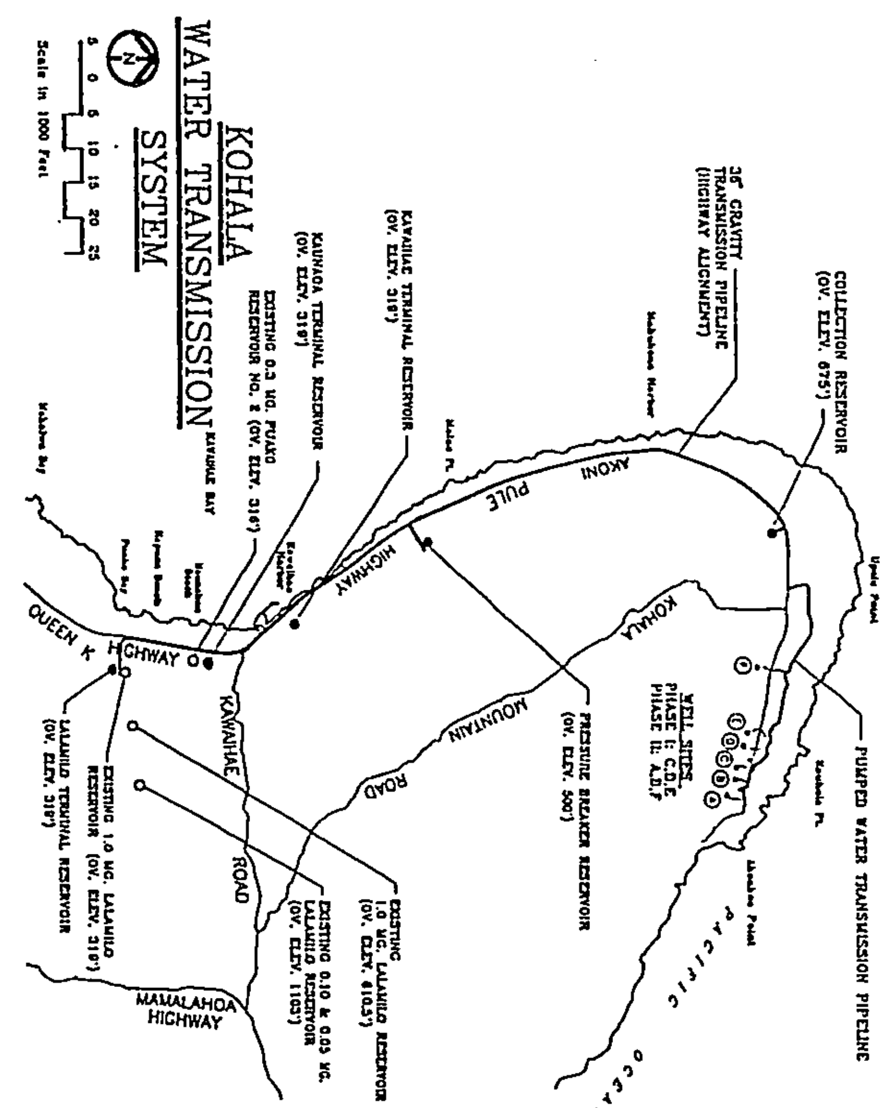


FIGURE 1

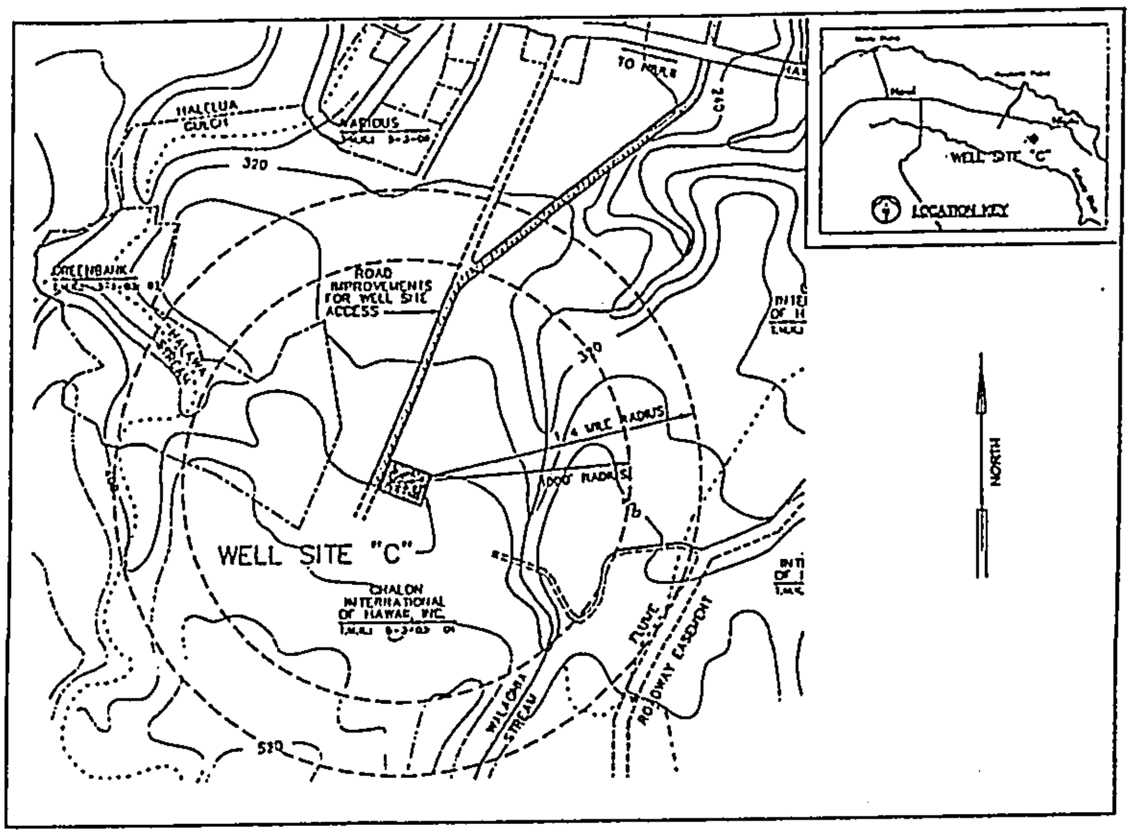


FIGURE 2

DETAILED MAP OF WELL SITE C

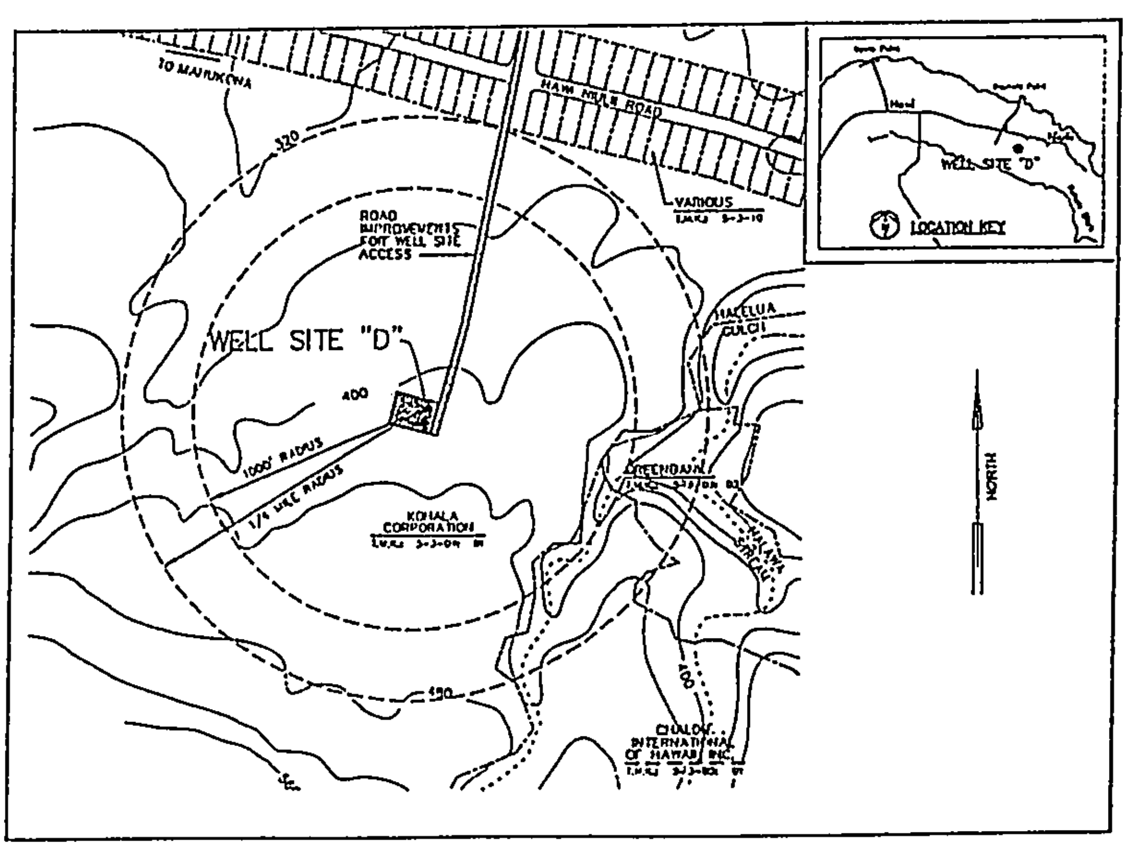


FIGURE 3

DETAILED MAP OF WELL SITE D

Table 1

SUMMARY OF STATE OF HAWAII AND NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Units	Averaging Time	Maximum Allowable Concentration: National Primary	National Secondary	State of Hawaii
Particulate Matter[a]	µg/m³	Annual	50	50	50
		24 Hours	150[b]	150[b]	150[b]
Sulfur Dioxide	µg/m³	Annual	80	-	80
		24 Hours	365[b]	-	365[b]
		3 Hours	-	1300[b]	1300[b]
Nitrogen Dioxide	µg/m³	Annual	100	100	70
Carbon Monoxide	mg/m³	8 Hours	10[b]	-	5[b]
		1 Hour	40[b]	-	10[b]
Ozone	µg/m³	1 Hour	235[b]	235[b]	100[b]
Lead	µg/m³	Calendar Quarter	1.5	1.5	1.5

[a]Particles less than or equal to 10 microns aerodynamic diameter

[b]Not to be exceeded more than once per year

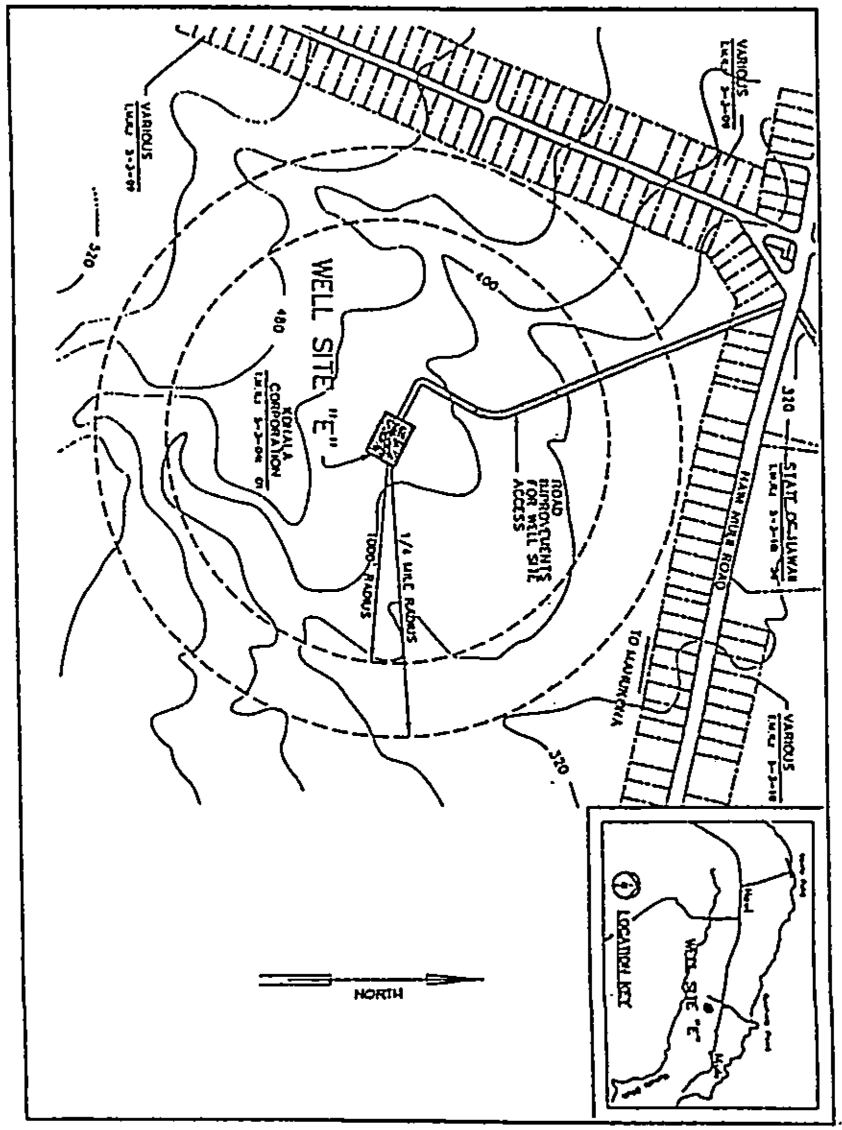


FIGURE 4

DETAILED MAP OF WELL SITE E

Table 3

SIGNIFICANT AIR POLLUTION EMISSION RATES

Air Pollutant	Significant Emission Rate (tons/year)
Carbon Monoxide	100
Nitrogen Oxides	40
Volatile Organic Compounds	40
Sulfur Dioxide	40
Particulate Matter (total)	25
Particulate Matter (<10 microns)	15

Source: Hawaii Administrative Rules, Title 11, Department of Health, Chapter 60, Air Pollution Control

Table 2

POTENTIAL AIR POLLUTION EMISSION ESTIMATES FOR KOHALA WATER TRANSMISSION SYSTEM (T/YR)

Emission Source	Air Pollutant					
	Total Suspended Particulate	Particulate Matter <10 Microns	Carbon Monoxide	Sulfur Dioxide	Nitrogen Oxides	Volatile Organic Compounds
Well Site C						
Generator Unit	2.5	2.5	22.6	7.9	112.4	1.9
Fuel Storage/Handling	-	-	-	-	-	nil
Well Site D						
Generator Unit	2.5	2.5	22.6	7.9	112.4	1.9
Fuel Storage/Handling	-	-	-	-	-	nil
Well Site E						
Generator Unit	2.5	2.5	22.6	7.9	112.4	1.9
Fuel Storage/Handling	-	-	-	-	-	nil

Notes:

1. Assumes Caterpillar Model 3508/820 kW sound-attenuated generator set or equivalent.
2. Emission estimates based on emission data for Caterpillar Model 3508/820 kW and assume 100 percent load and continuous operation.

Table 4

NITROGEN OXIDES EMISSION RATE AND EXHAUST DATA FOR DIESEL GENERATOR UNIT

	Discharge Plenum	Rooftop Stack	GEP Stack
Emission Rate (g/s)	3.24	3.24	3.24
Exhaust Height (m)	3.8	3.8	9.5
Exhaust Diameter (m)	2.2	0.25	0.25
Exhaust Flow Rate (m^3/s)	32.7	3.48	3.48
Exhaust Exit Velocity (m/s)	8.6	68.7	68.7
Exhaust Exit Temperature (°K)	346	825	825

Notes:

1. Assumes Caterpillar Model 3508/820 kW generator set or equivalent.
2. All parameters based on 100 percent load.

Table 5

ESTIMATED MAXIMUM NITROGEN DIOXIDE CONCENTRATIONS FOR INDIVIDUAL DIESEL GENERATOR UNITS

	Discharge Plenum	Rooftop Stack	GEP Stack
1-Hour Average:			
Concentration ($\mu g/m^3$)	3857	3323	134
Distance (m)	30	30	180
Annual Average:			
Concentration ($\mu g/m^3$)	193	166	6.7
Distance (m)	N/A	N/A	N/A

Notes:

1. Based on Caterpillar Model 3508/820 kW generator set or equivalent operating at 100 percent load.
2. Concentrations shown are incremental only, i.e., the increase above existing background levels.
3. N/A indicates not available.

Table 6

ESTIMATED ODOROUS COMPOUND EMISSION RATES AND ODOR THRESHOLDS

Compound	Emission Rate (g/s)	Odor Threshold (mg/m^3)
Napthalene	0.000033	N/A
Alkylbenzenes	0.000011	N/A
Formaldehyde	0.0049	1.2
Benzaldehyde	0.00033	N/A
Crotonaldehyde	0.00071	N/A
Proprionaldehyde	0.0010	0.19
Acetaldehyde	0.0016	0.34
Acrolein	0.0000085	0.34

Note:

Assumes Caterpillar Model 3508/820 kW sound-attenutaed generator set or equivalent operating at 100 percent load.

APPENDIX F

ESTIMATE OF FUTURE WATER NEEDS

ESTIMATE OF SUSTAINABLE YIELDS AND GEOLOGY AND HYDROLOGY OF SELECTED AQUIFER SYSTEMS

Excerpts from DLNR-CWRM
Water Resources Protection Plan
By George A.L. Yuen & Associates, Inc.
Review Draft, March 1992

APPENDIX F
ESTIMATE OF FUTURE WATER NEEDS

South Kohala is the only district in the island where the estimated future water needs are greater than the estimated capacity of the water supply available from sources within the district. The County's Kawaihae-Lalamilo-Puako Water System's service area consists mainly of several large parcels of land. The existing major resorts on these parcels have expansion plans. Other land owners have projects in varying stages of planning. Since the configuration and implementation of these projects are largely dependant on market forces, estimating the amount and timing of their needs are difficult and projections can vary largely over time.

As part of the methodology to obtain future needs, the leeward coast of the northwest Hawaii region was divided into the nine subareas shown in **Figure F-1.** Except for subarea 1) Mahukona in North Kohala and the higher elevation sections of subarea 2) DHHL Kawaihae MPA, the remaining subareas fall within the service area of the County's Kawaihae-Lalamilo-Puako Water System in South Kohala. The Waikoloa area is not included since the needs of that area are serviced by the private Waikoloa Water Company.

The estimated amount and timing of needs for subareas 1, 2, 3, 5, and 6 were obtained from the owners or developers of the subareas. The Department of Water Supply provided the projection for subarea 4, which includes the Kawaihae Harbor and Village vicinities, state lands at Hapuna and lower Lalamilo, and Puako community vicinity. Although there are no defined development plans at this time for subareas 7, 8, and 9, estimates of possible needs are included since they are in areas designated for resort or urban expansion in the County General Plan. The estimates for the subareas are summarized in the table below and discussed in the following pages.

Table F-1 KWTS - FUTURE NEEDS ESTIMATE - Average Day

Sub-Area Pot = Potable Wtr Non-Pot = Non-Potable Wtr	Total		Present		1995-1999		2000-2004		2005-2009		Yr-2010 to Buildout or Unscheduled	
	Pot	Non Pot	Pot	Non Pot	Pot	Non Pot	Pot	Non Pot	Pot	Non Pot	Pot	Non Pot
1) Chalon Mahukona Lodge	0.39	*1.00*			0.28	*1.00*					0.11	
2) DHHL Kawaihae MPA	7.05	*5.04*					1.28		1.86		3.91	*5.04*
3) Mauna Kea/S.Kohala Resort	2.48	1.40	1.02	1.40	0.14		0.07		0.13		1.12	
4) DWS Kawaihae to Puako	0.98	0.65	0.46		0.12		0.14		0.11		0.15	0.65
5) Mauna Lani Resort	3.56	6.00	1.34	3.00	0.70	1.00	0.51	1.00	0.57	1.00	0.44	
6) Nansay Puako Golf Comm.	2.52	3.23			0.75	1.12	0.61	1.04	0.61	1.03	0.55	0.04
7) Tri-Kohala Development	1.00										1.00	
8) Queen Emma Foundation	1.00	1.00									1.00	1.00
9) Lower Lalamilo	1.00										1.00	
Totals Grd Wtr **Totals Surface Irr Wtr**	**19.98**	**12.28** ***6.04***	**2.82**	**4.40**	**1.99**	**2.12** ***1.00***	**2.61**	**2.04**	**3.28**	**2.03**	**9.28**	**1.69** ***5.04***
Cumulative Totals			**2.82**	**4.40**	**4.81**	**6.52**	**7.42**	**8.56**	**10.70**	**10.59**	**19.98**	**12.28**

1) Chalon Hawaii - Mahukona Lodge & Lands

Chalon International of Hawaii, as part of its development plans for the former Kohala Sugar Company lands, is proposing to construct a 240-room lodge, golf course, and agricultural lots at its Mahukona property. Chalon intends to use surface water from its Kohala Ditch to meet the irrigation needs of the lodge and golf course.

Land Use	Total Need	1995-1999 Period Estimate		2000-2004 Period Estimate		2005-2009 Period Estimate		Yr-2010 to Buildout or Unscheduled	
	mgd	acres	mgd	lots	mgd	lots	mgd	lots	mgd
Lodge + Makai Lots	0.280	476	0.280						
Mauka Agri Lots	0.110							110	0.110
G.C.& landscape Irr np->	*1.00*		*1.00*						
Total **Potable Wtr->** *Surface Wtr->*	**0.390** *1.00*		**0.280** *1.00*						**0.110**

2) DHHL Kawaihae Project Area

The Department of Hawaiian Home Lands has completed a long-range master plan to develop its 10,000 acre Kawaihae tract. The first 10-year plan calls for development of 2115 acres of the tract immediately above the Akoni Pule Highway. The proposed Kohala Water Transmission System is seen as the best potable water source alternative for the Kawaihae DHHL project. The County is working with DHHL to seek funds to participate in the project. In the interim, the DHHL is negotiating a short term arrangement to obtain water from the Kohala Ranch water system. The full potable water requirement of the DHHL project is included for estimate purpose although the time schedule for the development of the full project is not definite.

Land Use	Total Need	1995-1999 Period Estimate		2000-2004 Period Estimate		2005-2009 Period Estimate		2010 plus or unscheduled	
	mgd	lots	mgd	lots	mgd	lots	mgd	lots	mgd
Low / med residential	2.177			1,440	0.634	2,056	0.870	1626	0.673
Agr / rural residential	2.298							2610	2.298
Agr/GC - irrigation water	*5.040*								*5.040*
Community Center	1.550			8 ac	0.024	162 ac	0.590	242ac	0.936
Industrial / Business	1.022			161 ac	0.621	104 ac	0.401		
Total **Potable Wtr->** *Irrigation Wtr->*	**7.047** *5.040*				**1.279**		**1.861**		**3.907** *5.040*

3) Mauna Kea Beach & South Kohala Resort

The Mauna Kea Beach Resort is one three major beach-front resorts on the Kohala coast. It currently has two hotels, three fairway residential projects, and two golf courses with clubhouse and other facilities. The resort's expansion plan visualizes single and multiple family residential developments and agricultural lots for the remainder of its lands. The resort utilizes non-potable brackish water from its own well sources and effluent from its STP for golf course irrigation.

Land Use	Total Need	1995-1999 Period Estimate		2000-2004 Period Estimate		2005-2009 Period Estimate		Yr-2010 to Buildout or Unscheduled	
	mgd	Exist	mgd	units	mgd	unit	mgd	units	mgd
Exist facilities + SF/MF	1.025								
SF residential	0.379	112	0.139	45	0.072			105	0.168
MF residential	0.365					125	0.125	240	0.240
Recr Ctr / Commercial	0.030								*0.030*
Upland SF	0.520							400	0.520
Upland Agr	0.160							100	0.160
G.C.& landscape irri np->	*1.404*								
Total **Potable Wtr->** *Brackish wtr->*	**2.479** *1.404*	**1.025** *1.404*	**0.139**		**0.072**		**0.125**		**1.118**

4) DWS-Kawaihae Harbor & Village, Hapuna Park & GC, Puako

The Puako and Kawaihae Village areas are supplied with potable water from this system. The future needs of the State's Kawaihae Harbor and Hapuna Park development plans are also included in this group. The proposed Kawaihae Elementary and Intermediate Schools' needs are included in the DHHL Kawaihae MPA project estimates. Although Mauna Kea and Mauna Lani resorts currently draw their potable water from this system, their current and future need requirements are accounted for in their own projections. (See Sub-area 7 for lower Lalamilo estimate.)

Land Use	Total Need	1995-1999 Period Estimate		2000-2004 Period Estimate		2005-2009 Period Estimate		Yr-2010 to Buildout or Unscheduled	
	mgd	Exist	mgd		mgd		mgd		mgd
ExisDWS less resorts, DOT	0.420	0.420							
DWS miscellaneous	0.040		0.010		0.010		0.010		0.010
Puako resort parcels	0.260		0.060		0.060		0.070		0.070
State DOT harbors	0.230	0.040	0.048		0.066		0.038		0.038
Hapuna Beach Park MP	0.036							0.650	0.036
Total **Potable Wtr->** *Hapuna Brackish wtr->*	**0.976** *0.650*	**0.460**	**0.118**		**0.136**		**0.118**	*0.650*	**0.154**

5) Mauna Lani Resort

The Mauna Lani Resort is one of three resorts that make up the existing South Kohala resort complex, along with the Mauna Kea Beach and Waikoloa Beach. It currently has two major hotels, two golf courses, a racquet club, several fairway residential projects and multiple family residential projects, and related support facilities. The resort's expansion plans include additional golf courses and single family and multiple family residential units. The resort will utilize non-potable brackish water from its own wells for golf course irrigation.

Land Use	Total Need	1995-1999 Period Estimate		2000-2004 Period Estimate		2005-2009 Period Estimate		Yr-2010 to Buildout or Unscheduled	
	mgd	unit	mgd	unit	mgd	unit	mgd	unit	mgd
Exist facilities + SF/MF	1.336								
Hotel	0.420	175	0.210			175	0.210		
SF residential	0.338	25	0.113	25	0.113	25	0.112		
MF residential	1.437	150	0.375	150	0.375	100	0.250	175	0.437
Commercial / Other	0.025			5	0.025				
Existing G.C. I & II	*2.000*								
New G.C. III, IV, V	*3.000*	1	*1.000*	1	*1.000*	1	*1.000*		
Total **Potable Wtr->** *Brackish Wtr->*	3.556 *5.000*		0.698 *1.000*		0.513 *1.000*		0.572 *1.000*		0.437

6) Nansay-Puako Residential Golf Community

Nansay Hawaii's Puako residential golf community proposes to have six golf courses (each with its own clubhouse and support facilities), a golf academy and fairways, and over 1800 single family residential units. Nansay plans to utilize non-potable brackish water from its own wells for golf course and landscape irrigation.

Land Use	Total Need	1995-1999 Period Estimate		2000-2004 Period Estimate		2005-2009 Period Estimate		Yr-2010 to Buildout or Unscheduled	
	mgd	unit	mgd	unit	mgd	unit	mgd	unit	mgd
Golf academy	0.132		0.132						
Club house, gc maint fac	0.201		0.067		0.067		0.067		
SF / MF residential	2.192	665	0.548	665	0.548	665	0.548	665	0.548
G.C.+ other irri *np Wtr->*	*3.227*		1.120		1.040		1.033		0.034
Total **Potable Wtr->** *Brackish Wtr->*	2.525 *3.227*		**0.747** *1.120*		**0.615** *1.040*		**0.615** *1.033*		**0.548** *0.034*

7) **Tri-Kohala Parcel**

The land owners are currently reviewing their development options. The parcel is located in an area designated for urban expansion in the County General Plan. Since the lower section has G.P. designated lands the amount shown below has been included in the unscheduled period for estimating purposes. Estimates made after plans are prepared may vary largely.

Land Use	Total Need	1995-1999 Period Estimate		2000-2004 Period Estimate		2005-2009 Period Estimate		Yr-2010 to Buildout or Unscheduled	
	mgd	unit	mgd	unit	mgd	unit	mgd	unit	mgd
Potable Wtr->	**1.000**								**1.000**

8) ***Queen Emma Foundation Land***

The Queen Emma Foundation has two large parcels in Kawaihae. The Foundation recently gained control of the makai parcel and is currently reviewing its options for future use of the lands. The County General Plan designates the lower part of the makai parcel for a mix of urban expansion, industrial, resort and open space land uses. The upper part of the makai parcel and the mauka parcel are designated for extensive and intensive agricultural land uses. Since the lower parcel has G.P. designated lands the amounts shown below have been included in the unscheduled period for estimating purposes. Estimates made after plans are prepared may vary largely.

Land Use	Total Need	1995-1999 Period Estimate		2000-2004 Period Estimate		2005-2009 Period Estimate		Yr-2010 to Buildout or Unscheduled	
	mgd	unit	mgd	unit	mgd	unit	mgd	unit	mgd
Potable Wtr->	**1.000**								**1.000**
Brackish Wtr->	*1.000*								*1.000*

7) **Lower Lalamilo**

The State's West Hawaii Regional Plan shows a portion of its lower Lalamilo lands as a proposed support community. The County's General Plan designates an area within the Lalamilo lands for urban expansion. The Northwest Hawaii Open Space and Community Development Plan-Review Draft recommends a planned community on the Lalamilo lands. Because of these planning proposals an amount has been included in the unscheduled period to indicate a potential future need in this land tract. Estimates made after plans are prepared may vary largely.

Land Use	Total Need	1995-1999 Period Estimate		2000-2004 Period Estimate		2005-2009 Period Estimate		Yr-2010 to Buildout or Unscheduled	
	mgd	unit	mgd	unit	mgd	unit	mgd	unit	mgd
Potable Wtr->	**1.000**								**1.000**

NORTH AND SOUTH KOHALA (WORKSHEET)
RECONCILIATION OF ESTIMATES FOR FIGURE 2.2-2 AND TABLE F-1

Avg Day Demand
kwts:B03075

Aquifer System	District		Potable Water	Potable Water	NonPot Water	Combined Total		
80101	5NKoh	grd		3.25		3.25		DWS/Chalon NK Plan less Mahukona
80101	5NKoh	grd		0.63		0.63		DWS/Existing county systems
80101	5NKoh	grd	0.39			0.39		DWS/Chalon Mahukona Dev Plan
Sub-total for Hawi 80101			0.39	3.88		4.27		
			->	0.39				
Total for Fig. 2.2-2 Hawi 80101				4.27		4.27		
80301	6SKoh	grd	3.14			3.14		DWS/HHL Kawaihae MP (10 Yr)
80301	6SKoh	grd	3.91			3.91		DWS/HHL Kawaihae MP (10+Yr)
80301	6SKoh	grd	2.48			2.48		Priv(DWS?)/P-Mauna Kea Prop
80301	6SKoh	grd	0.98			0.98		DWS/Kawaihae Puako System
80301	6SKoh	grd	3.56			3.56		Priv(DWS?)/P-Mauna Lani Resort
80301	6SKoh	grd	2.52			2.52		Priv(DWS?)/P-Nansay Puako
80301	6SKoh	grd	1.00			1.00		Priv(DWS?)/P-Tri Kohala
80301	6SKoh	grd	1.00			1.00		Priv(DWS?)/P-Queen Emma
80301	6SKoh	grd	1.00			1.00		DWS/State-Lower Lalamilo
Sub-total for Waimea 80301			19.59			19.59		
80301	6SKoh	grd/NP			0.65	0.65		State/NP-Hapuna GC
80301	6SKoh	grd/NP			1.40	1.40		Priv/NP-Mauna Kea Prop GC
80301	6SKoh	grd/NP			1.00	1.00		Priv/NP-Queen Emma GC
Sub-total for Waimea 80301					3.05	3.05		
80701	6SKoh	grd/NP			6.00	6.00		Priv/NP-Mauna Lani Resorts GC
80701	6SKoh	grd/NP			3.23	3.23		Priv/NP-Nansay (Puako GC)
Sub-total for Anaehoomalu 80701					9.23	9.23		
Total for Table F-1, Appendix F			19.98		12.28	32.26		
From Sub-total for Waimea 80301			19.59			19.59		
From Sub-total for Waimea 80301					3.05	3.05		
From Sub-total for Anaehoomalu 80701					9.23	9.23		
Add Waikoloa Res/Vill and Nansay Ouli:								
80301	6SKoh	grd	0.74			0.74		Priv(DWS?)/P-Nansay Ouli
80301	6SKoh	grd	16.05			16.05		Priv/P-Waikoloa Resort/Village
80301	6SKoh	grd/NP			0.70	0.70		Priv/NP-Waikoloa HLGC
80701	6SKoh	grd/NP			2.80	2.80		Priv/NP-Waikoloa Res/Village GC
Total for S.Kohala coast properties			36.38	0.00	15.78	52.16	52.16	
From Sub-total for Waimea 80301			19.59			19.59		
From Sub-total for Waimea 80301					3.05	3.05		
Add Waikoloa Res/Vill and Nansay Ouli:						0.00		
80301	6SKoh	grd	0.74			0.74		Priv(DWS?)/P-Nansay Ouli
80301	6SKoh	grd	16.05			16.05		Priv/P-Waikoloa Resort/Village
80301	6SKoh	grd/NP			0.70	0.70		Priv/NP-Waikoloa HLGC
Total for Fig. 2.2-2 Waimea 80301			36.38		3.75	40.13	40.13	
80701	6SKoh	grd/NP			6.00	6.00		Priv/NP-Mauna Lani Resorts GC
80701	6SKoh	grd/NP			3.23	3.23		Priv/NP-Nansay (Puako GC)
80701	6SKoh	grd/NP			2.80	2.80		Priv/NP-Waikoloa Res/Village GC
Total for Fig. 2.2-2 Anaehoomalu 80701					12.03	12.03	12.03	
80103	6SKoh	grd	1.60			1.60		Priv/P-Kohala Joint Venture
80103	6SKoh	grd		1.50		1.50		Priv/NP-Kohala Joint Venture GC
Total for Fig. 2.2-2 Mahukona 80103						3.10		

NORTH AND SOUTH KOHALA (WORKSHEET)
DISTRICT SUMMARIES – ESTIMATES OF FUTURE WATER NEEDS

Avg Day Demand
kwts:B03075

Aquifer	District	Source	Muni	AgrIrr	PrivDCI	Others	Military	Total	Comments	
NORTH KOHALA DISTRICT										
80101	5NKoh	grd	0.16					0.16	DWS/Kaauhuhu Kokoiki Sys	
80101	5NKoh	grd	0.15					0.15	DWS/Halawa Halaula Sys	
80101	5NKoh	grd	0.32					0.32	DWS/Hawi Koko Kynn Kapaau Sys	
80101	5NKoh	grd	3.64					3.64	DWS/Chalon Development Plan	
Total 80101 – Hawi SY=27			4.27	0.00	0.00	0.00	0.00	4.27		
80102	5NKoh	surf		8.00	3.00	9.00		20.00	Priv/Chalon (KD–agri,GC,hydro)	
80102	5NKoh	surf			1.00			1.00	Priv/Kahua Ranch	
Total 80102 – Waimanu SY=110			0.00	8.00	4.00	9.00	0.00	21.00		
80103	5NKoh	grd			1.60			1.60	Priv/Kohala Joint Venture	
80103	5NKoh	grd/NP			1.50			1.50	PrivNP/Kohala Joint Venture (GC)	
Total 80103 – Mahukona SY=17			0.00	0.00	3.10	0.00	0.00	3.10		
								28.37		28.37
Total Grd Wtr–Pot			4.27	0.00	1.60	0.00	0.00	5.87		5.87
Total Grd Wtr–NPot			0.00	0.00	1.50	0.00	0.00	1.50		1.50
Total Grd Wtr			4.27	0.00	3.10	0.00	0.00	7.37		7.37
Check			4.27	0.00	3.10	0.00	0.00	7.37		
Total Surf Wtr			0.00	8.00	4.00	9.00	0.00	21.00		21.00
Total Grd+Surf Wtr			4.27	8.00	7.10	9.00	0.00	28.37		28.37
Check			4.27	8.00	7.10	9.00	0.00	28.37		
% of Total G+S			15.1%	28.2%	25.0%	31.7%	0.0%	100.0%		
SOUTH KOHALA DISTRICT										
80102	6SKoh	surf	1.48					1.48	DWS/Waimea Puukapu System	
80102	6SKoh	surf	0.17					0.17	DWS/HHL Puukapu Farm Lots	
80102	6SKoh	surf	0.02					0.02	DWS/SandlewoodWaimea	
80102	6SKoh	surf			2.00			2.00	Priv/Parker (ind,,agri)	
80102	6SKoh	surf		11.12				11.12	State/Waimea Irr System	
80102	6SKoh	surf		5.04				5.04	State/HHL Kawaihae MP (10+Yr)	
80102	6SKoh	grd	0.72					0.72	DWS/Parker 2020 Plan Well	
80102	6SKoh	grd		1.25				1.25	State/Waimea Irr Sys Well	
Total 80102 – Waimanu SY=110			2.39	17.41	2.00	0.00	0.00	21.80		
80301	6SKoh	grd	0.98					0.98	DWS/Kawaihae Puako System	
80301	6SKoh	grd	3.14					3.14	DWS/HHL Kawaihae MP (10 Yr)	
80301	6SKoh	grd	3.91					3.91	DWS/HHL Kawaihae MP (10+Yr)	
80301	6SKoh	grd	1.00					1.00	DWS/State–Lower Lalamilo	
80301	6SKoh	grd	0.74					0.74	Priv(DWS?)/P–Nansay Ouli	
80301	6SKoh	grd	1.00					1.00	Priv(DWS?)/P–Queen Emma	
80301	6SKoh	grd	1.00					1.00	Priv(DWS?)/P–Tri Kohala	
80301	6SKoh	grd	2.52					2.52	Priv(DWS?)/P–Nansay Puako	
80301	6SKoh	grd	2.48					2.48	Priv(DWS?)/P–Mauna Kea Prop	
80301	6SKoh	grd	3.56					3.56	Priv(DWS?)/P–Mauna Lani Resort	
80301	6SKoh	grd			16.05			16.05	Priv/P–Waikoloa Resort/Village	
80301	6SKoh	grd/NP	0.65					0.65	State/NP–Hapuna GC	
80301	6SKoh	grd/NP			1.40			1.40	Priv/NP–Mauna Kea Prop GC	
80301	6SKoh	grd/NP			1.00			1.00	Priv/NP–Queen Emma GC	
80301	6SKoh	grd/NP			0.70			0.70	Priv/NP–Waikoloa HLGC	
Total 80301 – Waimea SY=24			20.98	0.00	19.15	0.00	0.00	40.13		
80701	6SKoh	grd/NP			6.00			6.00	Priv/NP–Mauna Lani Resorts GC	
80701	6SKoh	grd/NP			2.80			2.80	Priv/NP–Waikoloa Res/Village GC	
80701	6SKoh	grd/NP			3.23			3.23	Priv/NP–Nansay (Puako GC)	
Total 80701 – Anaehoomalu SY=30			0.00	0.00	12.03	0.00	0.00	12.03		
								73.96		73.96
Total Grd Wtr–pot			21.05	1.25	16.05	0.00	0.00	38.35		38.35
Total Grd Wtr–NPot			0.65	0.00	15.13	0.00	0.00	15.78		15.78
Total Grd Wtr			21.70	1.25	31.18	0.00	0.00	54.13		54.13
Check			21.70	1.25	31.18	0.00	0.00	54.13		
Total Surf Wtr			1.67	16.16	2.00	0.00	0.00	19.83		19.83
Total Grd + Surf Wtr			23.37	17.41	33.18	0.00	0.00	73.96		73.96
Check			23.37	17.41	33.18	0.00	0.00	73.96		
% of Total G+S Wtr			31.6%	23.5%	44.9%	0.0%	0.0%	100.0%		

V. INVENTORY AND ASSESSMENT OF RESOURCES

AQUIFER CLASSIFICATION

In the Hawaiian Islands, the occurrence of groundwater resources is highly variable in extent and type. Aquifers range from being quite limited in size to being very extensive, and from being isolated to being connected with other aquifers. The variety of aquifer types is great in which groundwater ranges from unconfined in sedimentary deposits to confined in basal lenses resting on seawater. This array of aquifer types and groundwater occurrences cannot be sensibly incorporated into hydrographic divisions based on topography or political boundaries. Because groundwater is the premium water resource in the State, classification based on aquifer and groundwater parameters is desirable.

A consistent scheme of classification and nomenclature for the aquifers of the State of Hawaii has been created to assist in planning studies. The effort was initiated several years ago by the State DOH in response to U.S. Environmental Protection Agency directives and is being formulated by the Water Resources Research Center of the University of Hawaii.

Aquifer classification starts with an island as the largest component in the hierarchy, following by Aquifer Sectors and Aquifer Systems. Eventually Aquifer Types and Aquifer Units will be identified, but for general planning purposes, the Sector-System categories are sufficient.

Each island is divided into Aquifer Sectors which reflect broad hydrogeological similarities yet maintain traditional hydrographic, topographic and historical boundaries where possible. Aquifer Systems are more specifically defined by hydraulic continuity among aquifers in the System.

Each island is identified by its USGS number (1=Niihau, 2=Kauai, 3=Oahu, 4=Mokolai, 5=Lanai, 6=Maui, 7=Kahoolawe, and 8=Hawaii) as the first digit in the Aquifer Code, followed by two digits for an Aquifer Sector, followed by two more digits for an Aquifer System. Sectors and Systems are also assigned names. Hawaiian place names are preferred, but for some Sectors geographic orientation such as North, East, South, West, Central and Windward are required for clarity. All Aquifer Systems have Hawaiian names.

Simplified maps of Aquifer Sectors and Systems in the principal Hawaiian Islands are shown on the following pages. Detailed maps are included in the Appendix.

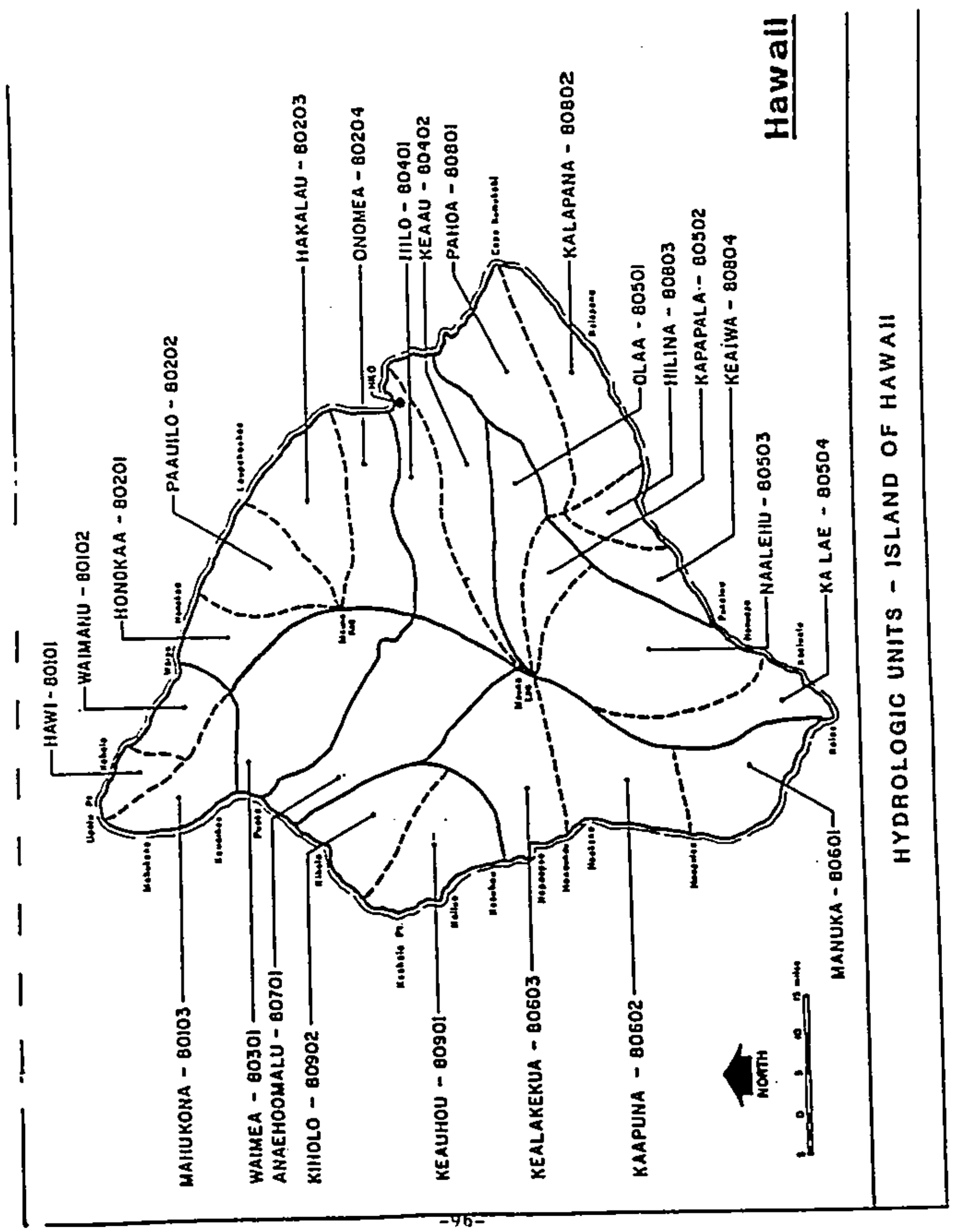
SUSTAINABLE YIELD - METHODOLOGY OF DETERMINATION

"Sustainable Yield" refers to the forced withdrawal of groundwater at a rate that could be sustained indefinitely without affecting either the quality of the pumped water or the rate of pumping. This definition was created in Hawaii in response to the need to protect the utility of groundwater resources. It is especially applicable to island environments where aquifers are small and salinity is a constant threat.

The word "sustainable" is used because exploiting groundwater is like exploiting the product of a natural living system, such as a forest. In order to sustain production in a forest a balance must be established among input (planting and seeding), growth, harvesting and natural mortality. In the case of an aquifer, infiltration from atmospheric moisture and subsurface inflow from other sources is the input; accumulation of water in the saturated zone is growth; harvesting is removal of groundwater by pumping or other artificial means; and discharge is equivalent to natural mortality.

Other terms are often employed to convey a meaning similar to sustainable yield, but they lack comprehensiveness in definition. The terms "dependable yield" and "safe yield", for instance, are common but imprecise synonyms for sustainable yield; each lacks a clear appreciation of the time constraint. Both dependable yield and safe yield often are used to refer to a yield which is possible only for the period during which the water will be needed, while in other instances the definitions are broadened to refer to continuous draft for an indefinite period. The definition of sustainable yield, on the other hand, unequivocally incorporates infinite time as a fundamental condition.

In Hawaii, sustainable yield has become the governing concept by which exploitation of groundwater is permitted and practiced because groundwater in the most voluminous aquifers rests on sea water. Should a judicious balance among input, the volume of water stored in the aquifer, draft and natural leakage not be established, salinization of pumped water will eventually take place when draft exceeds sustainable yield. The concept is also applicable where salt water is not a threat. In that case, dewatering is the problem.



HAWAII
Estimated Sustainable Yields by Aquifer Sectors

Sector	System	Code	A(sq.mi)	P(in/yr)	SY(mgd)	h(0)
Kohala	Hawi	80101	56.95	68	27	5
Kohala	Waimanu	80102	69.95	144	110	HL
Kohala	Mahukona	80103	113.91	25	17	4
		Total:	240.81		154	
E.MaunaKea	Honokaa	80201	105.82	57	31	5
E.MaunaKea	Paauilo	80202	150.16	64	60	5
E.MaunaKea	Hakalau	80203	166.72	143	150	7
E.MaunaKea	Onomea	80204	180.35	157	147	7
		Total:	603.05		388	
W.MaunaKea	Waimea	80301	282.14	18	24	5
		Total:	282.14		24	
NE.MaunaLoa	Hilo	80401	193.73	134	347	7
NE.MaunaLoa	Keaau	80402	207.27	140	393	7
		Total:	401.00		740	
SE.MaunaLoa	Olaa	80501	129.51	88	124	7
SE.MaunaLoa	Kapapala	80502	83.50	47	19	7
SE.MaunaLoa	Naalehu	80503	352.00	60	117	5
SE.MaunaLoa	KaLae	80504	134.77	44	31	4
		Total:	699.78		291	
SW.MaunaLoa	Manuka	80601	167.26	49	42	4
SW.MaunaLoa	Kaapuna	80602	241.76	42	50	4
SW.MaunaLoa	Kealakekua	80603	226.75	33	38	4
		Total:	635.77		130	
NW.MaunaLoa	Anaehoomalu	80701	291.01	23	30	5
		Total:	291.01		30	
Kilauea	Pahoa	80801	222.00	144	435	7
Kilauea	Kalapana	80802	193.36	81	157	5
Kilauea	Hilina	80803	59.24	29	9	5
Kilauea	Keaiwa	80804	89.99	38	17	4
		Total:	564.59		618	
Hualalai	Keauhou	80901	166.72	45	38	5
Hualalai	Kiholo	80902	146.22	25	18	5
		Total:	312.94		56	
		Total:	4,031.09		2,431	

RO

D. Sustainable Yield Determination

The sustainable yield balance equation is simply stated: For an aquifer in equilibrium, the average rate of water input to the system must be equal to the sum of the average rate of withdrawal and a natural rate of discharge. In an aquifer not undergoing exploitation, the average rate of input will equal the average rate of discharge, and the average volume of storage in the aquifer will be constant. In the real world, of course, the averages are statistical abstractions of continuously varying rates within a range of probabilities.

For aquifers with large storage, the allowable range for the rates and the length of time they persist is obviously greater than for a small system. For example, a severe drought lasting for months may have a minor effect on a voluminous aquifer while it might be catastrophic to a small one. Similarly, the effect of excessive pumping over lengthy intervals in a voluminous basal aquifer may not induce salt water to rise as high as the pump intake whereas in a thin lens the well would easily become salinized.

The components of the elementary balance equation for the steady state are:

$$I(av) = D(av) + L(av)$$

in which I(av) is average input, obtained from the hydrologic budget; D(av) is average rate of draft; and L(av) is average rate of leakage. In this balance, D(av) must be less than I(av). The leakage is governed by the gravity potential, or head, in the system. The common datum against which head is measured in Hawaii is mean sea level because of the preponderance of basal aquifers in which fresh to brackish groundwater floats on sea water as a result of density differences.

To establish the sustainable yield of an aquifer, the dynamic and equilibrium states of the aquifer must be understood. The history of the response of an aquifer to exploitation by means of wells and infiltration galleries, augmented by pumping tests to determine the characteristics of the aquifer medium, allows the dynamics of groundwater behavior to be completely described and future behavior to be predicted. This type of fundamental knowledge, however, is available for only a few aquifer systems in the State, in particular in Oahu and West Maui. Elsewhere, the record of aquifer response over time is sporadic and fragmentary.

In the absence of a reliable history of the dynamics of an aquifer, hydrologic budgeting must be employed to provide a general balance relating continuity between inflows and outflows. Hydrologic budgets are broad approximations of water balances and are colored by variability among investigators in interpreting the data. An exhaustive hydrologic budget determined by an apparently logical line of reasoning may differ significantly from an equally exhaustive budget employing the same data base but relying on a different but similarly logical interpretation of the data. In contrast, a record of the dynamical response of a groundwater body to natural and imposed stresses can be described in terms of the classical laws of hydraulics from which future behavior can be predicted.

Nevertheless, most quantifications of groundwater occurrence depend on hydrologic budgeting because data bases of aquifer response are insufficiently long in time or broad in content to permit reliable interpretation of groundwater behavior. The sustainable yields for all Aquifer Systems in the State of Hawaii, with the exception of those in southern Oahu, Koolauloa in Oahu, and West Maui, are derived from hydrologic budgets. In Oahu and West Maui, budgeting is joined with aquifer response to seasonal changes and pumping stresses for modeling groundwater behavior.

To accommodate the great variety of hydrological environments in the islands, standardizations have to be made in the assignment of values to budget components. The result is a basic balance algorithm that is applicable, with some allowance for local conditions, to all Aquifer Systems.

The fundamental water balance is expressed as:

$$P = Q + ET + I$$

in which P is rainfall (or rainfall and fog drip in certain areas), Q is stream runoff, ET is actual evapotranspiration and I is deep infiltration to a saturated aquifer. The variables P, Q, and ET are either measured or approximated, while I is the unknown.

In the above, Q includes all water which leaves the Aquifer System as stream flow, including both direct overland flow and groundwater seepage. The infiltration component (I) is water that does not re-emerge as surface flow but continues downward to the zone of saturation. The sustainable yield depends upon, but is not equal to, infiltration, also called recharge.

In Hawaii, high-level groundwater discharges into stream channels and wetlands to become surface water. To account for this phenomenon, the balance equation is written as:

$$P = Q(DRO) + Q(GW) + ET + I$$

in which Q(DRO) is direct runoff and Q(GW) is the groundwater component of stream flow. Perennial streams are sustained by groundwater seepage, which constitutes base flow. The fraction of total flow attributed to groundwater seepage is the 90 percentile flow (90 percent of the time the flow is equal to or greater than the given flow).

The value of runoff and how it is divided into the two principal components is the most unreliable part of the balance equation for those regions where rainfall and recharge are high. A large data base of stream flow records exist, providing accurate runoff values in the whole or portions of drainage basins, but reliable extrapolation of the records are restricted to ungaged basins that are environmentally similar to gaged basins.

Evapotranspiration (ET) values, on the other hand, fall within a narrow range in high rainfall regions which supply most of the recharge to groundwater bodies. In dry leeward areas, potential ET is 70 to 80 inches per year, but here rainfall is insufficient to satisfy this high rate. Actual ET is thus a function of available moisture. In high rainfall areas, potential ET is considerably less than in the warm, arid leeward lowlands.

In each area, estimates of actual ET are restricted to a narrow range. The error band is no wider than 10 inches per year, which in high rainfall areas does not seriously distort the balance equation. In low rainfall areas, ET accounts for the major fraction of rainfall input.

Rainfall has been recorded in Hawaii for more than a century, but even for this easily measured variable, volume determinations are questionable in wet areas because of the scarcity of gages in the rugged terrain and the extraordinary gradient of the isohyets. Depending on how the isohyets are drawn in areas where no gages exist, enormous volumes of water can be either assigned or denied to a drainage basin.

Input and draft may be made time dependent, giving the simple transient equation:

$$I(t) = D(t) + f(h)$$

where f(h), or function of head, replaces leakage, L. This mass balance combined with Darcy's Law, the fundamental relationship defining hydraulic flow in porous media, leads to the sustainable yield equations.

Sustainable yield is not a fixed value but depends on the equilibrium of the state of the system at which neither the quality nor the quantity of water pumped degrades over time. Thus there is a maximum possible sustainable yield constrained by an equilibrium head that is lower than any other head. At a higher equilibrium head, a lesser value of sustainable yield would result. For example, a system in which the lowest equilibrium head meeting the conditions of the sustainable yield definition is 5 feet will allow a greater draft than if 10 feet were selected as the equilibirum head.

The choice of equilibrium head may be constrained by factors other than hydraulics, in particular the location and depth of extracting units. As an example, to guarantee that poorly placed and designed wells already pumping from a basal lens will continue to be useful, the selected equilibrium head must be higher than the one that would optimize draft if all wells were perfectly designed and sited.

Sustainable yield, of course, is never equal to the rate of recharge. If sustainable yield and recharge were equivalent, which is a common assumption in hydrologic budgeting, the head and volume would go to zero because positive head would continue to force leakage. Extraction of as much water as is recharged would permit the storage volume in the aquifer to dissipate. It is therefore axiomatic that average allowable draft must always be less than average input for the system to survive.

Sustainable yield treats an aquifer as a whole unit and is computed from an elementary equation, which is:

$$D = I\{1 - (h/H)^{2}\}$$

in which D is allowable average draft, equivalent to sustainable yield; I is average input to the aquifer; h is the equilibrium head, which is chosen to maximize output; and H is the original head before draft started. This equation applies to an aquifer having at least one free surface, such as an unconfined aquifer with a phreatic upper surface, an unconfined basal lens with two free surfaces (the upper one phreatic and the lower one the interface between fresh and salt water), or a basal lens confined from above but having a free interface surface.

If the aquifer is bounded both above and below, and the thickness of the saturated zone is the vertical distance between these boundaries, the applicable equation is:

$$D = I\{1 - (h/H)\}$$

These equations are global, that is, they combine continuity with hydraulic flow in an entire system and assume that extraction is uniformly distributed. They do not reflect behavior at the local level of the pumping site. For this fine discrimination the equations of well hydraulics are required, or numeric modeling. Nevertheless, the computed sustainable yield, or allowable average draft, is the amount of water that can be extracted at a given equilibrium head by means of units which are optimally located and designed.

The use of the sustainable yield equation can be illustrated by employing it in reference to an aquifer with at least one unconfined surface, a common condition in southern Oahu where caprock along the coast confines the aquifer from above. In the Nuuanu Aquifer System of Honolulu the original head was 42 feet, and the current head maintained by the Honolulu Board of Water Supply is approximately 22 feet.

Thus the allowable draft, or sustainable yield, is equal to 73 percent of the average input. Average recharge to this Aquifer System is about 20 mgd while average draft is 15 mgd, about the same as allowable draft for the equilibrium head. The Aquifer System has been in equilibrium for many years.

Thinner basal lenses would not allow the extraction of as large a percentage of input as in the thick Nuuanu Aquifer. A typical Ghyben-Herzberg lens without a caprock to inhibit outflow along the coast might have an initial head of 5 feet several miles inland. If experience indicates that fresh water is not developable when the head is less than 3.5 feet, then the maximum sustainable yield of the System would be just 49 percent of the recharge.

The head ratio used to obtain sustainable yield is based on experience with known aquifers, such as those of Honolulu and southern Oahu. Sustainable yields are calculated from the following:

H Range (ft)	h/H	D/I
4 - 10	0.75	0.44
11 - 15	0.70	0.51
16 - 20	0.65	0.58
21 - 25	0.60	0.64
>26 and HL	0.50	0.75

in which H is initial head before groundwater exploitation started, h is the selected equilibrium head, D is allowable draft, I is average input to the aquifer, and HL is high-level aquifers. Many initial heads have had to be estimated because of the absence of information.

The estimates are limited to basal aquifer conditions except where high-level groundwater is dominant or reaches to the coast. The typical sequence of aquifers in the Hawaiian Islands is from a zone of high-level water in mountainous regions to a basal aquifer terminating either at the coast or beneath caprock some distance off the coast. Groundwater in the high-level aquifers passes into basal aquifers. Where groundwater is removed directly from a high-level source, the sustainable yield calculated for the basal aquifer must be reduced.

Sustainable yield is a fundamental tool for managing groundwater resources. The yields are estimated both through hydrologic budgeting and analyses of groundwater response to exploitation. Yet even after more than a century of extensive groundwater development in the islands, only in southern Oahu and West Maui do we have an accurate appreciation of groundwater behavior. In these sectors the excellent records of rainfall, evapotranspiration, stream flow and aquifer behavior in response to pumping have provided a reliable framework for computing hydrological balances and creating analytical and numerical models.

The estimates of sustainable yield are not meant to be an exact number which could be used in final planning documents. The estimates are constrained not only by the scanty data base but also by the fact that they do not consider the feasibility of developing the groundwater. The estimates should not be equated to developable groundwater. In many regions, taking advantage of a high estimate would not be economically feasible.

Considerations restricting the unqualified use of the sustainable yield estimates are as follows:

1. The estimate is computed by the water balance method for pre-development conditions except in the case of leeward Oahu. This means that transfer of water from one Aquifer System to another for irrigation is not taken into account in the System affected by recharge from surplus irrigation.

2. The sustainable yield is correlated with an equilibrium head chosen on the basis of experience in the islands. The experience may not be relevant to a given aquifer, however. An equilibrium head higher than the one selected would result in a lower sustainable yield and the converse would be true for a smaller equilibrium head.

3. Assumptions about the state of an aquifer may be faulty, in particular for the initial head.

4. Sustainable yield is calculated as the total supply developable. In most cases the estimate would be potable where optimal extraction techniques were employed, but in some instances none of estimate would be potable.

5. The sustainable yield estimate should not be equated to feasibly developable water, either technically or economically.

In view of the above limitations, the sustainable yield estimates should be used as a guide in planning rather than as an inflexible constraint.

A discussion of sustainable yields for each Aquifer Sector and System in all islands except Niihau and Kahoolawe follows. Tables of basic data and a discussion of the method employed in determining the estimates are included in the Appendix.

HAWAII

AQUIFER SYSTEM SUSTAINABLE YIELDS

Aquifer Sector: Kohala

Aquifer System: Hawi(80101)

Most of the region contains basal groundwater in the basement rock of the Pololu volcanic series. The coast is rocky and is not rimmed with a sedimentary caprock. High level dike water extends in a band about two miles wide reaching toward the coast from the crest of the Kohala Mountains. Perched high level groundwater occurs in the andesitic rocks of the Hawi volcanics which mantle the Pololu inland.

The estimated sustainable yield of 27 mgd refers to the basal lens and is fairly reliable. Groundwater exploration is underway in the System.

Aquifer System: Waimanu(80102)

The System embraces the canyons and gulches which cut deeply into the Pololu series to drain high level water from the rift zone of the Kohala Mountains. Most of the high level water is impounded between dikes; some drains from perching members in the Hawi volcanics. Basal groundwater in the Pololu series reaches a mile or two inland of the coast. Its flow is not impeded by caprock.

The estimated sustainable yield of 110 mgd assumes that none of the groundwater drains to streams and all is developable. Much of the estimate is already diverted by the Upper and Lower Hamakua Ditches, and the Kohala Ditch system. The estimate is speculative, but undoubtedly a very large quantity of groundwater is developable.

Aquifer System: Mahukona[80103]

Basal and high level dike water occurs in the Pololu basalt along with along with a small amount of perched water in the overlying Hawi volcanics. High level water may reach as far as two miles seaward of the Kohala Mountains crest in the mid section of the System. Basal groundwater may be potable two or more miles inland but brackish toward the coast. Groundwater discharges freely at the coast because no caprock is present.

The estimated sustainable yield of 17 mgd assumes that groundwater is taken far enough inland to be potable. The estimate is poor to fair.

Aquifer Sector: West Mauna Kea

Aquifer System: Waimea[80301]

A basal aquifer in the Hamakua formation contains brackish groundwater over a distance of four to five miles inland of the coast. Further inland the basal groundwater continues but with a head sufficiently high to allow withdrawal of potable water. Toward the crest of Mauna Kea high level dike water occurs at great depth in the Hamakua formation. Sedimentary caprock doesn't rim the coast.

The estimated sustainable yield of 24 mgd assumes that all water is extracted from the high head portion of the basal aquifer more than five miles inland. The estimate is poor.

Aquifer Sector: Northwest Mauna Loa

Aquifer System: Anaehoomalu[80701]

The surface is covered by Kau volcanics, but these Mauna Loa lava flows cover Hualalai volcanics to the south and Mauna Kea volcanics to the north. Basal groundwater occurs in highly permeable aquifers for at least five miles inland. At approximately ten or more miles from the coast high level water may occur at great depth. Lack of caprock at the coast prevents the buildup of a thick lens.

It is not possible to develop potable waterwhere the lens is thin, as it is in most accessible places. About five miles inland a discontinuity disrupts the smooth curve of the water table, causing head to rise several feet higher than expected. The estimated sustainable yield of 30 mgd assumes that all recharge taking place in the System discharges at the coast between Anaehoomalu and Puako. This may not be so. A significant portion of estimated sustainable yield is probably brackish. The estimate is not reliable.

Hawi Aquifer System (80101)

Geology

The geological map of Stearns and Macdonald (1946), shows that the bulk of the System is composed of Pololu Basalt, overlain by Hawi Volcanics in the couthern part. Both rock units include lava flows and pyroclastic deposits.

The western boundary of the System coincides with Kohala volcano's northwest rift zone. A linear alignment of large Hawi and Pololu cinder cones is the surface expression of this rift zone. Hawi Volcanics lava flows, separated from the Pololu Basalts by an erosional unconformity, were erupted from these vents and flowed west and east from the rift zone. Massive Hawi lava flows outcrop at the ocean near Pololu Valley; however, most Hawi lavas within the System end near elevation 1000 feet msl. Some lava flows follow pre-existing stream channels. Dikes do not outcrop with the System but occur at depth, underlying the northwest rift zone from forming the western boundary of the System.

Soils developed from the Pololu Basalts are thick to moderately thick and are well-drained. These are in contrast to soils developed from Hawi Volcanics which tend to be poorly drained and range from thin to thick (Sato and others, 1973).

Sediments other than recent alluvium do not occur within the System.

Hydrology

A. Rainfall

Mean annual rainfall for the System varies from 20 inches near Upolu Point to about 125 inches above the western wall of Pololu Valley, the southeastern boundary of the System. Calculated mean daily rainfall is 184 Mgal, of which 162 Mgal falls above the 50-inch isohyet.

B. Streamflow

Perennial streams within the System are relatively small and have not been gaged (Matsuoka, 1983). Most streams are intermittent. The nature of the soils overlying the Pololu lavas, in conjunction with ash deposits and somewhat fresh lava flows, encourages infiltration.

C. Infiltration

A basal aquifer exists in the Pololu Basalts. Hydrologic records of Kohala Sugar Company shafts and wells drained near Upolu Point and Hawi indicate low strategic water levels indicative of lack of sedimentary caprock and recharge. A static water level of two feet occurs near Upolu Point, while 7.5 feet is measured in wells near Hawi (State of Hawaii, 1970).

Numerous water tunnels were constructed by the sugar companies above Hawi and Kapau. The tunnels develop perched water occurring in the Hawi Volcanics on a soil zone marking the unconformity between the Pololu Basalts and the Hawi Volcnaics, and on ash layers intercalated with Pololu lavas (Stearns and Macdonald, 1946, p. 235). These tunnels are concentrated at an elevation of 1,000 - 1,500 feet msl.

High-level dike water may occur but at great depth, and its presence in the System would only be located by exploratory drilling. Overflow from dike water compartments feeds basal aquifers near the coast.

Waimanu Aquifer System (80102)

Geology

The large amphitheater-headed windward valleys which characterize this System are eroded deep into the shield-building and caldera-ponded Pololu Basalts. According to Stearns and Macdonald (1946) the Hawi Volcanics only outcrop above the headwalls of these large valleys, at the crest of the Kohala Mountains. Erosion has stripped off any Hawi lava flows and pyroclastic deposits which may have occurred at lower elevations.

In Pololu Valley, massive Hawi lava flows have cascaded over the headwall, partially flooding the valley floor (Stearns and Macdonald, 1946, p. 177).

Erosion has exposed numerous volcanic dikes associated with Pololu Basalts and a few which are chemically Hawi in origin. Some of the latter are thick trachyte dikes occurring in the upper reaches of Pololu, Honokanenui, and Waipio Valleys (Stearns and Macdonald, 1946, p. 197). In addition, coarse-grained instrusive bodies of gabbro and diabase outcrop in areas where caldera-ponded lavas and breccias occur.

Large alluvial flood plains occur in Waipio, Waimanu, and Pololu Valleys. These flood plains are wide and flat, estending several miles inland. Other large valleys such as Honokanenui and Honopue are long and narrow, with a rather thin and unsorted alluvial layer following the valley bottom. The upper reaches of these valleys typically have masses of talus which have collected as thick deposits at the bases of extremely steep valley walls. In some cases, these talus deposits have dammed streams, causing deposition of silt. These dams were subsequently breached by the streams.

Hydrology

A. Rainfall

The largest share of the Sector's rainfall occurs within the Waimanu System where annual rainfall varies from less than 75 inches near the mouth of Pololu Valley to greater than 175 inches windward of the Kohala Mountain summit. Calculated mean daily precipitation is 480 mgd. Mean distribution of the rainfall is 6.9 mgd.

B. Streamflow

The Waimanu System is the most water-rich of the Sector. Groundwater discharging from high-level dike compartments make up much of the base flow of the streams. Plantation ditch systems capture most of this water and some of the rainfall runoff.

All of the streamflow captured by the irrigation ditches is used outside the System. The Kohala and Kehena ditches transport water to the Hawi Aquifer System, while the Hamakua Ditch carries water to the Honokaa Aquifer System in the East Mauna Kea Aquifer Sector.

Only a small fraction of streamflow that remains in stream channels discharges at the coast as surface water. Much of the flow percolates into unconsolidated and unsorted stream alluvium. However, a large stream such as Waimanu will discharge a tremendous flow into the ocean regardless of the size of the flood plain.

c. Infiltration

High-level aquifers are the most prevalent in the System. Windward valleys are deep enough to tap water stored between dike compartments. The large baseflow of these streams is the release of high-level groundwater. Perched aquifers discharging as springs and seeps are numerous. Perching members include ash deposits, massive lava flows, and intrusives. Perched aquifers, though numerous, are much less important than the dike aquifers. Stearns and Macdonald (1946) list several 0.25 mgd springs near Kukuihaele. Truncated basal aquifers occur near the coast. Limited sedimentary aquifers probably occur in the large flood plain deposits of Waimanu, Waipio, and Pololu Valleys. These aquifers may be somewhat brackish.

Mahukona Aquifer System (80103)

Geology

The geology of the System is similar to the Systems previously described. Pololu Basalt outcrops throughout but is overlain by Hawi Volcanics from crest to sea in several localities. The System's upper boundary is primarily in Hawi Volcanics. Much of the flank outcrops of Hawi rocks are represented by massive flows of benmoreites, mugearites and trachytes, which are the differentiated products of the alkalic basalt suite. Pololu Basalts are thin-bedded to massive basaltic flows and pyroclastic deposits.

Weathering and erosion have not had much impact upon the topography. Gullies eroded into the massive Hawi lavas and Pololu Basalts are narrow and steep-sided.

Sedimentary deposits do not occur in the Mahukona System. Finer cinder deposits may have been transported by wind as eolian soil downwind from the rift zone.

Hydrology

A. Rainfall

The Mahukona System is one of the driest regions of Hawaii. Rainfall varies from less than 10 inches to slightly greater than 75 inches at the upper boundary with the Waimanu System. Even though the System contains 47.3 percent of the Sector's land area, mean daily rainfall is only 17.2 percent of the Sector at 138 mgd. Distributed over the System, this only amounts to 1.2 mgd/sq. mi.

B. Streamflow

As mentioned previously, streams are almost nonexistent in the System. The few existing ones are intermittent and in the most juvenile stage of development. Where these water courses cross over massive Hawi lavas, little or no percolation takes place.

C. Infiltration

Records of coastal drill holes and abandoned wells from Mahukona to Kawaihae indicate low-water levels and brackish water occurring under unconfined basal conditions. Inland, at a much higher elevation, good quality water has been tapped.

Near the System's upper boundary with the Hawi and Waimanu Systems, high-level dike water and perched sources may be present due to dikes associated with the Kohala's rift zone and with Hawi pyroclastic deposits.

Waimea Aquifer System (80301)

Geology

The essential volcanic geology of the System and Sector is described above. Many of the lava flows associated with Hamakua and Laupahoehoe Volcanics are alkalic basalt to hawaiite in composition. The more differentiated flows tend to be massive and not conducive to recharge by rainfall. Thick ash deposits associated with the Pahala Ash and numerous cinder eruptions are ubiquitous thorughout the System.

Sediments include ash and cinder deposits reworked by water and wind, glacial moraine deposits at extreme elevations, and beach deposits of basaltic boulders and coral sand.

Hydrology

A. Rainfall

The Waimea System is one of the driest on the island. Annual rainfall ranges from less than 10 inches to nearly 50 inches. Most of the System receives less than 30 inches per year.

As typical of the dry, leeward areas of all the Hawaiian Islands, the greatest share of rainfall comes from a few Kona and frontal storms which occur sporadically throughout the year. Mean daily rainfall is 243 mgd, equivalent to a distribution of 0.9 mgd/sq. mi.

B. Streamflow

All streams in the System are intermittent. The gulches carry storm runoff, but most of the time remain dry. The USGS maintains two crest-stage partial-record stations at Kamakoa Gulch and Popoo Gulch.

C. Infiltration

Non-artesian basal groundwater forms the most extensive aquifer of the System. Wells drilled near the coast are brackish. Well 8-5948-01, 0.7 miles east of Hapuna Beach, is 268 feet deep. The bottom of the well elevation is -24 feet msl. Water levels vary from 1.4-4.5 feet msl. Chloride values range from 460-480 ppm (USGS, 1987).

Four Lalamilo wells (State Well No. 8-5946-01, 02, 03, 04) drilled several miles inland and at elevations between 1,084 to 1,172 feet msl, have a head of about eight feet msl. Chloride values are less than 100 ppm (USGS, 1987).

Deep well 8-5239-01, drilled at Waikii at elevation 4,260 feet msl, penetrated 4,350 feet of Hamakua lava flows. Dike-impounded water was reached at elevation 1,509 feet msl. Chloride content measured during the pump test was 18 ppm. Temperature measurements taken of the water column was 79°F at the top and 100°F at the bottom. The elevated temperatures can be explained by the normal geothermal gradient, and also by latent volcanic heat.

Perched water springs occur at high elevations and are associated with glacial moraine deposits and pyroclastics. Waihu Spring and seeps are the primary sources of water for Pohakuloa Military Camp and the State Park. The spring and seeps occur between 8,935 feet and 10,390 feet in Pohakuloa Gulch. Stearns and Macdonald (1946, p. 292) report total spring discharges of about 50,000 gpd.

Anaehoonalu Aquifer System (30701)

Geology

The lavas represented in the System are historic and prehistoric flows of Kau Basalt (Stearns and Macdonald, 1946; Lockwood and Lipman, 1987). The 1859 lava flow is the longest and most voluminous historical flow on record (Macdonald and Abbott, 1970, p. 56), and traces the western boundary of the System.

Other historical flows from Mauna Loa's northeast rift zone lap up against Mauna Kea in the Humuula saddle area. Many prehistoric Kau lava flows interfinger at depth with Mauna Kea flows in this area. Stearns and Macdonald (1946) mapped numerous Laupahoehoe Basalt cinder cones and one Kohala cinder cone surrounded by Kau Basalt within the Sector. Prehistoric pyroclastic cones of Kau Basalt also occur.

Sedimentary deposits are limited to beach deposits, and possibly reworked ash and cinder.

Hydrology

A. Rainfall

The Anaehoomalu System is one of the driest on the island. Annual rainfall varies from less than 10 inches at the coast to about 45 inches in the interior. Mean daily rainfall is calculated at 317 mgd. Distributed evenly over the System's 291 square miles, daily rainfall is 1.1 mgd/sq. mi.

B. Streamflow

Due to the Sector's youthful geology, streams are not well-developed. Storm runoff is channeled between lava flows, in depressions, lava channels, spatter ramparts or escapes as sheet flow. The USGS has not gaged any runoff in the Sector (Matsuoka, 1983).

C. Infiltration

The lower portion of the Sector/System is underlain by basal groundwater of low head. Ancient dug wells and water holes produce brackish water.

There are no wells in this Sector to record water levels or chloride values. However, wells 8-5548-01 and 8-5648-01, drilled at elevation 814 feet msl and 620 feet msl, respectively, at Waikoloa near the Sector's boundary, have heads of five to six feet with chloride content between 300 and 500 ppm. Other Waikoloa wells 8-5745-01, 02, drilled at an altitude of 1,213 feet msl and 1,203 feet msl, respectively, yield excellent quality water at 23 ppm chloride. Static water level for these wells is about 16 feet msl.

High-level groundwater may exist far from the coast as dike-impounded water. Perched water may also be present in small quantities. None of these supplies has been explored.

END

CERTIFICATION

I HEREBY CERTIFY THAT THE MICROPHOTOGRAPH APPEARING IN THIS REEL OF FILM ARE TRUE COPIES OF THE ORIGINAL DOCUMENTS.

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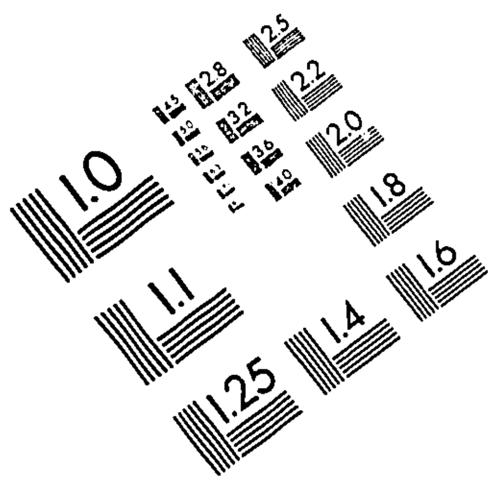
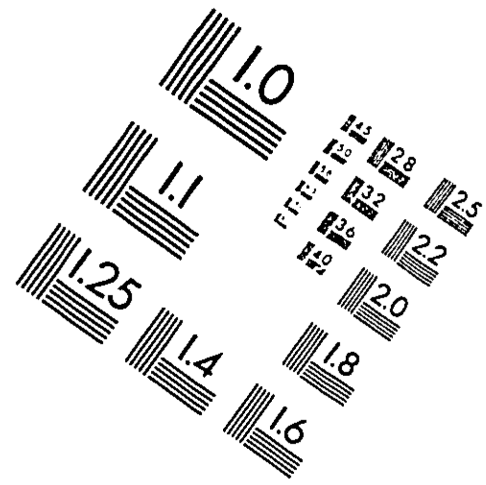
J. Kaai
SIGNATURE OF OPERATOR





TOP

Film Identification

A & P International

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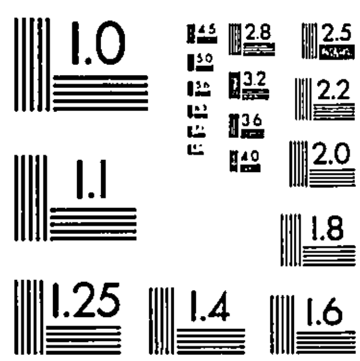
PRECISION[SM] RESOLUTION TARGETS

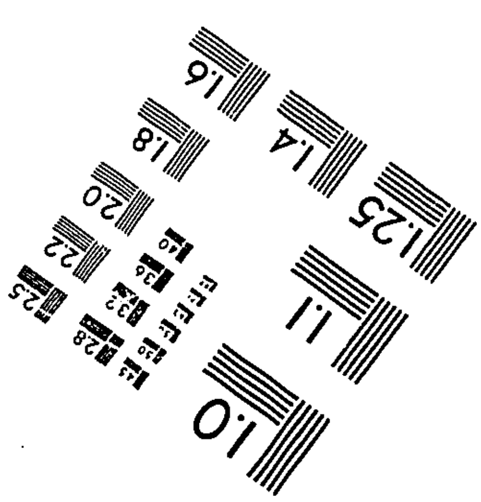
LEFT

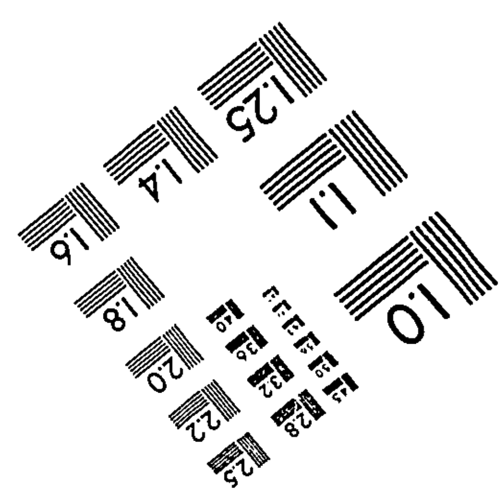


RIGHT

150 MM

6″





PA-3 8½″x11″ PAPER PRINTED GENERAL TARGET

DENSITY TARGET

ADVANCED MICRO-IMAGE SYSTEMS HAWAII