1993-05-23-OA-FEA- Ihilani Resort & Spa

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IHILANI RESORT AND SPA
KO OLINA, OAHU, HAWAII
Final
ENVIRONMENTAL ASSESSMENT
FOR A FLOW-THROUGH
SEA WATER SYSTEM

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Prepared For:

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April 1993

Final
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SECTION I.

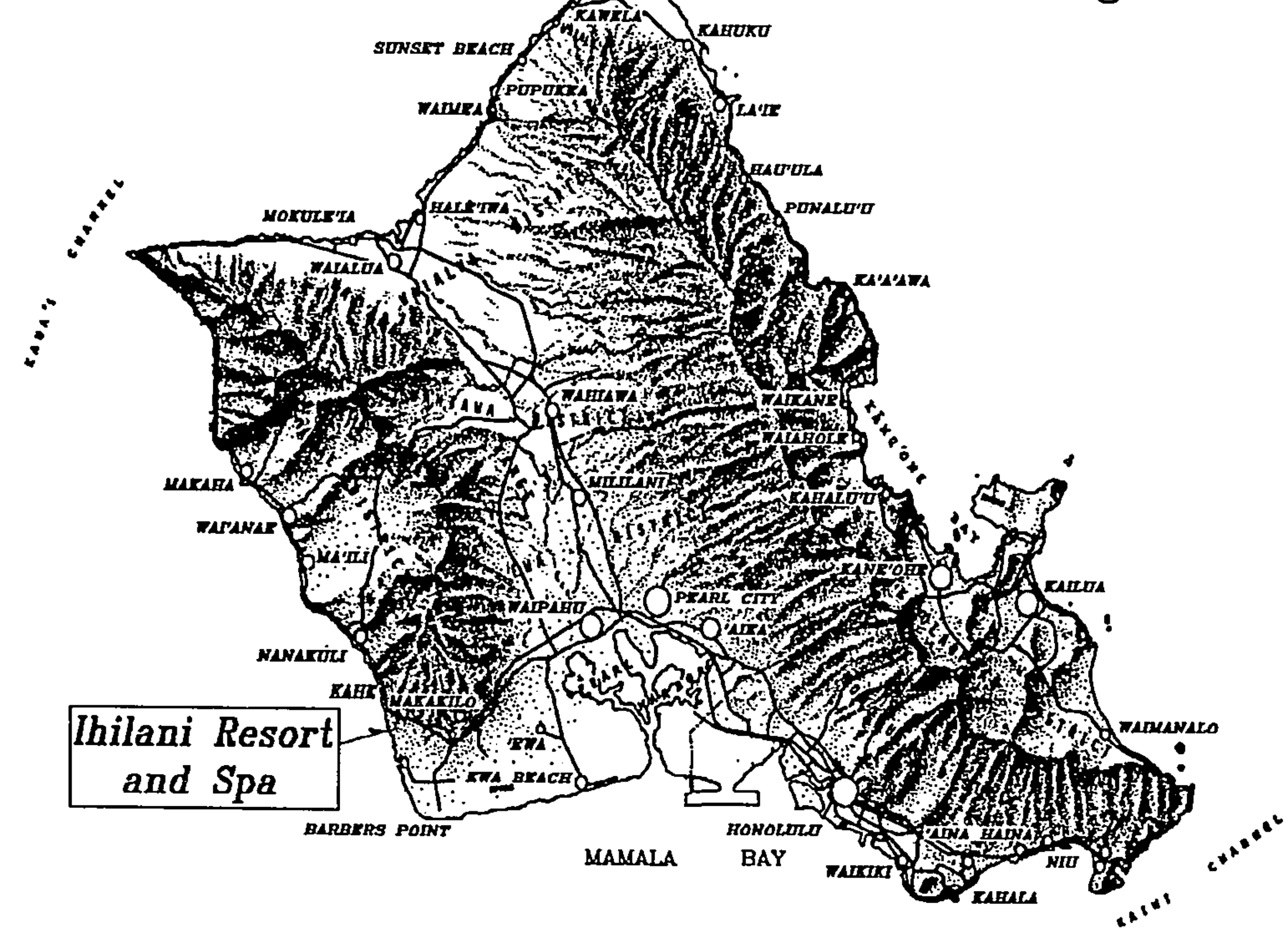
INTRODUCTION

I.A. PROJECT SUMMARY

This final environmental assessment (EA) provides information and background, and an assessment of the environmental impacts, for a proposed sea water transmission system with ocean intake and discharge at the Ihilani Resort and Spa, Ko Olina Resort, Oahu. The project location on O'ahu is indicated in Figure I-1. The Ihilani parcel in relation to the master plan for the Ko Olina Resort is indicated in Figure I-2. As defined here, the project encompasses only the sea water transmission system (intake and discharge pipes, pump house and pumps, and accessories to the pipes and pumps) (Figure I-3).

Applicant	Pan Pacific Hoteliers, Inc. 1001 Bishop St., Pauahi Tower, Suite. 710 Honolulu, Hawaii 96813
Construction Contractor, Water Features	Hardscapes Hawaii 2045 Kam IV Road, Suite 200 Honolulu, Hawaii 96819
Construction Contractor, Ihilani Resort and Spa	PPC-Tokyu Joint Venture 92-1001 Olani St., West Beach Ewa Beach, Hi 96707
Agent / Environmental Consultant	*AECOS*, Inc. 970 N. Kalaheo Ave., Suite C311 Kailua, Hawaii 96734
Land Owner	Pan Pacific Hoteliers, Inc. 1001 Bishop St., Pauahi Tower, Suite. 710 Honolulu, Hawaii 96813
Tax Map Key (TMK)	9-1-57: 1
Land Use Classifications:	Zoning Districts: Resort and P-2. State Land Use: Conservation (R) and Urban.
OEQC Bulletin Publication Date(s)	(Draft EA) March 8, 1993 (Final EA)
Accepting Agency:	Dept. of Land and Natural Resources 1151 Punchbowl Street Honolulu, Hawaii 96813

Figure I–1



KAWELA
KAHUKU
SUNSET BEACH
PUPUKEA
WAIMEA
LA'IE
HAU'ULA
PUNALU'U
MOKULE'IA
HALE'IWA
WAIALUA
KA'A'AWA
KAUA'I CHANNEL
WAHIAWA
WAIKANE
WAIAHOLE
MILILANI
KAHALU'U
MAKAHA
WAI'ANAE
MA'ILI
KANE'OHE
KAILUA
PEARL CITY
WAIPAHU
AIEA
NANAKULI
MAKAKILO
Ihilani Resort
and Spa
'EWA
'EWA BEACH
WAIMANALO
BARBERS POINT
MAMALA
BAY
HONOLULU
'AINA HAINA
NIU
WAIKIKI
KAHALA
KAIWI CHANNEL

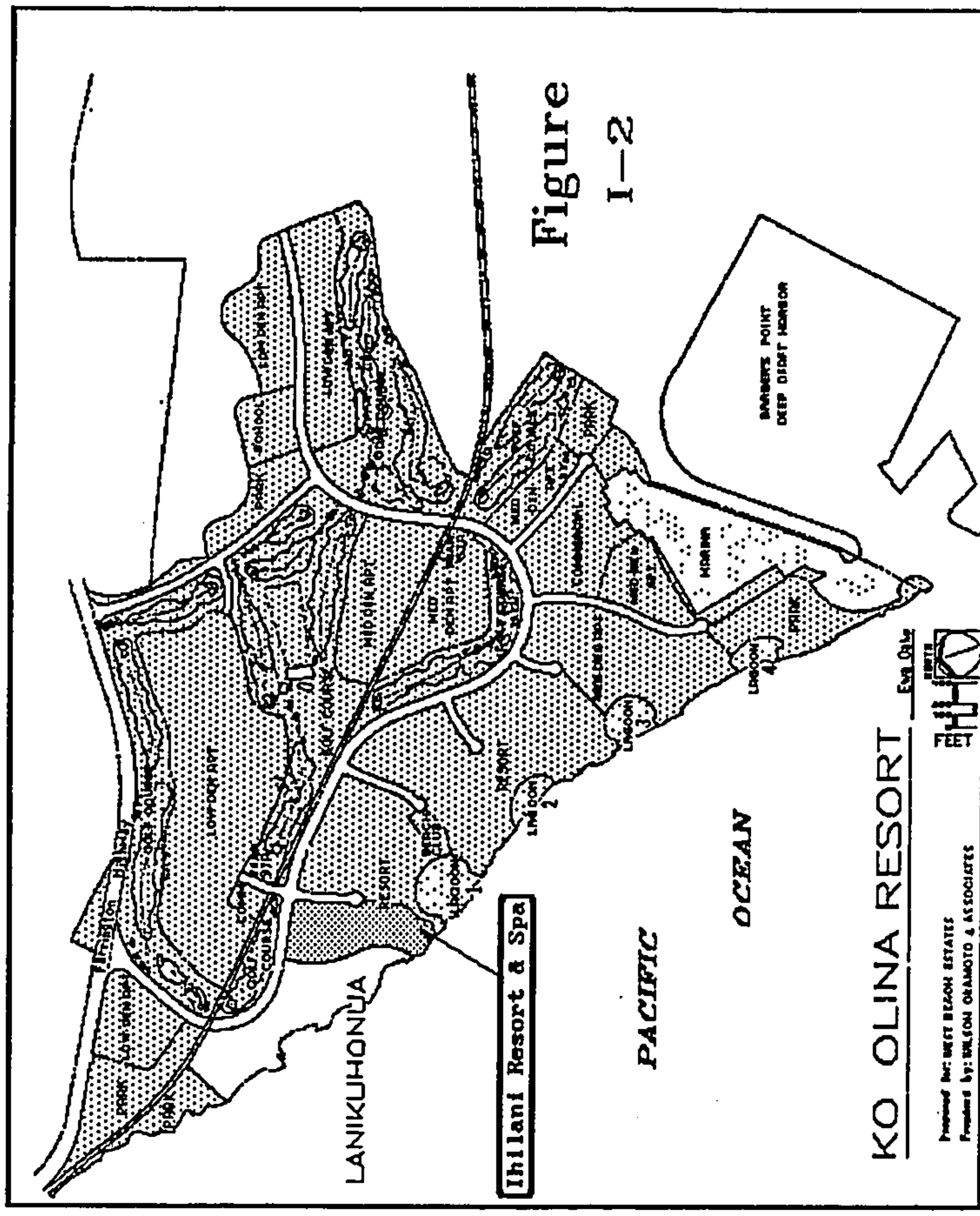

KO OLINA RESORT
PACIFIC
OCEAN
LANIKUHONUA
Ihilani Resort & Spa
BARBERS POINT DEEP DRAFT HARBOR
FEET

Figure I—2

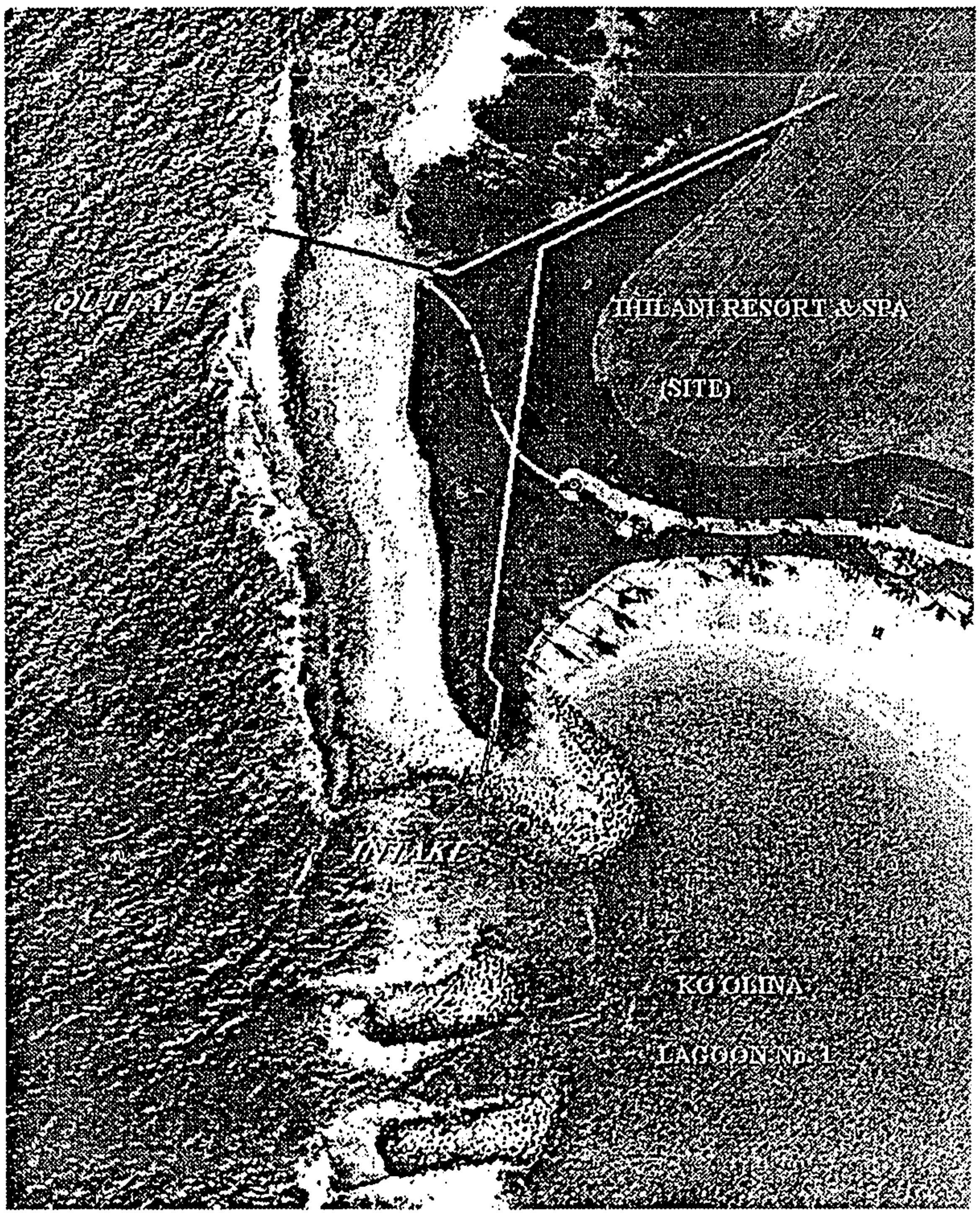


Figure I-3. Proposed sea water intake and discharge system superimposed on a July 1990 aerial photograph of the Ihilani Resort and Spa site at the north end of Ko Olina Lagoon No. 1. Figure III-3 provides an interpretation of many of the features shown, and is based on the same photograph.

I.B. PROJECT RATIONALE

The grounds of the Ihilani Resort and Spa, now under construction at the Ko Olina Resort, will include some 13 different water features ranging from swimming pools and spas, to fountains, ponds, and "lagoons". The largest system is a series of four "lagoons" (ponds) designed to utilize sea water in a flow-through system. Sea water is desired for this system because 1) resource constraints are far less for non-potable water sources than for potable water sources which must recirculate to conserve water usage, and 2) examples at several resorts in Hawaii have demonstrated that marine systems fulfill the purposes of decorative water features in garden settings as well as or better than most fresh or brackish water systems. Proper design can reduce or eliminate the unique maintenance problems associated with salt water systems; And, where well tended, salt water biota can attract greater visitor interest than the usual fresh water biota of koi or acclimated estuarine fishes.

From a strictly regulatory perspective, it is certainly preferable to draw water from on-site wells and to discharge system effluents into dry wells, sumps, or injection wells. Such a system requires few or no environmental permits, depending upon proximity to potable ground water supplies. However, exploratory drilling at the Ihilani site (Nance, 1992) has failed to locate a source of saline water within reasonable depths beneath the ground. Consequently, the Ihilani Resort will need to obtain sea water from the adjacent ocean.

Decorative waterscapes are often designed as recirculating systems. However, the initial construction cost and the long term operation and maintenance costs for a recirculating salt water system intended to support marine life tend to offset the advantages of using salt water instead of fresh water in purely decorative situations. The high costs of purifying and filtering might be justified for an inland marine aquarium, but usually not for decorative features which are not the basis for generating revenues. Sea water systems perform better when water exchange is at a high rate and physico-chemical changes in the water are held to a minimum. The geology of the Ihilani site will not allow injection wells or sumps for disposal of water from a non-recirculating system. Thus, a flow-through system, discharging back into the ocean, is the most practical alternative for the Ihilani Resort and Spa outdoor water features.

This environmental assessment (EA) considers the impacts on the environment of a flow-through sea water system at the Ihilani Resort and Spa. The system is designed to draw approximately 1000 gpm (63 liters/sec) of sea water from the outer part of Ko Olina Lagoon 1, pass this water through ponds and other water features on the grounds of the hotel, and return the water through an effluent discharge pipe located just off the shore of the Pacific Ocean northwest of the hotel. Impacts considered in Section IV of this EA are (short term) those of the construction of intake and discharge pipes across the shore, and (long term) those of the water quality of the discharge on the receiving water. Alternatives considered are presented in Part I.E. below.

I.C. ENVIRONMENTAL CERTIFICATIONS AND PERMITS

The proposed sea water system is described in detail in Section II. With respect to environmental permits, the essential parts of the system are the intake and discharge pipes, and the water proposed to be discharged into the waters of the State of Hawaii. The pipes are planned to cross the shore at two different locations adjacent to the Ihilani Resort. Both pipes will terminate just off the shore at a depth within about one meter (3 feet) of lowest lower low water (LLLW).

I.C.1. Federal Policies and Controls

Federal jurisdictions are limited in this project site to construction activities within the navigable waters of the United States (The River and Harbor Act of 1899, Section 10) and to effluent discharges into the nation's waters. The installation of water intake and discharge systems is permited under U.S. Department of the Army, Nationwide Permit No. 7. However, the nature of the construction activities associated with the installation (for this project described in Section II) must be reviewed by the U.S. Army Corps to determine if an individual permit is more appropriate. Application for the permit will generate requirements under the Coastal Zone Management Act of 1972 to insure compliance with the State of Hawaii CZM program, and under Sections 401 and 402 of the Clean Water Act, for water quality certification from the State of Hawaii. Consultation with National Marine Fisheries under Section 7 of the Endangered Species Act may also be requested in the permitting process if impacts to endangered marine species are anticipated.

Effluent discharges are regulated under the Clean Water Act, National Pollutants Discharge Elimination System (NPDES) by the U.S. Enivronmental Protection Agency (EPA). In Hawaii, the State of Hawaii, Department of Health (DOH) is authorized to issue these permits subject to review by EPA.

I.C.2. State of Hawaii Policies and Controls

The Ihilani Resort and Spa is located on land that is in the State Urban District. However, portions of the intake and discharge pipes would have to be laid across the shoreline and lands classified by the Department of Land and Natural Resources (DLNR) as

Conservation District, General Subzone. Development of "water transmission" is a permitted use in the "G" Subzone of the Conservation District (HAR, §13-2-14). A Conservation District Use Application (CDUA) must be made to the State of Hawaii, Department of Land and Natural Resources to obtain a permit (CDUP) for the portions of the pipes within the Conservation District. Construction activities below the high tide line will require a Shore Waters Work Permit from the State of Hawaii, Department of Transportation.

The national permit under NPDES is described above. Issuance is authorized by the Environmental Protection Agency for the State of Hawaii, Department of Health. Additionally, a Zone-of-Mixing Permit (HAR, §11-54-09) may be required in the case of certain discharges which cannot comply at the discharge point (end-of-pipe) with the State of Hawaii water quality standards. Consistency with the State Coastal Management Program (15 CFR 930) is determined by the Coastal Zone Management Program at the Office of State Planning.

This Draft Environmental Assessment (EA) has been prepared and is being filed with the State of Hawaii, Offiice of Environmental Quality Control (OEQC) in compliance with requirements recently enacted in Act 241 SLH 1992 (House Bill 3946) for projects for which a negative declaration is anticipated. The new law requires that EAs undergo a formal 30-day review period including publication announcements in the OEQC Bulletin and inclusion of public comments and responses in a final EA prior to agency determination that either an EIS or a negative declaration is appropriate.

I.C.3. City and County of Honolulu Policies, Controls, and Development Plans

Portions of the proposed project are within the City and county of Honolulu, Shoreline Setback Area and all of the project is within the Special Management Area (SMA) requiring review by the Department of Land Utilization for a Shoreline Setback Variance and a SMP. Total cost of the water transmission lines, pumps, and pump house are estimated at $120,000 (construction plus materials). All of these items will be located below ground. An access hatch to the pump room will be the only visible feature of the entire project once completed.

No part of the proposed project is inconsistent with either the county General Plan, the Ewa Development Plan, or land use ordinances, except for the variance requirement under the county Shoreline Setback Ordinance. The project is within lands designated resort or preservation on the Ewa Development Plan Land Use Map and the Land Use Ordinance map (Resort and P-2 designations). The project is within the West Beach Special Area which extends from Kahe Point Beach Park to Barbers Point Deep Draft Harbor. This area is designated as a "water-oriented residential and resort community for the West Beach-Makakilo Secondary Urban Center". The project is consistent with designated uses and will not interfere with either public access requirements or public view corridors of the West Beach Special Area.

I.D. LIST OF AGENCIES AND OTHER CONSULTED PARTIES

Following is a list of agencies and other parties provided copies of either the brief project description prior to preparation of the draft Environmental Assessment or the draft Environmental Assessment. A copy of the pre-preparation letter, dated September 18, 1992, is included in Appendix A along with written responses to this letter and the draft Environmental Assessment. In the following list a "□" indicates that a written response was received and is included in Appendix A of the final Environmental Assessment. A "✓" indicates that the proposed project and impacts were discussed with the indicated individual and a written response is anticipated under other permit requirements of the project.

□ Department of the Army
U.S. Army Engineer District, Hionolulu
Fort Shafter, Hawaii 96858-5440

U.S. Department of Commerce
National Marine Fisheries Service
2570 Dole Street
Honolulu, Hawaii 96822
✓ Eugene Nitta

□ Department of Land and Natural Resources
1151 Punchbowl Street
Honolulu, Hawaii 96813

Dept. of Land and Natural Resources
Division of Aquatic Resources
1151 Punchbowl Street
Honolulu, Hawaii 96813
✓ Francis G. Oishi

□ Department of Health
Environmental Management Division
500 Ala Moana Blvd.
Five Waterfront Plaza, Suite 250
Honolulu, Hawaii 96813

□ Office of State Planning
250 South Hotel Street, 4th Floor
Honolulu, Hawaii 96813

Office of State Planning
Coastal Zone Management Office
P.O. Box 3540
Honolulu, Hawaii 96811-3540
✓ John Nakagawa

□ Department of Transportation
869 Punchbowl Street
Honolulu, Hawaii 96813
Rex D. Johnson

Office of Hawaiian Affairs
711 Kapiolani Blvd., Suite 500
Honolulu, Hawaii 96813

University of Hawaii
Water Resources Research Center
2540 Dole Street, Holmes Hall 283
Honolulu, Hawaii 96822

University of Hawaii
Environmental Center
2550 Campus Road, Crawford 317
Honolulu, Hawaii 96822

□ City and County of Honolulu
Planning Department
650 South King St.
Honolulu, Hawaii 96813

City and County of Honolulu
Department of Land Utilization
650 South King St.
Honolulu, Hawaii 96813
✓ Ardis Shaw-Kim

☐ City and County of Honolulu
Department of Public Works
650 South King St.
Honolulu, Hawaii 96813

Waianae Coast Neighborhood Board No. 24
P.O. Box 869
Waianae, Hawaii 96792

Ewa Beach Neighborhood Board No. 23
P.O. Box 1633
Pearl City, Hawaii 96782

Councilman John DeSoto
c/o City Council
530 South King Street, 2nd Floor
Honolulu, Hawaii 96813

Cambell Estate
828 Fort Street Mall, Suite 500
Honolulu, Hawaii 96813

Pan Pacific Hoteliers, Inc.
1001 Bishop St., 710 Pauahi Tower
Honolulu, Hawaii 96813
✓ Jon Bolner

West Beach Estates
1585 Kapiolani Blvd., Suite 1430
Honolulu, Hawaii 96814

I.E. PROJECT ALTERNATIVES CONSIDERED

The rationale for utilizing a flow-through sea water system is briefly explained within the introduction above (Part I.B). Alternatives for decorative water features at the Ihilani Resort and Spa include utilizing different sources of water and recirculating all or a portion of the volume of the water within these features. This section provides a more detailed rationale for the system design presented in Section II and the possible options and related impacts of alternative designs.

The "no project" alternative for water features in this instance must be considered an alternative outside the capability of the applicant because the land owner, West Beach Estates, has included waterscapes as a requirement within the design guidelines established for all development projects at Ko Olina. These guidelines attempt to establish a unifying theme through the landscape and waterscape elements. The architectural guidelines (West Beach Estates, 1987) contain the following statements:

> Each parcel to be developed for resort, residential or community business use will contain a variety of waterscape features. These are to be located primarily along the periphery of each parcel's boundaries.....
>
> The types of features to be included in the waterscape should satisfy a variety of purposes, including aesthetic and recreational.
>
> In order to ensure the visual prominence of waterscape features on each parcel, recommended and minimum surface water area guidelines are provided. For resort parcels, the recommended area is 10 percent, with a 5 percent minimum.

The Ko Olina Resort project has completed environmental review and permitting under both state and federal NEPA guidelines (Anon., 1980; USACOE, 1986).

However, another "no project" alternative would be to construct the water features at the Ihilani Resort and Spa without the sea water intake and discharge system proposed herein. Alternative sources of water were considered. Exploratory drilling sought to develop a source of high quality saline water on the hotel property (Nance, 1992). Drilling also assessed the possibility of injection wells or sumps for disposal of water from the water features. In all, seven test wells were drilled in the area between the hotel and the shoreline to depths of 50 feet failed to find an adequate source of sea water and indicated that injection would be difficult at best. Although brackish water was found, this water was deemed of marginal value for the water features. Because the underlying geology will not support injection wells, the adverse impacts of discharging a poorer quality water obtained from on-site wells into the nearshore environment would certainly be greater than the proposed sea water intake and discharge system. An intake system can be built into the revetment structure of the Ko Olina lagoon with no adverse impacts on either the marine environment or the recreational amenities of the Ko Olina Resort.

Water features traditionally have utilized fresh water from onsite wells or even potable water (city water). Fresh water systems must either be located adjacent to a substantial source of flowing water (e.g., a stream or river), or must recirculate to conserve what has become a precious resource. Recycled water from waste water reclamation facilities is not an acceptable alternative for water features around the living spaces of the hotel, but may be practical for certain man-made lakes in less accessible locations (e.g., water traps on golf courses). Large water features which recirculate must contend with evaporative losses which can amount to 3% of the volume per day. Whether salt water or fresh water is recirculated, makeup water for evaporative losses must be fresh (or slightly brackish) to avoid a steady increase in salinity with time.

Recirculating systems are conservative of water resources, but do not generate less waste material and may generate more than flow-through systems. Recirculating systems usually must treat the water by (at minimum) filtration of some sort. Filter beds must be cleaned or changed, creating wastes that are disposed of on land. In general, recirculating systems will utilize more energy because of the need to move water through the filter systems. Some recirculating systems require additional energy and/or resource expenditures for sterilization (e.g., ozonation) as part of the treatment process. A recirculating system for the Ihilani waterscapes could be built, but would have greater long-term adverse impacts on environmental resources than the proposed sea water intake/discharge system.

SECTION II.

PROJECT DESCRIPTION

II.A. IHILANI RESORT MARINE WATER FEATURES

The salt water system planned for the Ihilani Resort and Spa will consist of four interconnected "lagoons" or ponds with a total area of 22,000 square feet (2044 m^2). The depth of these ponds will vary between 1.5 feet and 3.5 feet (0.5 to 1.1 m), yielding a total volume capacity of around 300,000 gallons (1135.5 m^3 or 1,135,500 liters) of sea water.

Water will be pumped from the intake manifold located inside the mouth of Ko Olina Lagoon No. 1 to the Ihilani water features via a distribution system with ports throughout the edges and bottom areas of the four ponds, as well as to a stream at the east end of the system. After an average residence time of less than six hours, the water will flow out through a gravity overflow and into a discharge pipe terminating along the ocean shore (Figure II-1).

Various marine fishes will be maintained within the lagoons. Large numbers of herbivores will be used to control the growth of benthic (attached) algae. The short residence time is sufficient to prevent the development of algal (phytoplankton) blooms in the water column. A total of 3,000 fish are anticipated to be maintained in the system.

II.B. INTAKE PIPE SYSTEM AND PUMP HOUSE

The sea water intake system will consist of a pair of 8 inch, polyethylene pipes drawing from an intake manifold located below the shoreline of Lagoon 1 at the Ko Olina Resort. The location is shown in Figure II-1 In this part of the Ko Olina lagoon, the source of the water drawn into the sea water system will be the water recently flushed into the lagoon in the waves breaking across the wave shelf. The entire intake line and manifold structure are outside of the State Conservation District, but a portion may impinge on the City and County 40-foot setback as measured from the certified shoreline established in 1990. All parts of the intake structure and lines are within the SMA.

II.B.1. Intake Manifold Design

The intake manifold will consist of nine, 3-inch intake openings feeding each of the two 8-inch intake lines. The entire manifold structure is to be precast in concrete as shown in Figure II-2. The manifold will be set in place at a minimum depth of 3 feet below MLLW

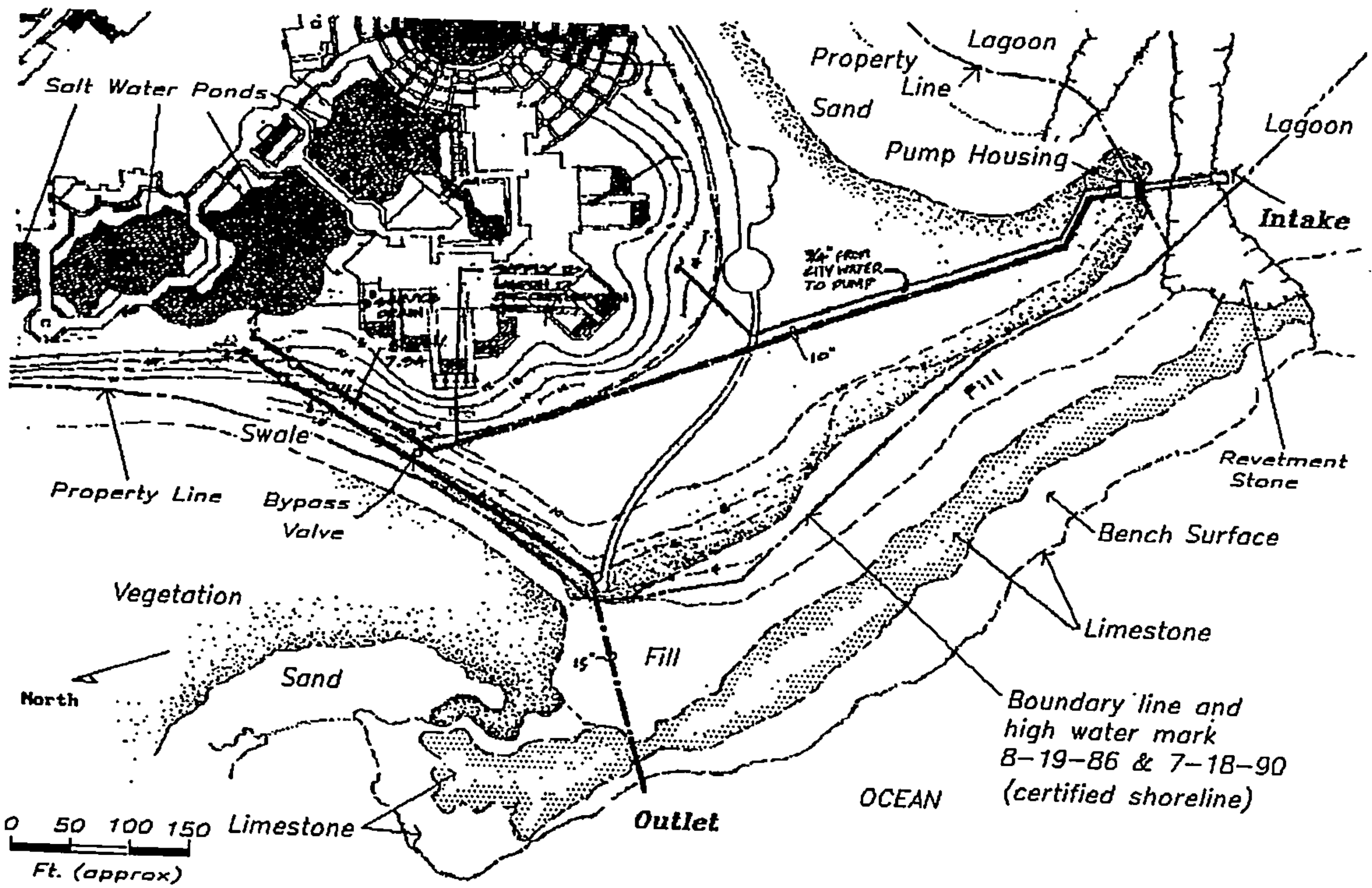

Salt Water Ponds
Property Line
Sand
Lagoon
Pump Housing
Lagoon
Intake
¾" from city water to pump
10"
Swale
Property Line
Bypass Valve
Fill
Revetment Stone
Bench Surface
Limestone
Vegetation
Sand
North
15"
Fill
Boundary line and high water mark 8-19-86 & 7-18-90 (certified shoreline)
OCEAN
Outlet
Limestone
0 50 100 150
Ft. (approx)

Figure II-1.

within the basalt boulder revetment which protects the north end of the beach of Lagoon 1. This revetment is constructed of large basalt (and some limestone) boulders (mostly 3 to 4 feet in diameter) having sufficient void space to permit a free flow of seawater around the large stones. The manifold will be positioned such that the ends of the 8-inch lines will be accessible for clean-out purposes, but these openings would be capped during normal operation of the pump.

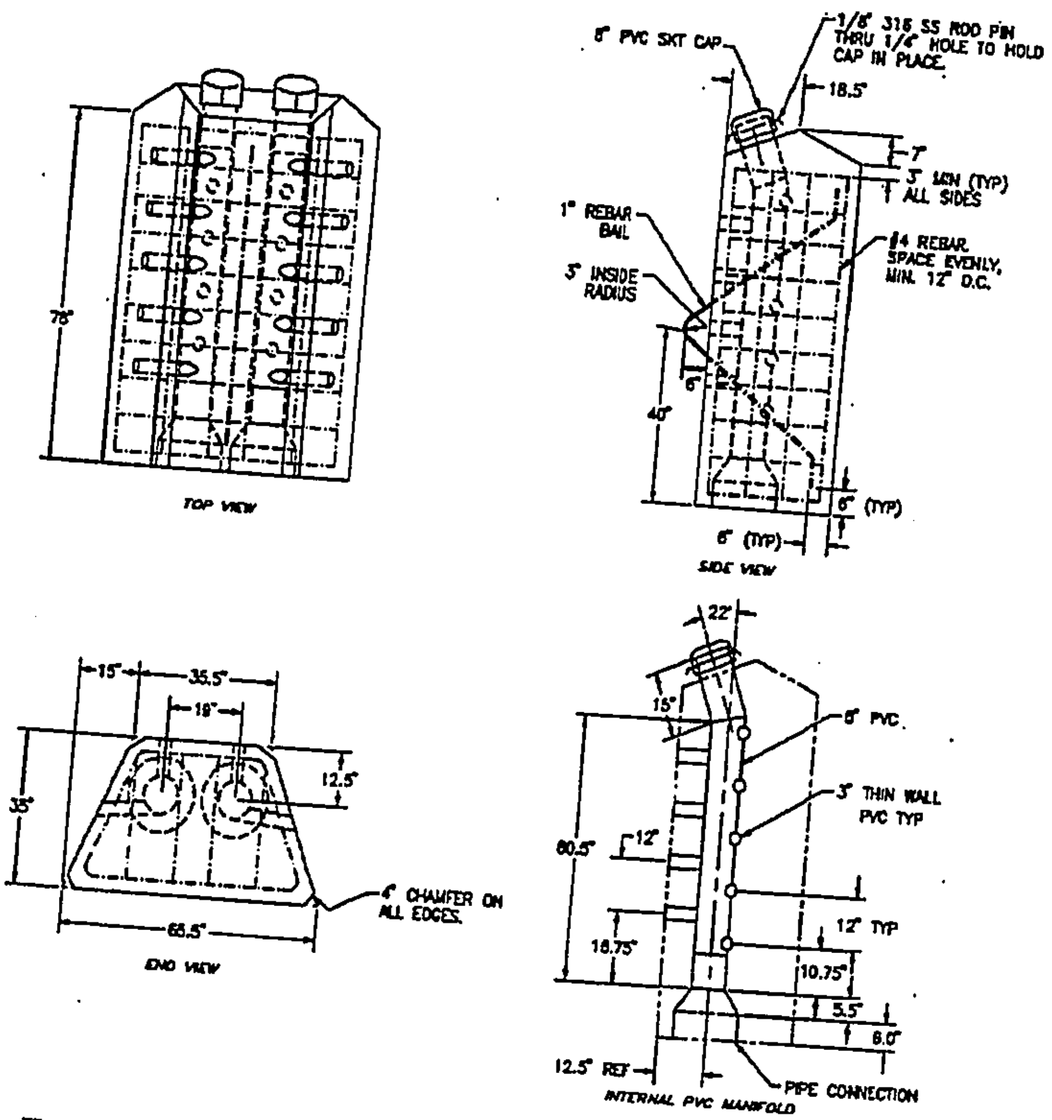


Figure II-2. Engineering diagrams of proposed concrete intake block (manifold).

The manifold would be located on the ocean side of the revetment in a part of the lagoon not to be used by swimmers. Nonetheless, the design of the manifold and its placement within the revetment structure are intended to insure that neither persons, fishes, nor other animals can be held against any openings by suction created from the pumping action.

Placement of the intake manifold and intake pipe lines within the boulder revetment will require temporary removal of the boulders. These stones are to be replaced, after the lines are laid, in a manner consistent with the arrangement existing prior to removal.

II.B.2. Pump Compartment

Two 500 gpm, self-priming pumps are to be located within a vault on the Ihilani property close to the intake structure (see *Figure II-1*). The vault will be a concrete structure buried underground within the vegetation area behind the north end of Lagoon 1. Internal dimensions are 8 ft. wide by 9 ft. long by 6 ft. deep. The structure will be covered by 12 inches of soil except for a 5 ft. by 5 ft. hatch cover set flush with the ground surface. In addition to the pumps, the vault will house in-line strainers and valving for the two 8-inch intake lines connecting these to a single, 10-inch supply line. A 3/4-inch service line will provide water in the event that the self-priming mechanism fails to function properly.

The pump "house" or vault is located within the SMA, but not within the City and County Shoreline Setback, nor the State Conservation District.

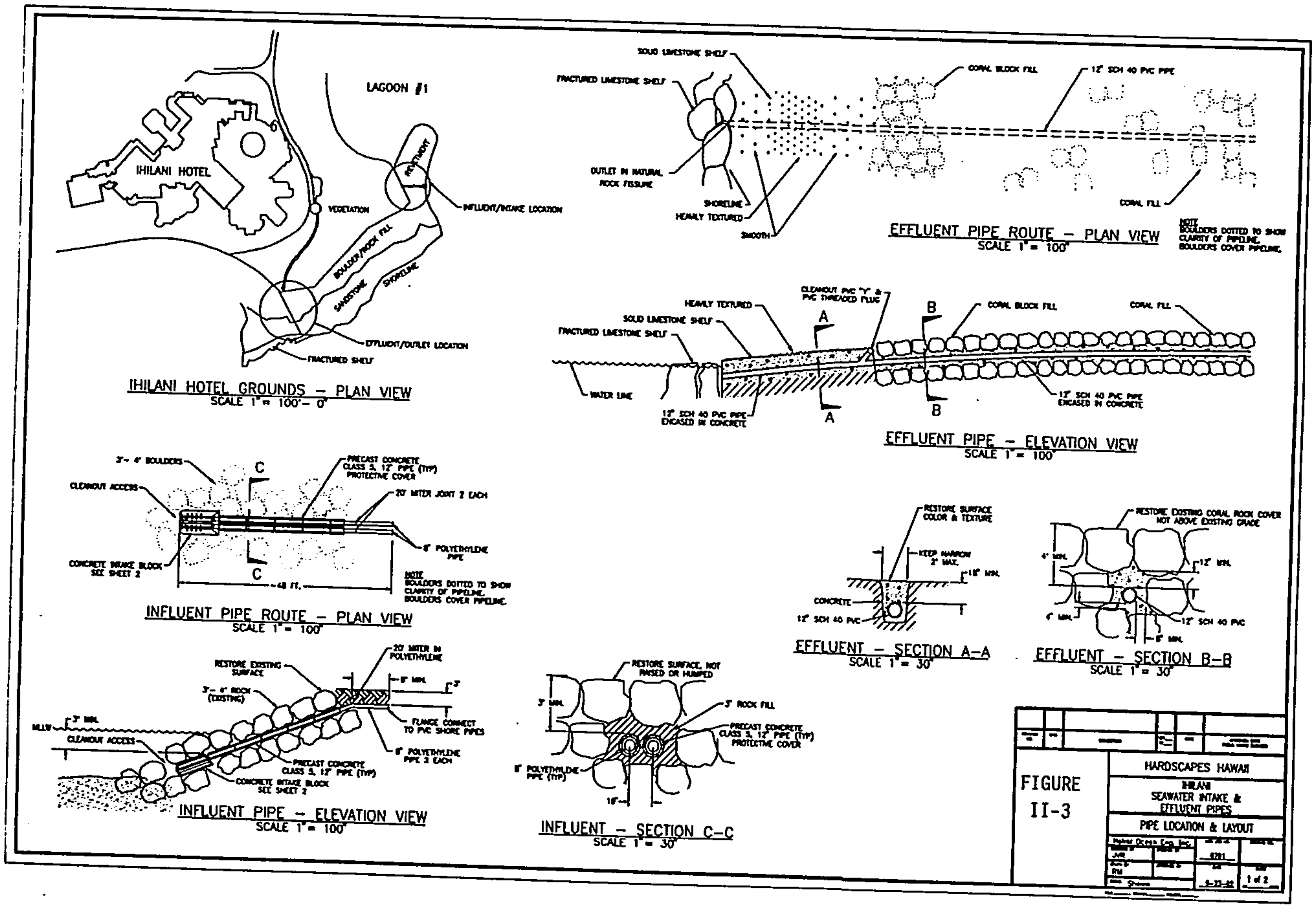
II.B.3. Pipe Routing Across the Landscaped Area

The routes of both the 10-inch intake line and the 15-inch discharge line between the shore and the Ihilani Resort water features are shown in Figure I-3 and Figure II-1. The two 8-inch intake lines described above in Part II.B.1. feed into a single 10-inch line laid between the pump vault and the sea water distribution system on the grounds of the Ihilani Resort and Spa. The 10-inch line extends to the north end of the property where the 15-inch discharge line is located. The two lines run more or less together to the salt water lagoons on the Ihilani Hotel grounds. A bypass valve is located in this area to permit bypassing the ponds with the pump on; the pump would then pump directly to the discharge line.

II.C. DISCHARGE PIPE SYSTEM

The sea water discharge system will consist of a single 15-inch, Sch 40 PVC pipe buried across the backshore and terminating within a natural fissure below the water line at the shore west of the Ihilani Resort (Figure II-3). The pipe has been sized to be half full during normal discharge rates. No special screen or any other structures are contemplated for the end of the pipe.

Approximately 200 feet of pipe will be located within the State Conservation District. The pipe will cross the City and County 40-foot setback. All of the discharge pipe will be located within the SMA.



IHILANI HOTEL GROUNDS - PLAN VIEW
SCALE 1" = 100'- 0"
LAGOON #1
IHILANI HOTEL
VEGETATION
BOULDER/ROCK FILL
SANDSTONE
SHORELINE
INFLUENT/INTAKE LOCATION
EFFLUENT/OUTLET LOCATION
FRACTURED SHELF
EFFLUENT PIPE ROUTE - PLAN VIEW
SCALE 1" = 100'
SOLID LIMESTONE SHELF
FRACTURED LIMESTONE SHELF
OUTLET IN NATURAL ROCK FISSURE
SHORELINE
HEAVILY TEXTURED
SMOOTH
CORAL BLOCK FILL
12" SCH 40 PVC PIPE
CORAL FILL
NOTE: BOULDERS DOTTED TO SHOW CLARITY OF PIPELINE. BOULDERS COVER PIPELINE.
EFFLUENT PIPE - ELEVATION VIEW
SCALE 1" = 100'
CLEANOUT PVC "Y" & PVC THREADED PLUG
HEAVILY TEXTURED
SOLID LIMESTONE SHELF
FRACTURED LIMESTONE SHELF
WATER LINE
12" SCH 40 PVC PIPE ENCASED IN CONCRETE
CORAL BLOCK FILL
CORAL FILL
INFLUENT PIPE ROUTE - PLAN VIEW
SCALE 1" = 100'
3'- 4' BOULDERS
CLEANOUT ACCESS
CONCRETE INTAKE BLOCK SEE SHEET 2
PRECAST CONCRETE CLASS 5, 12" PIPE (TYP) PROTECTIVE COVER
20' MITER JOINT 2 EACH
8" POLYETHYLENE PIPE
48 FT.
NOTE: BOULDERS DOTTED TO SHOW CLARITY OF PIPELINE. BOULDERS COVER PIPELINE.
EFFLUENT - SECTION A-A
SCALE 1" = 30'
RESTORE SURFACE COLOR & TEXTURE
KEEP NARROW 2' MAX.
18" MIN.
CONCRETE
12" SCH 40 PVC
EFFLUENT - SECTION B-B
SCALE 1" = 30'
RESTORE EXISTING CORAL ROCK COVER NOT ABOVE EXISTING GRADE
4' MIN.
12" MIN.
12" SCH 40 PVC
INFLUENT PIPE - ELEVATION VIEW
SCALE 1" = 100'
RESTORE EXISTING SURFACE
3'- 4' ROCK (EXISTING)
20' MITER IN POLYETHYLENE
FLANGE CONNECT TO PVC SHORE PIPES
8" POLYETHYLENE PIPE 2 EACH
PRECAST CONCRETE CLASS 5, 12" PIPE (TYP)
CONCRETE INTAKE BLOCK SEE SHEET 2
CLEANOUT ACCESS
MLLW
3' MIN.
INFLUENT - SECTION C-C
SCALE 1" = 30'
RESTORE SURFACE, NOT RAISED OR HUMPED
3' ROCK FILL
PRECAST CONCRETE CLASS 5, 12" PIPE (TYP) PROTECTIVE COVER
8" POLYETHYLENE PIPE (TYP)
18"
FIGURE II-3
HARDSCAPES HAWAII
IHILANI
SEAWATER INTAKE & EFFLUENT PIPES
PIPE LOCATION & LAYOUT
1 of 2

SECTION III.

ENVIRONMENTAL SETTING

III.A. 'EWA PLAIN - BARBERS POINT - WEST BEACH

West Beach is the western edge of the 'Ewa Plain located along the southwest shore of the Island of O'ahu 7 miles west of Pearl Harbor and southeast of the Waianae coast (see Figure I-1) adjacent to Kahe. The climate of this part of O'ahu is generally hot and dry. The average annual precipitation for the entire 'Ewa Plain is approximately 20 inches (Anon., 1980). Winds are predominantly from a northeasterly direction (i.e., the Northeast Trades, here offshore winds). Winds from a southeasterly direction (onshore) may be expected 5 to 8 percent of the time (USACOE, 1986).

Most of the West Beach Project site is located on limestone from a Pleistocene reef structure formed during stands of the sea higher than present sea level, mostly during the Waimanalo (+25-foot) stand of the sea (McDonald & Abbott, 1970). Along the inland boundary to the north, the limestone is interbedded with terrestrial alluvium. Together, the old reef material, marine sediments, and terrestrial alluvium form a caprock of variable permeability, but generally comprising a barrier which retards the movement of fresh water in the basaltic aquifer below the caprock and inland. Larger dredging projects, such as the Barbers Point Deep Draft Harbor and, to a lesser extent, the Ko Olina Lagoons, have raised concerns that deep cuts made into the raised reef would greatly increase the outflow of nutrient enriched, brackish ground water to the marine environment. While it appears that these features are areas of enhanced brackish outflow, particularly after major rainy periods, the long term environmental consequences have not been great.

Prior to development of the Ko Olina Resort complex, the west shoreline of the 'Ewa Plain was little utilized, except by shore fishermen, limu gatherers, and adventuresome body surfers. Access along the shore was from Kahe and Brown's Camp on the north, Barbers Point Beach Park and a few access roads that terminate behind the shore in Campbell Industrial Park on the south, and the old barge harbor and several cane field roads off Malakole Road in the middle sector. Construction of the Barbers Point Deep Draft Harbor severely restricted access to areas north of the new harbor because Malakole Road was ended at the south side of the new harbor. The Paradise Cove operation at the north end of Lanikuhonua has tended to restrict access southward from Brown's Camp and Kahe. Once all construction is completed at the Ko Olina Resort, public access to the water and shoreline should improve considerably. The lagoons at the resort will provide for beach and swimming activities previously not available along this coast except at privately-owned Lanikuhonua.

III.A.1. The Ko Olina Resort

The Ko Olina Resort (Figure I-2), formerly referred to as the West Beach Project, is an area of West Beach (Honouliuli) once used for sugarcane cultivation (about 420 acres) or was undeveloped (about 200 acres) which today is a planned urban center for hotel and apartment condominium developments (Anon., 1980; USACOE, 1986). Ko Olina Resort provides a developed infrastructure including roads and utilities, off-site landscaping of public access areas, man-made lagoons (actually coves) with beaches, and golf courses. Within the 620-acre site, Ko Olina Resort hopes to attract individual hotel and condominium projects to the amenities already established. The Ihilani Resort and Spa Project is one of the first of potentially several hotels to be constructed within the resort complex. A part of the requirements imposed on developments by Ko Olina Resort is the inclusion of water features.

Because the shoreline at West Beach is almost entirely a rocky one lacking sand beaches or other safe access to the water, a significant and necessary enhancement to attract resort development at Ko Olina are the four lagoons constructed behind the shore and connected to the ocean by a system of specially designed channels. The lagoons are patterned after similar natural features at Lanikuhonua, which previously provided the only occurrences of sand beach and sheltered swimming on this shore between Barbers Point Beach Park and Kahe Beach Park, a distance of almost six miles. The lagoons vary in size from 2 to 5.5 acres, but each is built along the same general plan as shown in Figure III-1 (drawing based on Lagoon 1). From the view of the visitor, each lagoon is a broad, curving sand beach and quiet, turquoise water. A complex of massive boulders and openings stretch across the far (seaward) side. The shape of the lagoon and the design of the several openings between the lagoon and the ocean enhance water circulation while maintaining a maximum amount of beach area. Each lagoon is connected to the ocean by two or more shallow channels and a single, deep central channel. Waves of almost any size impinging on this coast, break across the "wave shelves" establishing a flow of water into the lagoon. This inflow is compensated for by outflow through the deeper, "flushing channel". This channel is relatively narrow to limit the translation of large wave energies into the lagoon. The result is a good exchange of sea water between the lagoon and the coastal waters.

III.A.2. Project Area Terrestrial Environment

Around the lagoons and behind the natural limestone shoreline features, landscaping has transformed the former open kiawe (*Prosopis pallida*) forest and koa haole (*Leucaena leucocephala*) thickets into a park setting with concrete walkways, extensive lawn areas, and other amenities for the public and the residents and guests of the resort complex. Native strand plants (mostly beach naupaka, *Scaevola sericea*, and beach morning-glory, *Ipomoea pes-caprae*) have been planted in the buffer zone between the consolidated limestone (which does not support terrestrial pants) at the shore and the manicured lawns and garden areas of the resort promenade. The environment as restored in these buffer zones is very suitable for the strand plants selected. A multitude of coconut trees (*Cocos nucifera*) have been planted on the promenade grounds. An introduced coastal strand plant (*Mesembryanthemum* sp.) covers most of the graded slopes between the public promenade and the (planned) hotel and condominium grounds.

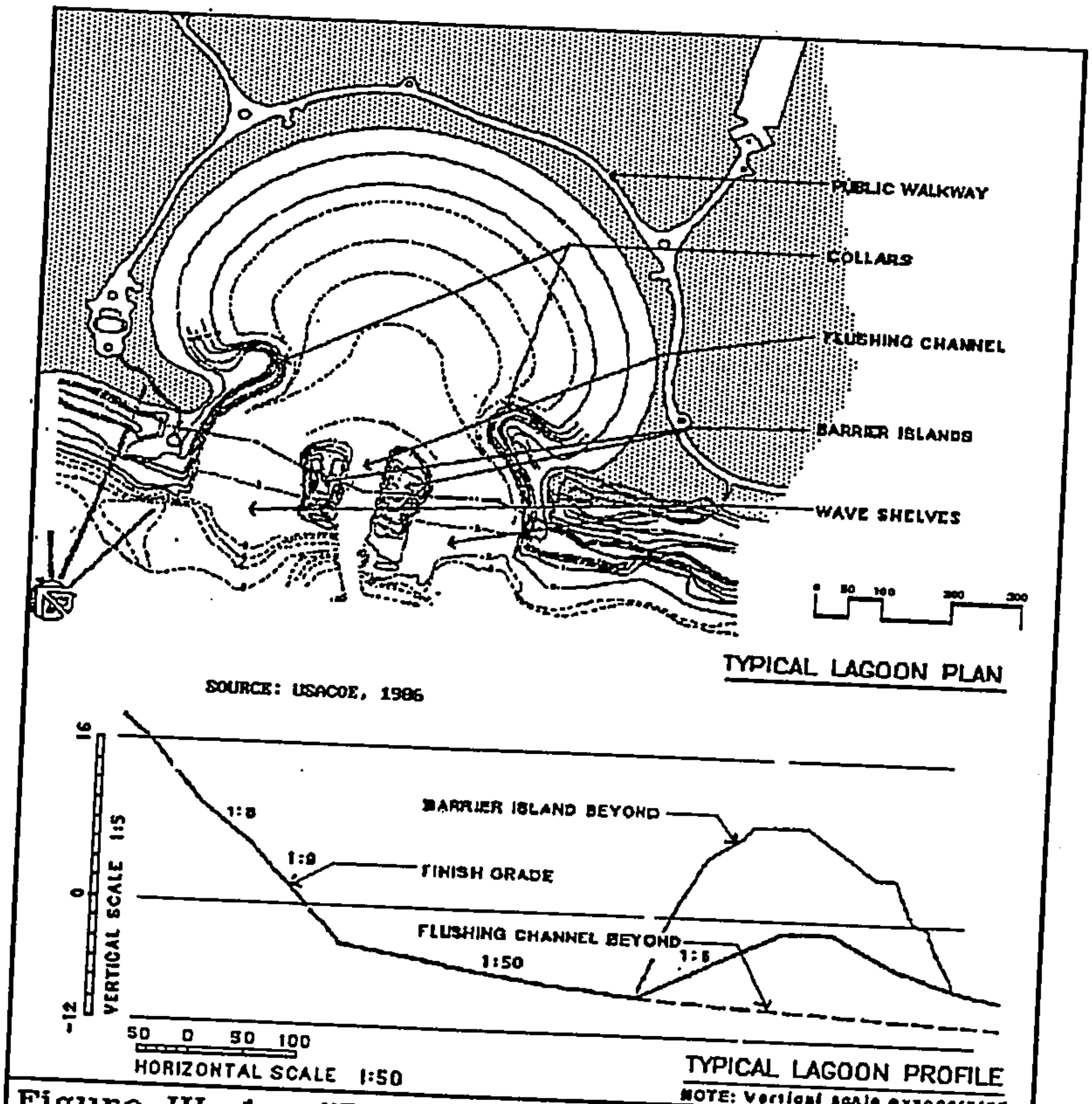


Figure III–1. "Typical" Lagoon at Ko Olina.

III.A.3 Historical Sites

An extensive survey of historical and archeological sites (PHRI, 1992) was undertaken for the Ko Olina Resort project of which the Ihilani Resort and Spa is a part. All of the sea water intake and discharge structures proposed for the Ihilani sea water system fall within the archaeologist's *ecozone* Ia described in the PHRI report as consisting of the "...low sand dunes fronting most of West Beach". Within this zone, in the general vicinity of the Ihilani, some habitation deposits and skeletal remains were found (sites 1438-4 and 1455). The actual sites appear to have been in the area now occupied by Lagoon 1 of the Ko Olina Resort or in an area south of Lagoon 1. All of the land across which both the intake and the discharge lines would be buried is fill land created as part of the general grading and site amenities created by West Beach Estates for the Ko Olina Resort. No coastal dunes remain in this area.

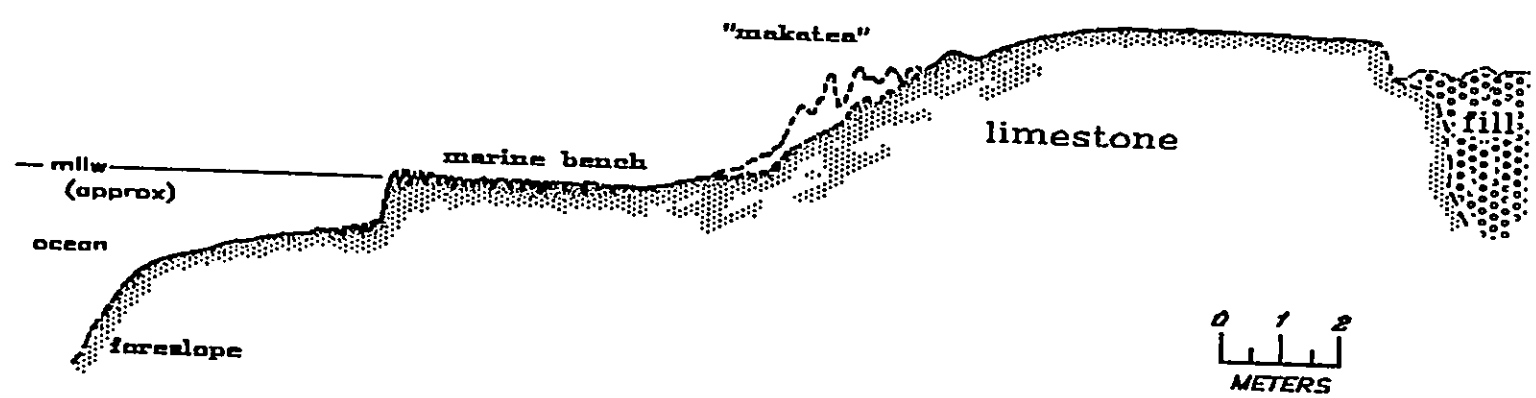
III.B. THE SHORELINE ENVIRONMENT

III.B.1. The Marine Bench

With very few exceptions, the entire shoreline of the West Beach area between Kahe Point and Barbers Point is limestone outcrop (AECOS, 1981), characteristically eroded at the shore as a solution bench (Wentworth, 1939) or level platform near sea level. In the vicinity of Ko Olina Lagoon 1, the limestone formation rises 2 to 3 meters above the water, and the solution bench is in places 2 to 3 meters (6 to 10 feet) across. The bench form is complex, the platform surface varying in absolute elevation from place to place by a few to several decimeters.

A profile of the limestone formation just north of the Lagoon 1 is depicted in Figure III-2 (after *AECOS*, 1991a). At this location the solution bench is divided into two parts: a forward or seaward portion which slopes downward and is continuous with the frontal slope, and a landward platform which is nearly level and separated from the former by a 0.5 meter high lip. Behind the solution bench is a short ramp rising to a pitted zone or zone of "makatea" limestone. The latter area is typified by pits, pools, and sharp-pointed ridges and spikes. Higher on the shore, the surface becomes more even, and eroded with rounded depressions, but lacking the sharp crests and spikes that typify the makatea surface.

The limestone formation separates the shoreline from more loosely consolidated and unconsolidated sediments of the 'Ewa Plain. The channels connecting the Ko Olina Lagoons with the ocean were made by cutting through selected portions of the limestone



SOURCE: AECOS, 1991a.

Figure III-2. Vertical profile of the limestone formation north of Ko Olina Lagoon 1 (based on leveling survey). Vertical exaggeration is 2x.

These cuts were made deep for the outflow channels, but the limestone was planned down to about -30 cm (-1-foot) below mean sea level to form the "wave shelves" intended to establish an inflow of water by a process known as wave set-up: the mass movement of water in the direction of the wave movement when a wave breaks across a shoal (see Tait, 1972).

III.B.2. Intertidal Biota

The limestone formation occupies all of the intertidal and extends downward into the subtidal. Marine plants and animals inhabiting the intertidal environment are distinctly zoned; that is, distributed in bands arranged parallel to the shoreline. This zonation pattern is the result of organisms responding to the different amounts of exposure and submergence related to elevation on the shore as the tide and waves move the water up and down. The biotic zone on any shore that is subject to the rise and fall of the tides is termed a littoral zone. A sublittoral zone encompasses those surfaces which are always submerged (that is, are subtidal) as well as those surfaces that might be exposed at the lowest tides when such tides are coincident with very calm seas, but are ordinarily always wetted by wave wash.

The littoral zone can be subdivided into a eulittoral zone and a littoral fringe. The littoral fringe extends upwards across the shore to the maximum elevation inhabited by marine organisms. This zone is the top of the limestone formation where the snail, *Littorina pintado*, is to be found in crevices and around the margins of small splash pools extending most of the way back across the high, nearly level surface. The shoreline blenny fish, *Istiblennies zebra*, inhabits these pools.

The boundary between the littoral fringe and the eulittoral zone below it is usually defined at the shore by the occurrence of barnacles. For tropical shores, the eulittoral is defined as extending from the upper limit of barnacles down to the first appearance of corals (Doty, 1957; Taylor, 1978). At West Beach the barnacle, *Chthamalus intertextus*, forms discontinuous and widely spaced patches within the makatea surface of the pitted zone. Overlapping the range of the *Chthamalus*, is the pulmonate limpet, *Siphonaria normalis*, the neritid snail, *Nerita picea*, and the littorinid snails, *Littorina pintado* and *Nodilittorina picta*. The latter two species extend up across the shore to higher elevations than the barnacles. Although hermatypic corals are not a common inhabitant of the limestone bench environment, very small heads of a common species, *Porites lobata*, can be found in widely scattered locations on the bench at West Beach. In similar situations elsewhere around O'ahu, the upper growth of corals is better demonstrated by their occurrence in large, well-flushed tidepools, where an upper limit of growth can usually be established at an elevation a little below the bench surface.

Establishing a boundary between the eulittoral and sublittoral is partly a matter of definition, but any definition must take into account the principals established for shoreline zonation schemes established in other parts of the world. Wentworth (1939) proposed that the solution bench owes its origin to the destructive erosion of an emergent limestone formation by fresh water dissolution (evidence for which is the "makatea" surface). The generally level aspect of the bench results where seawater has constant access to the rock surface, slowing or stopping dissolution and supporting constructive biological process: chiefly the growth of calcareous algae which preserve or rebuild the bench. Recognized more recently is the role of littoral fringe snails, feeding by scraping the surface for microscopic algae, in the erosion of the pitted zone. The fact that the solution bench surface is essentially always awash and is inhabited by marine algal species whose preferred habitats mostly extend downward into the sublittoral, argues that this surface is below the eulittoral zone.

By this reasoning, the eulittoral zone is inhabited by a few species of algae (e.g., cyanopytes and *Hincksia breviarticulata*), whereas the dense growth of fleshy species and coatings of calcareous red algae (mostly *Porolithon onkodes* on Hawaiian shores) are considered to be below the eulittoral zone (Taylor, 1978). However, because this zone is distinct from the sublittoral, where it is usually seen that fleshy algae decrease in abundance, the term sublittoral fringe is applied to the zone between the eulittoral and sublittoral. The sublittoral fringe (Stephenson, 1944; Doty, 1957) has been defined as the area of the shore between the lowest levels regularly exposed by spring tides and the lowest part ever or only rarely exposed to the air.

At the ocean shore by the Ihilani Resort, the top of the sublittoral fringe is marked by sparse growth of some macrophytes (*Hincksia breviarticulata* and *Chnoospora minima*), an abundance of vermetid molluscs (*Dendropoma gregaria*), and encrusting calcareous algae (*Porolithon onkodes*). Another invertebrate which typifies this zone, although not abundant at West Beach, is the chiton, *Acanthochiton viridis*. At a slightly lower level, the fleshy macrophytes become very abundant, as does the sea urchin, *Echinometra oblonga* (while much less numerous are *E. mathaei* and *Colobocentrotus atratus*). The inner (uppermost) subzone is characterized by the algae, *Laurencia* spp. and *Acanthophora spicifera*, the outer by *Pterocladia capillacea*. A variety of other algae species are present and discussed in greater detail in *AECOS* (1991a). Other common invertebrates in this zone at West Beach are the molluscs, *Morula uva*, *Drupa ricina*, and *Cypraea caputserpentis*. Less common are the octocoral, *Anthelia edmondsoni*, the molluscs, *Thais intermedia* and *Cypraea maculifera*, and a small white crab (Family Xanthidae). Numerous other invertebrates are abundant, notably amphipods and polychaetes, but these are too small and cryptic to enumerate in the field.

Marine algae are the most conspicuous biological components of the marine bench environment. A listing of the algal species observed in the littoral and upper sublittoral zones, that is, on the limestone bench, at West Beach is given in Table III-1. This table is modified from the species list presented in OI Consultants, Inc (1987) and includes those species recorded in 1988-89 (*AECOS* 1991a) (column 3), and those recorded by a University of Hawaii survey team in March through May of 1988 (column 2) from sites which ranged from off Lagoon 1 at the north to off Lagoon 4 at the south end of Ko Olina (Smith, 1988).

The shore and upper sublittoral on massive armor stones inside the lagoons harbor a less diverse assemblage of algae usually dominated by species of *Ulva*, *Enteromorpha*, *Porolithon*, and *Acanthophora*. In some areas, *Colpomenia sinuosa* and/or *Codium edule* may be found in the quiet waters within the lagoons on these boulder surfaces. Usually positioned high on the massive boulders will be *Hincksia breviarticulata* and/or *Cladophora* spp.

A number of qualitative surveys of macroalgae distribution on the marine bench at Ko Olina Resort are reported in *AECOS* (1992). Included in these surveys is the area of the proposed outlet pipe for the Ihilani Resort and Spa sea water system (see Figure III-3 for summary and relationship to other biological studies). Quantitative surveys of algae were conducted on the same marine bench, at the location indicated as "Sta. 1", close to the north entrance channel of Lagoon 1 (*AECOS*, 1991a; Smith 1988).

III.C. NEARSHORE BENTHIC BIOLOGICAL SURVEYS

III.C.1. Introduction

Because of the scope of the major developments which have been undertaken along this coast, notably the Barbers Point Deep Draft Harbor and the Ko Olina Resort, a number of benthic biological surveys have been completed in these waters. These studies have been recently discussed in Brock (1990) and *AECOS* (1990), and are summarized here in Figure III-4, a biotope map produced by Dr. R.E. Brock based upon several surveys of the offshore biota. As part of this environmental assessment a reconnaissance of the bottom directly seaward of the marine bench was undertaken for the purpose of providing environmental input to the process of selecting a discharge point.

III.C.2. Method of Present Site Survey

The objectives that may be considered desirable for the location of the outfall pipe are as follows: 1) Sufficient distance from the intake that recirculation of effluent will not occur.

Table III-1. West Beach/Ko Olina Limestone Bench Surveys, Algal Species List

Species	Common Name	Year 86	Year 88	Year 89-90
CYANOPHYTA				
Lyngbya sp.		x		x
CHLOROPHYTA				
Acetabularia sp.				x
Boodlea composita			x	
Boodlea sp.			x	
Caulerpa racemosa	ararucip	x		x
Chaetomorpha antennina	limu nohomahe	x	x	x
Cladophora fascicularis			x	
Cladophora patula			x	x
Cladophora patentiramea				x
Cladophora sp.		x	x	x
Cladophoropsis luxurians			x	
Cladophoropsis sp.				x
Codium arabicum			x	
Codium edule			x	
Dictyosphaeria cavernosa			x	x
Dictyosphaeria versluysi	limu lipuupuu	x	x	x
Enteromorpha sp.	limu 'ele'ele	x	x	x
Microdictyon setchellianum			x	x
Ulva fasciata	limu palahalaha	x	x	x
Valonia aegagropila			x	
PHAEOPHYTA				
Chnoospora minima		x	x	x
Colpomenia sinuosa	puha		x	x
Dictyota acutiloba	limu alani	x	x	
Dictyota bartayresii			x	x
Dictyota sandvicensis			x	x
Endarchne binghamiae		x		
Hincksia breviarticulata	limu hulu'ilio	x	x	x
Lobophora variegata		x		x
Mesopora pangoensis		x		x
Padina japonica	limu pepe-iao	x		x
Padina sp.		x		
Sargassum echinocarpum	limu kala	x	x	x
Sargassum obtusifolium			x	x

Table III-1. Continues				
Species	Common Name	Year		
		86	88	89-90
Sargassum polyphyllum			x	
Sphacelaria furcigera		x	x	x
Sphacelaria tribuloides				x
Turbinaria ornata				x
RHODOPHYTA				
Acanthophora spicifera		x	x	x
Amphiroa sp.		x	x	
Amansia glomerata	limu -iao	x	x	x
Asparagopsis taxiformis				x
Bornetella sphaerica			x	
Botryocladia skottsbergii			x	
Caulerpa racemosa			x	
Caulerpa serrulata			x	
Caulerpa sp.			x	
Centroceras clavulatum	limu kikala	x		x
Centroceras sp.			x	
Ceramium sp.		x	x	x
Champia sp.		x	x	
Chondria sp.		x		
Coelothrix irregularis			x	x
Corallina sp.				x
Dasya corymbifera			x	
Dasyopsis sp		x	x	x
Desmia hornemanni			x	x
Falkenbergia rufulanosa		x		
Gelidiella acerosa		x	x	x
Gelidiella sp.		x		
Gelidiopsis scoparia			x	
Gelidiopsis sp.		x		
Gelidium pusillum	limu loloa	x		
Gelidium sp.			x	
Gracilaria sp.		x		
Grateloupia hawaiiana		x		
Grateloupia phuquoensis			x	x
Grateloupia sp.			x	x
Gymnogongrus spp.			x	
Herposiphonia sp.			x	x

Table III-1. Continues

Species	Common Name	Year 86	Year 88	Year 89-90
Hydrolithon rheinboldi				x
Hypnea cervicornis	limu huna		x	x
Hypnea chordacea	limu huna	x	x	x
Hypnea musciformis			x	x
Hypnea sp		x	x	
Jania sp.	limu huluilio	x	x	
Laurencia majuscula			x	x
Laurencia nidifica	limu mane'one'o	x	x	x
Laurencia obtusa (?)		x		
Laurencia succisa	limu lipe'epe'e	x	x	x
Laurencia yamadana		x		
Laurencia spp.		x		
Lithophyllum sp.		x		
Martensia fragilis		x	x	x
Plocamium sandvicense		x		
Polysiphonia sp.		x	x	x
Porolithon onkodes		x		x
Porolithon gardineri		x		
Pterocladia caerulescens			x	x
Pterocladia capillacea	limu loloa	x	x	x
Spyridia filamentosa			x	x
Spyridia sp.			x	

2) Close proximity to the Ihilani waterscapes, yet removed from areas likely to be used by hotel guests or the general public. 3) Placement just beyond the intertidal zone, minimizing the extent of trenching required to lay the pipe and the impact of construction. 4) Discharging into relatively deep water close to shore in an area well mixed by waves and currents. 5) Distant from areas of live coral or other sensitive organisms that might be adversely affected by contact with the effluent.

A preliminary survey was conducted on May 13, 1992 along the shoreline from the northern entrance channel of Lagoon No. 1 to the cove and beach at Lanikuhonua just north of the Ihilani Resort site. Using snorkeling gear, an observer swam just off the intertidal bench and up to 50 m (165 feet) offshore to gain a perspective of the general layout of the area. Five sites (Figure III-3) were closely inspected for their degree of bottom relief, type of substratum, general benthic biological coverage and proximity to areas of live coral. Depths were measured at 5 and 10 m (15 to 30 feet) out from the seaward edge of the intertidal bench. Following the dive, measurements were made at each of the sites of the width of the intertidal bench from its outer lip to the makatea zone on the landward side.

Table III-2. Species of marine macroalgae indicated by letter codes on map shown as Figure III-3 (after *AECOS*, 1992).

SPECIES LIST CODES			
A	*Acanthophora spicifera*	G	*Gelidiella acerosa*
Af	*Amphiroa fragilissima*	H	*Hypnea musciformes*
Am	*Amansia glomerata*	Hc	*Hypnea chordacea*
Br	*Bryopsis plumosa*	j	*Jania* sp.
C	*Chnoospora minima*	K	*Asparagopsis taxiformis*
Ca	*Chaetomorpha antennina*	L	*Laurencia* spp.
Cd	*Codium edule*	Lc	*Laurencia crustiformans*
Ce	*Centroceras* sp.	M	*Mesopora pangoensis*
cl	*Cladophora* sp.	P	*Pterocladia capillacea*
Cp	*Colpomenia sinuosa*	Pd	*Padina japonica*
Cr	*Caulerpa racemosa*	Pg	*Porolithon gardineri*
D	*Desmia hornemanni*	Po	*Porolithon onkodes*
Dc	*Dictyosphaeria cavernosa*	Pt	*Pterocladia caerulescens*
Dv	*Dictyosphaeria versluysi*	S	*Sargassum echinocarpum*
Dy	*Dictyota* spp.	Sy	*Spyridia filamentosa*
e	*Enteromorpha* sp.	T	*Turbinaria ornata*
E	*Hincksia breviarticulata*	U	*Ulva fasciata*

III.C.3. Reconnaissance Survey Results

The general structure of the shoreline opposite the Ihilani Resort and Spa site is a consolidated limestone bench 2 to 10 m (6 to 30 feet) wide with a more or less level surface that is awash at low tide. Shoreward of the intertidal wash zone is the makatea zone where dissolving and precipitation of limestone by fresh water forms large solution pits and sharp spikes in the substratum. Outside of the bench a wall drops steeply along most of the shoreline, but in places the wall slopes more gradually at about 45°. Massive limestone blocks that have apparently broken away under extreme wave assault are common just outside the bench front. Further outside at distances of 15 to 20 m (50 to 65 feet) the reef becomes shallow, generally only 1 to 2 m (3 to 6 feet) deep. At the south end of the survey area near the lagoon channel entrance, a series of small spur and grooves occurs that moderately resembles those found on the frontal slopes of well developed coral reefs.

Below the intertidal zone, which is dominated by a profusion of algal species and boring sea urchins (*Echinometra* spp.), the bench wall is generally barren of macrofauna due to the substantial water turbulence that is a controlling factor in this zone. For most of the

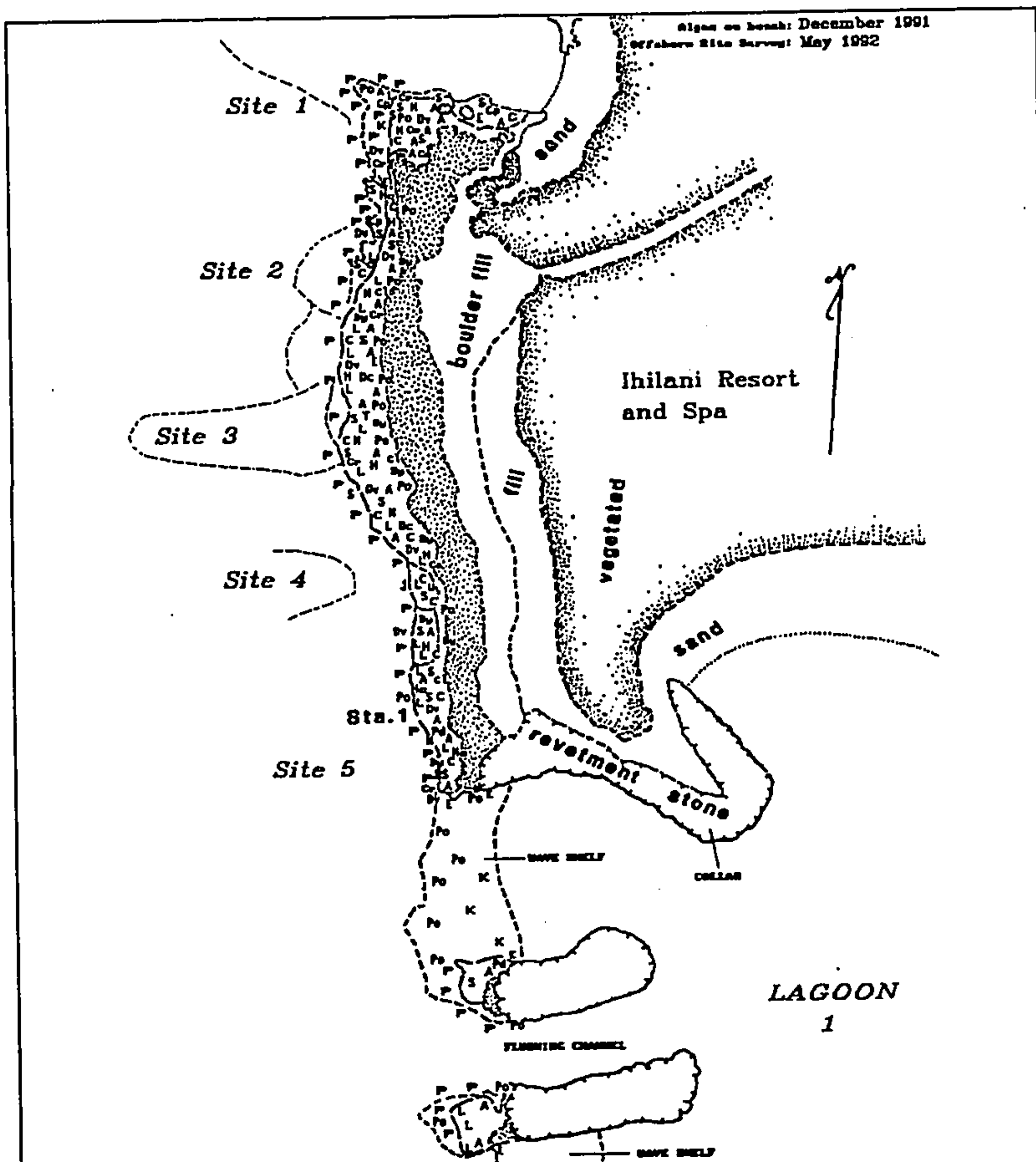


Figure III-3. Map of the West Beach shoreline at Ko Olina Lagoon 1 and immediate vicinity of the Ihilani Resort and Spa. **Letter symbols** on limestone bench indicate distribution of dominant species of macroalgae in December 1991 (see text Table III-2 for legend). Sites 1 to 5 are areas of nearshore reconnaissance survey discussed in text Section III.C.3. Sta. 1 is AECOS (1990, 1991a) quantitative bench biota station.

area a sparsely inhabited limestone bottom extends for considerable distance offshore, where finally a coral reef assemblage typical for a leeward Hawaiian Island environment occurs. However, in the grooves at the south end of the survey area reef corals can be abundant within 5 to 10 m from the seaward edge of the limestone bench. Specific observations at each of the five sites shown in Figure III-3 are as follows.

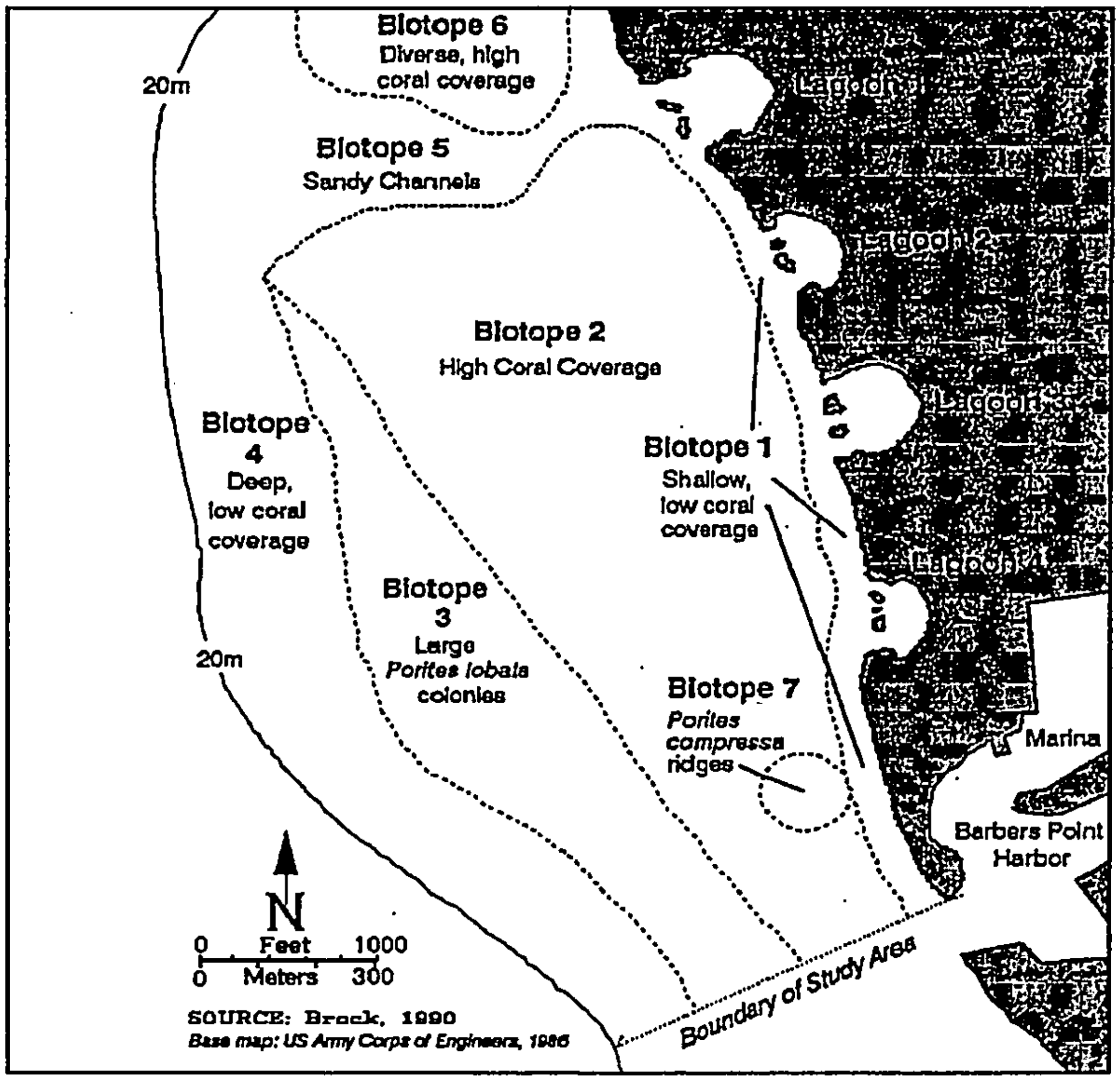


Figure III-4. Map of West Beach offshore area showing seven biotopes described in Bienfang and Brock (1980) and Brock (1987, 1990) The biotopes reflect ecologically significant differences in water depth, coral coverage, coral species, and substratum types.

Site 1. Limestone bench width 5 m. Depth 5 m from shore = 2.5 m
10 m from shore = 3.0 m.

Site 1 is just south of a shoal area that extends seaward as a point and defines the northern limit of the intertidal bench, this being here broken by the southernmost cove at Lanikuhonua. Massive limestone blocks extend outside of the bench edge, where depth increases immediately to a platform 2.5 m (8 feet) deep which is barren of coral or other conspicuous macrofauna. Nearest significant coral growth is 15 to 20 m (50 to 65 feet) from the bench and comprised of an area of nearly 50% coverage of encrusting *Porites lobata*.

Site 2. Limestone bench width 7 m. Depth 5 m from shore = 2.0 m
10 m from shore = 1.0 m.

Site 2 is similar to Site 1 except the frontal wall of the bench slopes more gradually to a boulder area about 10 m (30 feet) off the bench, then another reef platform at 2 to 2.5 m (6 to 8 feet) depth extends further offshore to an area of live coral, again some 15 to 20 m (50 to 65 feet) offshore. Substratum of frontal slope and platform is barren of conspicuous macrofauna out to the coral area which has 30 to 40% cover by *Porites lobata* and *Pocillopora meandrina* at 1 to 2 m (3 to 6 feet) depth.

Site 3. Limestone bench width 10 m. Depth 5 m from shore = 1.75 m
10 m from shore = 0.5 m.

At Site 3 a wide broken shelf drops to 1.75 m (5.7 feet) at 5 m (15 feet) from the front edge of the bench, shoals to 0.5 m (1.6 feet) depth at 10 m (30 feet) from the bench, then slopes down again to 2 m (6 feet) depth at 15 m (50 feet) offshore. The shelf is barren except for a few heads of the corals *Pocillopora meandrina*, *Montipora flabellata* and *Palythoa tuberculosa*. Significant coral coverage begins at 25 m (80 feet) offshore where cover is 10-20% of mostly *Pocillopora meandrina* with some *Porites lobata*.

Site 4. Limestone bench width 7 m. Depth 5 m from shore = 3.2 m
10 m from shore = 2.5 m.

Site 4 is an area of small spurs and grooves outside of a medium width bench. Depth in the grooves right next to bench exceeds 3 m (10 feet), shoaling to about 2 m (6 feet) further outside. The frontal slope or wall is barren, but the soft coral, *Palythoa tuberculosa*, is found right next to wall base in the channel, and 10% cover of *Porites lobata* and *Montipora flabellata* occur within 5 m (15 feet) of the wall. Further offshore the groove reef substratum shoals to 1.5 m (5 feet) and has high coverage of coral, mostly *Porites lobata* and *Pocillopora meandrina*.

Site 5. Limestone bench width 6 m. Depth 5 m from shore = 1.2 m
10 m from shore = 3.0 m.

The bench at Site 5 is a narrow sloping platform outside of which is a small spur and groove system only 1 to 2 m (3 to 6 feet) deep in the grooves. Some *Pocillopora meandrina* heads are growing on the platform and high (50%) coral cover of *Porites lobata, Pocillopora meandrina,* and *Palythoa tuberculosa* occurs only 5 to 10 m (15 to 30 feet) from the front edge of the bench. Coral becomes more abundant 15 m (50 feet) offshore reaching perhaps 80% cover at a depth of 2.5 m (8 feet).

III.C.4. Summary of Observations

Considering proximity to the hotel site, distance from areas of human water activities and the proposed point of intake of sea water, a narrow limestone formation and intertidal bench, proximity to good offshore relief, and distance from areas of significant coral growth, Site 1 is clearly the optimum location for placement of an outfall structure for water used in the Ihilani waterscapes. Site 1 is closest to the hotel but in an area that will not have much human traffic, has the narrowest intertidal bench width, good relief and proximity to deep water, and no substantial coral growth within 15 m (50 feet) of the front of the bench. The following ranking of the surveyed sites considering all of the qualities listed above is from best to worst as an outfall site: Site 1> Site 2> Site 4> Site 3> Site 5.

III.D. WATER QUALITY

III.D.1. Histrorical Measurements of Water Quality Off West Beach

Several long term water quality studies and a number of short-term studies have been conducted in conjunction with coastal zone construction activities along the western portion of the 'Ewa Plain between Kahe and Barbers Point. Most significant in terms of generating water quality data were: 1) the Barbers Point Deep Draft Harbor and Deep Draft Harbor Channel construction, and 2) the Ko Olina Resort lagoons construction. More recently, water quality data have been collected for assessments of a proposed new storm drain for Campbell Industrial Park and Kapolei Business-Industrial Park (*AECOS*, 1991b).

This marine area was not well represented in an early, defining survey of water quality around the island of O'ahu (Dillingham Environmental Co., 1971). An ocean station (Station 15) located offshore, south of Barbers Point was ranked 4th best out of 57 locations. The ranking is not surprising considering that compared parameters included salinity range, temperature range, water clarity, BOD, and coliform bacteria counts, with most of the other stations located along the shore and in embayments and estuaries. Total nitrogen and total phosphorus values reported for Station 15 (as average annual values) were 0.124 mg N/l and 0.026 mg P/l.

Preconstruction water quality measurements for the Barbers Point Deep Draft Harbor project are provided in ECI (1975). The results of nutrient analyses at five stations established along a line from inside the Barbers Point Barge Harbor to an offshore point where water depth was 25 meters (82 feet) are shown plotted in Figure III-5. This graph demonstrates the transition from an area strongly influenced by ground water influx (waters within the old barge harbor) to essentially open ocean conditions. Distances (in meters) are measured from the back shore of the old harbor.

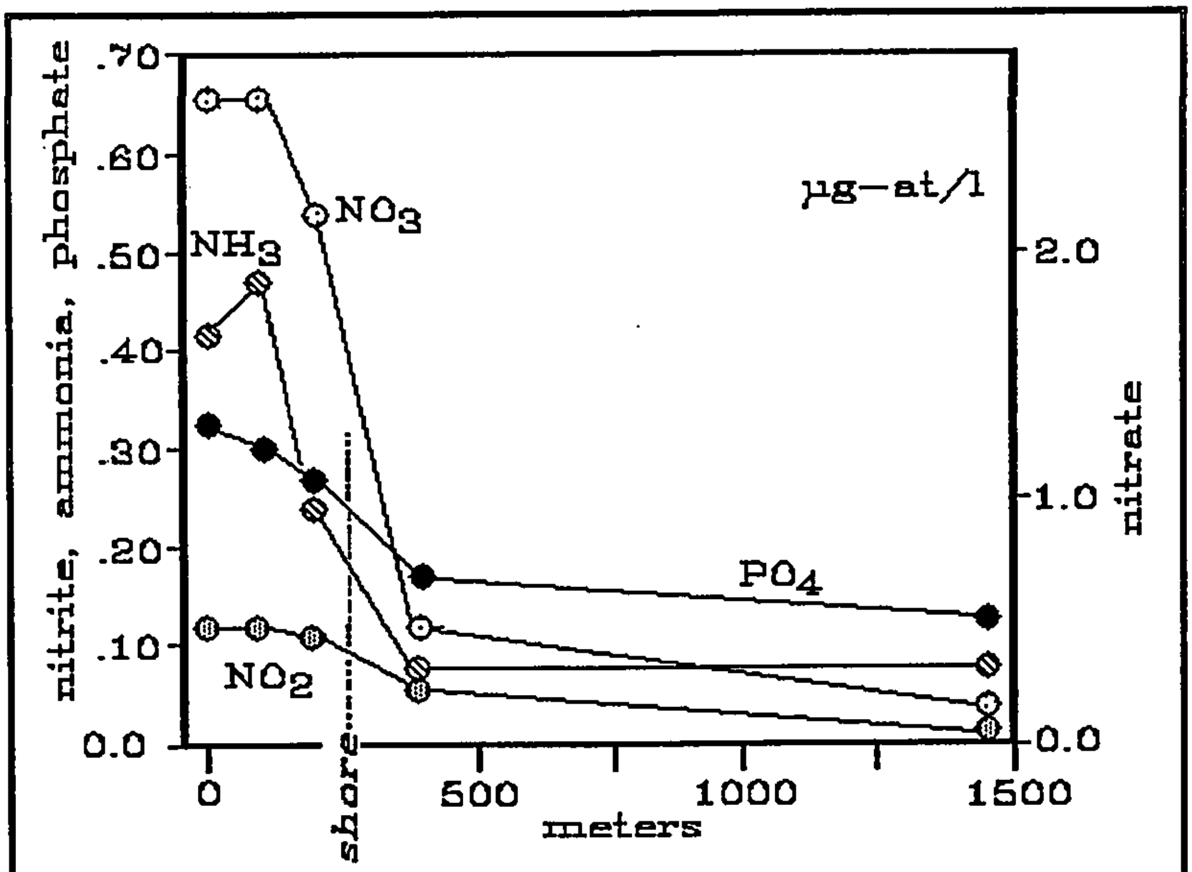


Figure III-5. A plot of mean nutrient concentrations at stations located inside the old Barbers Point Barge Harbor (left) and extending out to offshore (right). "Shore" is entrance to harbor. Note units are molar quantities. (After ECI, 1975).

Preconstruction water quality measurements for the Ko Olina (West Beach) project are provided in Bienfang and Brock (1980). These data encompass the area from near the barge harbor north to the vicinity of Kahe. The results of nutrient analyses at nine stations (with several depths sampled at some stations) are summarized in Table III-4. The findings were discussed in part as follows (Bienfang and Brock, 1980):

> The.. water quality data... describe a pristine, unperturbed coastal region. Temperature and salinity values are indicative of open, well-flushed coastal areas which are minimally affected by surface run-off. Water clarity is excellent overall; the bottom is clearly visible at nearly all areas..... with the possible and/or occasional exception of the nearshore southern [near harbor] areas.

Table III-4. Range of nutrient concentrations in the waters off West Beach from a *sampling at nine stations in November 1979* (after Bienfang and Brock, 1980).

Nitrate + Nitrite	0.0004	—	0.026	(mg NO_3+NO_2-N/l)
	0.286	—	1.86	(µM N/l)
Ammonia	0.0017	—	0.029	(mg NH_4-N/l)
	0.121	—	2.07	(µM N/l)
Phosphate	0.0022	—	0.010	(mg PO_4-P/l)
	0.071	—	0.322	(µM P/l)

Two points are further detailed in the discussion: 1) that the water quality is generally poorer to the south; and 2) that the data provide indications of ground water percolation along the shoreline. With respect to the water quality south of the West Beach area:

> The water quality parameters which appear to show some compromise in the south [i.e., towards the barge harbor] relative to the northern stations [i.e., towards Kahe] are turbidity, nitrite, phosphate, ammonium and chlorophyll. The enhanced levels of those criteria suggest that the area is presently under the influence of waters of poorer quality coming from the south. It is not possible to say whether or to what degree the origin of these waters is the...Barge Harbor, the...Refinery, or Pearl Harbor. Observations...indicated that definable areas of more turbid waters (occurring nearshore) from the south can be seen moving north under falling tide conditions.

The during construction and post-construction water quality monitoring for the Deep Draft Harbor channel are summarized in *AECOS* (1986). Most of the monitoring effort for the harbor project involved measurements of turbidity and suspended solids, resulting in a large data base for this location. Table III-5 summarizes turbidity and suspended solids data from this area obtained prior to the start of the deep draft harbor project.

Table III-5. Estimated ambient turbidity and suspended solids concentrations (geometric means) for the Barbers Point area (after *AECOS*, Inc. 1982 and 1986).

Sub-Area	Turbidity (NTU)		Suspended solids (mg/L)	
	mean	std. dev.	mean	std. dev.
Harbor entrance (Station 2)	3.3	±2.1	4.2	±2.7
Nearshore waters (Stations 1 & 3)	1.3	±2.3	4.2	±2.7
Mid-reef waters (Stations 4-6)	0.7	±0.5	2.1	±1.3
Offshore waters (Stations 7-9)	0.4	±0.2	1.4	±0.4

Surveys of water quality continued off the West Beach (Ko Olina) shore with sample collections over a wide area encompassing 12 stations in 1986 and repeated in 1990 (OI Consultants, 1987, 1990). The offshore area covered by these stations is essentially the same as the area covered by the benthic biology studies shown in Figure III-4. Water quality results from these efforts are summarized in Table III-6. In the 1986 survey, mean levels of turbidity, chlorophyll α, ammonia, total nitrogen, and total phosphorus all exceeded water quality criteria for "dry" coastal areas (OI Consultants, 1987). The results of the 1990 survey indicated that only mean phosphate levels exceeded state water quality criteria (OI Consultants, 1990). These calculated "means" in both cases are based on spatial, not temporal, data. Thus the relationship of the ambient water quality and the state water quality standards can only be inferred because the standards apply to time series data that encompass the range of conditions that typify a given location.

Time series measurements from the construction and post-construction periods for the Ko Olina lagoons have been published by S.E.A., Ltd. (1987-1990) as part of the West Beach Monitoring Program (WBOMP) reports. These measurements cover approximately monthly sample collections for a period from September 1987 through 1990. This extensive data set has yet to be summarized. However, OI Consultants (1990) plotted the nearshore nitrate plus nitrite and turbidity values over time. The plots show that the nearshore water exceeds both the nitrate + nitrite (0.0035 mg/l) and turbidity (0.2 NTU) geometric mean criteria essentially all of the time, with or without "events" related to natural circumstances (rainfall) or construction activities.

Table III-6. Summary of water quality conditions at West Beach, Oahu. Values are geometric means of all samples collected on the specified date.

Month/Day Year	1980[1]	8/26 1986[2]	9/10 1986[2]	4/07 1990[3]	4/08 1990[3]
Diss. Oxygen (% sat)	99	91	99	104	97
pH (pH units)	—	8.11	8.13	8.29	8.26
Light Ext. Coeff.(k units)	—	0.17	0.11	0.15	0.19
Turbidity (NTU)	0.2	0.4	0.2	0.3	1.0
NFR (mg/L)	—	6.27	1.77	3.77	5.93
Ammonia (mg N/L)	0.013	0.011	0.021	0.006	0.013
Nitrate (mg N/L)	0.001	0.005	0.002	0.002	0.002
Total N (mg N/L)	—	0.154	0.118	0.163	0.143
Orthophosphate (mg P/L)	0.002	0.005	0.002	0.005	0.005
Total P (mg P/L)	—	0.018	0.021	0.014	0.013
Chlorophyll α (μg/L)	0.36	0.45	0.34	0.19	0.20

1 — Bienfang and Brock, 1980.
2 — OI Consultants, Inc., 1987
3 — OI Consultants, Inc., 1990

A set of three water samples were collected on May 21, 1990 from an area south of the Barbers Point Harbor (south side of Camp Malakole) which is 9000 feet (2700 meters) south along the coast from the Ihilani Resort site. Samples were collected directly at, 500 feet north of, and 500 feet south of a proposed drainage outlet location (Stations S1, S2, and S3 respectively) and analyzed for many of the parameters included in the State of Hawaii, water quality criteria (DOH, 1989). The results of the analyses are presented in Table III-7. Also measured were salinity (by refractive index) and temperature. Salinity varied between 35.5 and 36.5 ppt (essentially sea water); temperature ranged from 26 to 26.5°C.

Table III-7. Results of water quality sampling from selected coastal sites in the vicinity of Camp Malakole, Barbers Point, Oahu. Samples collected on 05/21/90 from the seaward edge of the marine bench (i.e., shore samples).

Station	pH	Turb.	NO_2+NO_3	NH_4	Total N	Total P	Chl α
S1	8.34	1.78	0.003	0.012	0.37	0.03	0.56
S2	8.34	0.99	0.002	0.004	0.19	0.01	0.47
S3	8.32	1.10	0.003	0.001	0.20	0.01	0.44

Units:
Turbidity — NTU
Nutrients — ppm (e.g., ammonia in mg NH_3-N/L)
Chlorophyll α — ppb (mg/m^3 or μg/L)

Collections of baseline water quality data have continued offshore of a proposed drainage structure for the Kapolei Business/Industrial Park through Cambell Industrial Park. For these recent samples, measurements were made at distances of 460, 800, and 1180 feet (140, 245, and 360 meters) along a line extending offshore from the drainage outlet location. The results of two sample events are presented in Table III-8. The October 1991 measurements were obtained under conditions of clear skies, little or no wind (onshore at 1 mph), and small ocean swell (1 to 2 feet). Conditions in April 1992 included overcast skies, moderate NW Trades (15 to 20 mph), and 3 to 5 foot swells from the northwest.

III.D.2. Water Quality Patterns and Trends

To better illustrate water quality conditions off the Ihilani Resort with respect to differences which might exist between nearshore and offshore areas, the values reported for samples collected on two consecutive days in April 1990 by OI Consultants, Inc. (1990) were used to recalcultate average values for the stations grouped by distance from shore (Table III-9). These data represent water quality measurements well distributed in space, although of very limited distribution in time. The stations in this study were spread across an area of approximately 1 by 1 km, arranged in four "transects" extending seaward, each transect having three stations. All of the samples from a station, representing two days and three depths, have been included in the calculations. The results illustrate that gradients exist for most of the parameters along onshore-offshore lines. Even temperature seems to show a subtle decrease with distance offshore, although this change is really due to the greater depths of the near bottom samples in the offshore data set. In their summary, OI Consultants (1990) reported significant variation with depth only for temperature and dissolved oxygen (and phaeopigments).

Table III-8. Baseline water quality measurements for the proposed drain off of the west shore of Barbers Point and Campbell Industrial Park.			
	STATION		
	1	2	3
Offshore distance (meters)	140	245	360
pH (pH unit)			
10/31/91	8.20	8.22	8.19
03/12/92	8.00	8.03	8.04
Turbidity (ntu)			
10/31/91	0.94	0.87	0.74
03/12/92	0.66	0.69	0.66
NFR (mg/l)			
10/31/91	3.5	2.0	2.1
03/12/92	4.8	7.4	4.2
Ammonia (mg N/l)			
10/31/91	0.008	0.008	0.008
03/12/92	0.006	0.006	0.005
Nitrate+Nitrate (mg N/l)			
10/31/91	0.004	0.004	0.005
03/12/92	0.004	0.005	0.005
Total Nitrogen (mg N/l)			
10/31/91	0.149	0.118	0.109
03/12/92	0.151	0.152	0.108
Orthophosphate (mg P/l)			
10/31/91	0.010	0.008	0.006
03/12/92	—	—	—
Total Phosphorus (mg P/l)			
10/31/91	0.031	0.036	0.028
03/12/92	0.006	0.004	<0.001
Chlorophyll α (μg/l)			
10/31/91	0.41	0.49	0.36
03/12/92	0.48	0.56	0.51

The most significant gradients appear to be those of turbidity and nitrate plus nitrite. An increase in the clarity of the water with distance offshore is expected and further supported here by the total suspended solids (nonfilterable residue) and light extinction coefficient values. However, chlorophyll α decreases only slightly offshore, indicating that turbidity nearshore is caused by suspended particulates from land drainage and/or wave action on the shore and shallow bottom rather than biological productivity. The decline in nitrate plus nitrite offshore is a reflection of the decreasing influence of terrestrial water (as ground water or runoff) on the marine environment. All of the nutrient values, including total nitrogen and total phosphorus, are higher near the shore than offshore. The differences in total nitrogen can be accounted for by differences in nitrate and ammonia concentrations. While the gradients revealed by these data are probably real, it is interesting to note that as much variation appears to be present in the data sets for the two sampling dates (see Table III-6) as for the data grouped by distance from shore.

Table III-9. Summary of 1990 water quality data collected off the West Beach (Ko Olina) coastline grouped by distance from shore.

	Nearshore Stations	Middle Stations	Offshore Stations
Distance (meters)	100-140	330-480	665-985
Depth (meters)	0.5-4.5	0.5-8.5	0.5-13.0
Temperature (°C)	24.9	24.6	24.3
DO (mg/l)	6.88	6.78	6.93
pH (pH units)	8.26	8.28	8.29
Light Ext.Coeff. (k)	0.31	0.17	0.10
Turbidity (ntu)	1.55	0.49	0.22
TSS (NFR)(mg/l)	6.10	4.67	3.70
Ammonia (µg N/l)	10.54	8.44	8.57
Nitrate (µg N/l)	4.47	2.75	0.76
Total N (µg N/l)	157	152	150
Orthophosphate (µg P/l)	5.21	5.03	4.95
Total P (µg P/l)	17.0	11.8	12.4
Chlorophyll α (µg/l)	0.200	0.190	0.187

NOTE: Distance from shore and depth are ranges; Temperature, dissolved oxygen, pH, light extinction coefficient are mean values; All others are geometric mean values (n=24).

A discussion of water quality trends with time is also possible given the many samples collected from off this coast during the past 15 years. The geometric mean of the three turbidity values (Table III-7; 1990) from the shoreline near Camp Malakole is 1.24 NTU, essentially agreeing with "ambient" turbidity for nearshore water as presented in Table III-5 (1982 & 1986). The value is also consistent with the geometric mean turbidity of 1.2 NTU derived from post-construction (Deep Draft Harbor) monitoring of coastal waters in 1985 as reported in *AECOS* (1986). Somewhat lower turbidities (0.33 NTU) were reported (ECI, 1975) for the waters off the old harbor and for the waters north of the harbor (from 0.17 to 1.0 NTU) by Bienfang and Brock (1980) and OI Consultants (1990)

(Table III-5). However, turbidities were also lower off the area south of the harbor in the most recent samples taken (Table III-8).

The nutrient values from immediately off the shore (Table III-7) and from further seaward (Table III-9) south of the harbor tend to be somewhat lower than values from some of the earlier surveys. For example, higher nitrate plus nitrite (0.006 — 0.026 ppm) and ammonia (0.002 — 0.017 ppm) values were measured by Bienfang and Brock (1980) considering only their nearshore samples (Table III-4 gives ranges of all samples, Table III-6 gives the geometric means for all samples). In these data sets, neither phosphate nor ammonia showed a pattern of increasing concentration with closer proximity to the shoreline, although both older (see Figure III-5) and more recent (see Table III-9) surveys have. The ammonia and the nitrate plus nitrite levels measured in 1990 from the nearshore environment (Table III-7) are comparable to the 1986 and 1990 mean values (Table III-6) reported by OI Consultants (1990). Nearshore values off the Ko Olina Lagoons tracked by S.E.A., Ltd. (1987-1990) were higher, usually always between 0.004 and 0.015 mg N/L.

The two sets of chlorophyll α values reported for 1991 and 1992 (Table III-9) from south of the harbor are close to the chlorophyll α values for the inshore part of this same area in 1990 as given in Table III-7, and are slightly lower than the 1985 post-construction coastal value of 0.73 μg/L reported in *AECOS* (1986) from outside the deep draft harbor. Bienfang and Brock (1980) reported values between 0.11 and 0.31 μg/L from the waters north of the harbor, with the higher values occurring nearer to shore. The 1987 and 1990 surveys by OI Consultants (1990) also produced slightly lower mean values (see Table III-6).

The available data for this area has seldom been collected in a manner which permits ready comparisons with the State of Hawaii, Water Quality Criteria (DOH, 1989, 1992). Storm runoff and high surf conditions are not well represented in these data, yet tend to produce elevated values in comparison with those presented above for many of the parameters. Time series data, provided in the WBOMP reports, were plotted by OI Consultants (1990) for monthly turbidity and nitrate+nitrate measurements between 1987 and 1990. These nearshore measurements from off the Ko Olina lagoons during their construction nearly always exceeded the corresponding geometric mean criteria. More significantly, major rainfall events and wet periods in general appear to have an influence on the values to some degree. These data sets have otherwise not been summarized. The available data for this part of the ocean off O'ahu are not insubstantial, and conclusions are required even if subject to revision when new data are reported. Table III-10 provides in column 1 the range of values believed to be typical for coastal waters in this area based on the more recent measurements discussed above. The water quality is primarily that of the nearshore area, but not that found at the shoreline or in the immediate vicinity of influencing entities such as the Barbers Point Harbor.

Included in Table III-10 are the State of Hawaii, Water Quality Standards pertinent to these waters (i.e., the open coastal waters, perennially dry coast criteria). A criterion is presented in **bold** typeface if it is considered probable that the value would be exceeded by the waters under consideration. A larger data set would be needed to actually establish whether any particular criterion is exceeded. Not included in this table are site values for dissolved oxygen, temperature, and pH for which criteria have been promulgated.

Table III-10. State of Hawaii, Department of Health water quality criteria for open coastal waters applicable to the Barbers Point area.

Parameter	Project Site Approximate Range	State of Hawaii Criteria Geometric Mean Not to Exceed	Not to Exceed 10% of the Time	Not to Exceed 2% of the Time
Total Nitrogen (μg N/L)	110-157	**110.00**	180.00	250.00‡
Ammonia Nitrogen (μg NH_4-N/L)	8 - 10	**2.00**	**5.00**	**9.00‡**
Nitrate + Nitrite (μg NO_3+NO_2-N/L)	3 - 5	**3.50**	10.00	20.00‡
Total Phosphorus (μg P/L)	ND - 35	**16.00**	**30.00**	45.00‡
Light Extinction Coefficient (k units)	0.1 - 0.3	**0.10**	0.30	0.55‡
Chlorophyll α (μg/L)	0.2 - 0.5	**0.15**	0.50	1.00‡
Turbidity (ntu)	0.6 - 1.5	**0.20**	**0.50**	1.00‡

Criteria in bold print are those possibly exceeded by the waters off of West Beach and the west side of Barbers Point (see text).
‡ — Criteria values for a perennially dry coast.

Dissolved oxygen in these waters is nearly always close to saturation (the criterion limit is 75% of saturation). Temperature is ambient, and in the absence of specific effluent induced changes in water temperature, recorded values cannot violate an ambient standard. The pH is within the range (7.6 to 8.6) considered acceptable. The most recent (proposed) water quality standards (DOH, 1992) include an exception to the lower limit for pH allowing for coastal locations receiving inputs from streams, storm drains, and ground water discharges to record a minimum pH of 7.0. The salinity standard is, like temperature, an ambient standard.

SECTION IV.

ENVIRONMENTAL IMPACTS

This section discusses the environmental impacts of the construction and use of the proposed sea water intake and discharge system and structures. Construction impacts are essentially the impacts resulting from the placement across the shore and back shore of the intake and discharge pipe systems. Use or operational impacts are the impacts that would result from the draw of sea water into the intake lines and the discharge of the sea water after flowing through the water features at the Ihilani Resort and Spa.

IV.A. CONSTRUCTION IMPACTS

Because all of the land behind the shore across which the intake and discharge pipes must run to connect to the water features at the Ihilani has been recently modified and landscaped, no significant impacts will occur as a consequence of construction in this area. The pump house as well will be built within the landscaped grounds that surround Ko Olina Lagoon 1 (see Figure I-3 and Figure II-1). Construction activities related to the intake and discharge piping will involve approximately 30 days. The landscaped area is presently within designated construction areas for the Ko Olina lagoon and for the Ihilani Resort and Spa. Thus, no disruption of public access or use will occur. Upon completion of the structures (buried pipes and sunken pump house), landscaping will be restored to the condition existing prior to the start of construction.

The intake line will cross the shoreline through a man-made revetment of large boulders. A crane will be required to remove these boulders temporarily until the intake pipe and intake structure are put into place. The boulders will then be repositioned. Thus, a minor, temporary disruption of marine assemblages residing on the boulders will occur. Substrata and habitat will be returned to existing condition upon completion of construction.

Construction of the discharge line is anticipated to be somewhat more complicated. The discharge line will cross an area of boulder fill between the vegetation line and the limestone outcrop at the shore. This crossing will be accomplished by removal of boulders and trenching as required. Once the pipe is in place, the rock fill will be returned to cover the trench. A narrow trench, on the order of 20 inches across and 1 to 6 feet deep, will have to be cut through the limestone at the shore (Figure II-3). After the pipe is placed within the trench, a concrete material will be used to fill the trench and reconfigure the surface to match the surrounding limestone surface. Hardscapes Hawaii, Inc. specializes in creating surfaces out of various materials which match natural rock surfaces in color, texture, and durability.

Erosion of the limestone is a complex process representing a balance between dissolution by rain water, deposition by calcareous organisms (mostly *Porolithon onkodes* here), mechanical erosion by waves moving sand and stones across the surface, and mechanical erosion by various animals (e.g., *Echinometra* and *Littorina*). The concrete section is expected to closely resemble the natural stone, but probably will react differently to the errosive processes acting on the site. The result may be that after several decades, the surfaces (natural vs concrete) may not precisely match. Such uneveness, on the order of several inches, would not be unusual on the marine bench where low ridges and escarpments are common, some defining pool areas which retain water and thus promote dense coverage by macroalgae.

During trenching, a small section of the marine bench and it's flora will be disrupted. Recovery is expected to occur within several weeks to months of placement of the concrete. The area of impact is insignificant in comparison with the bench segment which exists between the northern entrance to Lagoon 1 and the cove at Lanikuhonua (see Figure III-3). Similar habitat exists along several miles of coastline between Kahe Point and Barbers Point. No permanent habitat loss is predicted. The replaced surface will provide a substratum for attachment utilized by most or all of the same organisms that are typically found on the adjacent limestone.

IV.A.1 Historical Sites

Impacts on historical and archaeological sites or resources will not occur because the project site is almost entirely fill land. Trenching for the pipelines and excavation for the pump house are not expected to exceed the depth of recent fill in the project area. Only at the point where the discharge pipe crosses the limestone formation at the shore, will a pre-development surface be subjected to excavation. The nature of the limestone formation and close proximity to the sea provide reasons to assume an absence of artifacts in this area.

IV.B. OPERATIONAL IMPACTS

Operational impacts are those long term impacts that are a consequence of the operation of the water features at the resort. Because the water features will be designed for continuous water flow, the water supplied by the intake system will be routed through the ponds and discharged after an average residence time of 6 hours or less. Two types of operational impacts are considered: 1) physical impacts arising from water motion set up by the pumping system, and 2) water quality impacts off the discharge point arising from physico-chemical changes in the water as it flows through the water features.

IV.B.1. Physical Impacts

Physically, the water drawn by pumps at the intake point and this same water discharged at the outlet point will be of insufficient volume or force to have any physical consequences on the environment at either location. The physical forces generated by the outflow will be quite small by comparison with the natural wave forces which regularly *impinge on the shore and nearshore botom in this location.*

Placement of the intake structure within the boulder revetment is intended to insure that a suction area is not accessible to swimmers. The outer part of the lagoon where the intake is to be located, is not an area to be used by swimmers or waders. The ends of the intake pipes will draw from a manifold structure cast in a concrete block. The maniflold will reduce suction pressure at each of the multiple intake ports to about the pressure which develops in a home bathtub drain.

IV.B.2. Water Quality Impacts

The quality of the water discharged from the water features at the Ihilani Hotel will be a consequence of both the quality of the water supplied and any changes which occur as the water flows through the system. The discharge may need to be permitted under the National Pollution Discharge Elimination System. The quality of the supply water is known from various studies conducted along this coast as summarized in Part III.B. This water will not differ in any respects from the receiving water.

In order to assess the potential for changes in water quality within the planned Ihilani Resort system, a study of the water quality in similar man-made systems was undertaken (Appendix B). Two systems at the Mauna Lani Hotel on the Kona Coast, Island of Hawaii were studied, initially (June 1991) over a 12-hour period and then again (in May 1992) over a 24-hour period. Discrete samples were collected from inlet (labeled IN) and outlet (labeled END) points on the Bungalows and Lobby pond systems at the Mauna Lani. A variety of water quality parameters were measured to assess differences attributable to the flow of water through systems of shallow pools, waterfalls, relatively large resident populations of marine fishes, and natural algal growth on surfaces within the water features. The Bungalows System has a volume of about 1.2 million gallons and a water residence time of 8 to 9 hours; the Lobby System is smaller, about 23,000 gallons, and has a residence time of just over one hour. These systems utilize well water as a source, and discharge into a sump (water samples from which are labeled SUMP) where the water percolates back into the highly permeable lava flows near the shore. The results of the study are presented in Appendix A and summarized below.

At least some of the parameters (such as pH and dissolved oxygen) showed fairly clear differences between day and night samples indicating diurnal patterns which follow expected cyclical changes for these parameters in aquatic environments. However, a summary comparison of the inlet and outlet values herein utilizes average (mean or geometric mean) values (see Table IV-1). A geometric mean is used for some of these data in part because the State of Hawaii, water quality criteria are based upon the log-normal distribution for which a geometric mean is appropriate.

Averaged numbers for the temperatures recorded at the inlet and outlet sides of the systems will combine both daytime heating and nighttime cooling of the water as it flows through a system. The increase of nearly 2 C° between inlet and outlet seen in May 1991 is certainly influenced by the fact that measurements were made only during daylight hours. The results of the 24-hour sampling in 1992 suggests a smaller average increase in temperature occurs in the ponds. A curious result of the measurements is the higher average temperature of the well water in 1992 as compared with 1991.

The pH of the water changed hardly at all between inflow and outflow when measurements are reduced to averages. While both arms of the Bungalows system produced a pH 0.1 unit less than the inlet water, the sump value (just below the outlet measuring points) averaged the same as the inlet water. The Lobby system average was 0.1 unit higher at the outlet than at the inlet. Curiously, despite the difference in salinity of these two fishpond systems, the pH values were not very different and about 0.3 to 0.5 units below typical open ocean values. A desirable pH range (Spotte, 1979) for maintaining animals in both brackish and sea water systems is 8.0 to 8.3. The low pH in these systems is a consequence of chemical reactions within the ground water body and thus not easily remedied.

The suspended solids (NFR) did increase as the water flowed through the systems, but results were highly variable. Considering the nature of the systems, variation in suspended solids is expected. The release of particulates depends upon a number of managed and unmanaged factors, and "typical" values will probably be difficult to define for these systems without collecting numerous random samples over a long period of time.

Average oxygen in the water was increased across a diurnal cycle in the Bungalows system, but not in the Lobby system. The difference is probably related to the reduced photosynthetic activity in the indoor Lobby System as compared with the outdoor Bungalows System.

Table IV-1. Summary of water quality data for two flow-through pond systems at the Mauna Lani Resort (Mean and Geometric Mean Values).

PARAMETER	IN(1)	END(1)	IN(2)	END(2)	SUMP
	SAMPLE LOCATION				
JUNE 1991 BUNGALOWS (n=4)					
Temperature (°C)	21.8	23.4	21.7	23.9	23.1
NFR (mg/L)	—	5.7	—	5.6	4.5
DO (mg/L)	4.7	6.2	6.1	6.8	9.3
NO_3+NO_2 (mg N/L)	0.087	0.002	0.089	0.004	0.002
NH_4 (mg N/L)	0.002	0.008	0.001	0.008	0.006
Total N (mg N/L)	0.179	0.165	0.152	0.202	0.161
PO_4 (mg P/L)	0.041	0.024	0.046	0.026	0.024
Total P (mg P/L)	0.043	0.035	0.046	0.041	0.034
MAY 1992 BUNGALOWS (n=8)					
Temperature (°C)	25.1	25.8	25.2	26.5	25.9
pH	7.8	7.7	7.8	7.7	7.8
NFR (mg/L)	0.9	2.6	0.7	5.8	3.8
DO (mg/L)	3.4	5.0	3.5	4.6	4.9
NO_3+NO_2 (mg N/L)	0.129	0.096	0.151	0.067	0.092
NH_4 (mg N/L)	0.005	0.018	0.006	0.007	0.008
Total N (mg N/L)	0.230	0.217	0.242	0.224	0.193
PO_4 (mg P/L)	0.051	0.045	0.055	0.032	0.039
Total P (mg P/L)	0.044	0.048	0.055	0.045	0.042
Chlorophyll α (µg/L)	—	2.35	—	2.89	1.44
MAY 1992 LOBBY (n=8)					
Temperature (°C)	25.6	26.0			
pH	7.8	7.9			
NFR (mg/L)	1.1	2.4			
DO (mg/L)	5.4	5.1			
NO_3+NO_2 (mg N/L)	0.664	0.624			
NH_4 (mg N/L)	0.006	0.009			
Total N (mg N/L)	0.812	0.763			
PO_4 (mg P/L)	0.075	0.095			
Total P (mg P/L)	0.064	0.062			
Chlorophyll α (µg/L)	—	1.56			

Temperature values are means; pH values are means of log scale values (= geometric means); all other values are geometric means; n = number of samples.

A fairly substantial reduction in inorganic nitrates and phosphates observed in 1991 in the Bungalows System was not so great in 1992, presumably because of real differences in the dynamics of the primary producers (algae) in the systems. Owing to management practices or perhaps "natural" cycles, the uptake of inorganic nutrients changes with time in these systems. Possibly contributing to the results reported herein was a greater concentration of nitrate plus nitrite in the well water in 1992 as compared with 1991. On the other hand, ammonia, a product of aquatic animal excretions, increased in all cases. The total N and total P results are variable, with slight average increases in some cases, and slight average decreases in all others. The 24-hour measurements suggest a decrease in total N as water flows through the system. About half of the total N is accounted for as inorganic nitrate, nitrite, and ammonia. If this result is correct, the systems must show an increase in fixed nitrogen and carbon with time as the attached algal biomass increases. An increases in the biomass of herbivores would account for some of the uptake. Obviously, a complete budget would need to consider mass loadings over a long period of time and include material (algae and particulates) removed during cleaning of the ponds and biomass gains by the pond's resident populations.

IV.B.3 Effluent Water Quality

Assessing the impacts of an effluent on the environment requires knowing or predicting the quality of that effluent. The system proposed for the Ihilani Resort and Spa will bring water in from Ko Olina Lagoon 1, water collected in an area that is constantly renewed by wave action. The effluent will be this supply water with whatever changes are imposed during the 6 hour residence time within the water feature. Measurements from the coastal waters (Part III.D) provide a characterization of the water to be drawn into the system. Because of the relatively high turnover rate, the characteristics of the intake water will be paramount in determining the quality of the effluent.

Measurements from the Mauna Lani pond systems provide an indication of the changes in water quality that can be expected in the proposed Ihilani Resort system. Table IV-2 attempts to combine these sources of information to predict the quality of the effluent in relation to the applicable water quality criteria (DOH, 1989, 1992) for the waters off the Ihilani Resort. While some of the parameters in the effluent may exceed certain water quality criteria, such values would be the result of the nearshore water not meeting the same criteria. Anticipated increases in the levels of ammonia and suspended solids (or NFR - no longer a parameter in the water quality regulations for open coastal waters) as water flows through the Ihilani system, will be diluted to essentially background by the initial dilution accomplished at the end of the effluent pipe (zone of initial dilution or ZID). From a physico-chemical perspective, no zone-of-mixing would be required for the proposed discharge.

IV.B.4 System Operation and Maintenance Activities

The sea water system will have two pumps with separate intake lines to allow maintenance on one side while the other side remains in operation. Beyond the pump house, single lines feed into and out of the ponds. For the most part, maintenance will require some attention to removing fouling from the intake area. The intake manifold is designed to allow direct access to the intake line. Mechanical removal of fouling would have no adverse consequences on the environment. Scrapings of biological fouling would either become part of the sedimentary bottom near the intake or be carried into the pond, possibly requiring later removal by hand.

Table IV-2. Predicted effluent characteristics in relation to the State of Hawaii, Department of Health water quality criteria for open coastal waters (perennially dry coast).

	INFLUENT	EFFLUENT	**State of Hawaii Criteria**		
Parameter	Estimated Ranges		Geometric Mean Not to Exceed	Not to Exceed 10% of the Time	Not to Exceed 2% of the Time
Total Nitrogen (μg N/L)	110-157	80-140	**110.00**	180.00	250.00
Ammonia Nitrogen (μg NH_4-N/L)	8 - 10	10	**2.00**	**5.00**	**9.00**
Nitrate + Nitrite (μg NO_3+NO_2-N/L)	3 - 5	2	3.50	10.00	20.00
Total Phosphorus (μg P/L)	ND - 35	14	16.00	30.00	45.00
Light Extinction Coefficient (k units)	0.1 - 0.3	NA	0.10	0.30	0.55
Chlorophyll α (μg/L)	0.2 - 0.5	0.3	**0.15**	0.50	1.00
Turbidity (ntu)	0.6 - 1.5	1.0	**0.20**	**0.50**	**1.00**

Criteria in bold print are those possibly exceeded by the proposed effluent without consideration of any zone of initial dilution (see text).

Most significant maintenance problems involve the removal of excessive growth of fouling-type organisms from the ponds to maintain a visually pleasing water feature. Experiences of similar systems in Hawaii have been quite variable with respect to excessive growth of fouling organisms, particularly of the green benthic algae (Chlorophyta, usually *Cladophora*, *Enteromorpha*, and/or *Ulva*). Systems that have particular problems in this regard are those with high nutrient inputs (some flow-through systems using ground water) and those with insufficient densities of herbivores. The sea water systems at the Mauna Lani Hotel (see Appendix B), which are well managed and appear to harbor large numbers of herbivorous fishes, nonetheless require some hand removal of benthic algal growth about once a month. At the Ihilani Resort and Spa, higher growth rates of attached chloropytes may occur in the rainy months when nutrient concentrations rise in the nearshore waters. "Blooms" of *Cladophora*, *Enteromorpha*, and *Ulva* do occur on the marine bench environment of the West Beach shore (*AECOS*, 1991a, 1992).

Hand removal of fouling organisms will prevent most of this biological material from becoming entrained in the effluent. Further, the Ihilani water features will drain over weirs with the water then passing through basket strainers. The strainer screens will catch all larger particulates in the effluent. All such material removed from the water will be disposed of on land. Smaller particulates generated by cleaning activities are not pollutants in the nearshore environment. These particulates will not settle out to form a layer on the bottom off the outfall. The considerable and nearly constant wave action will disperse particulates, which will become indistinguishable from the natural particulates generated as waves break across the marine bench environment all along this shore.

Similar marine waterscape systems do feed the animals kept in the ponds. At the Mauna Lani, Purina Trout Chow is added daily in an amount which leaves no visible residual. Once a week, chopped fish is fed to the predators in the system. Sea turtles are fed lettuce. The majority of fishes kept in these systems are herbivores and obtain food by cropping the algal growth on the sides and bottoms of the ponds. Because the outflow is via overflow weirs, only floating food would have much opportunity to exit the system before being eaten.

C. WATER QUALITY MONITORING

The permit process for the proposed outfall structure and discharge of sea water from the waterscapes at the Ihilani Resort and Spa will require critical review of the water quality implications of the project. The discharge plume would be difficult to model for several reasons: 1) the density difference between the discharge and the receiving water is expected to be slight or insignificant; 2) the important mixing processes at the outfall will be from breaking waves and not unidirectional currents; and 3) the end of the pipe is proposed for a physically complex area in which bottom effects on plume movement will be substantial. A significant part of this Environmental Assessment is devoted to present both qualitative and quantitative estimates of the discharge and receiving water quality. The small differences between the discharge and receiving waters and the considerable physical mixing activity at and just off the shore, suggest that the discharge will not be readily distinguishable within a few meters of the end of the pipe. Nonetheless, it is reasonable to expect that this lack of impacts be demonstrated by a monitoring program.

Following is a water quality monitoring plan as submitted to the Department of Health in compliance with the 401 Water Quality Certification process.

The monitoring program proposed would measure the following water quality characteristics:

Temperature	Total nitrogen
Salinity	Ammonia nitrogen
pH	Nitrate + nitrite nitrogen
Suspended solids (NFR)	Total phosphorus
Turbidity	Chlorophyll α

These physical and chemical characteristics would be obtained from samples collected at three or four locations:

1) The north entrance channel to Ko Olina Lagoon No. 1 in the immediate vicinity of the sea water intake manifold. This sample will be used to define the quality of the ocean water supplied to the salt water ponds.

2) The salt water ponds on the grounds of the Ihilani Resort & Spa in an area close to the discharge collection point <u>or</u> the water in the discharge pipe before discharge. This sample would characterize the effluent from the salt water ponds.

3) The shoreline in the immediate vicinity of the discharge pipe outlet. This sample would characterize the coastal waters influenced by the outfall (within the Z-o-M).

4) The shoreline outside the north entrance channel to Ko Olina Lagoon No. 1 at a point approximately 650 feet south of the outlet. This sample would characterize the coastal waters outside of the Z-o-M and may replace the location 1) sample once it is demonstrated (as anticipated) that water quality at these two locations is essentially the same.

Samples from several points surrounding the Z-o-M are not anticipated because the true Z-o-M will be limited to a small area around the outlet. Samples from location 3) are expected to demonstrate an absence of water quality impacts resulting from the discharge. Should initial results prove otherwise, additional sample locations may have to be added at points along the shore on either side of the discharge point to define the dimensions of the Z-o-M. Note that this approach is actually more stringent than ordinary Z-o-M monitoring because samples from directly adjacent to the outlet are anticipated to reveal no significant deviation in water quality when compared with the Station 1) and Station 4) results representing the natural background conditions.

Sampling frequency is proposed to be twice per month (or approximately fortnightly). Sampling would begin one month prior to actual construction. A report would be prepared at the end of 12-months of sampling, detailing the results and providing recommendations concerning the need for additional sampling. Because this activity involves a discharge permit, the monitoring program, DMRs, and future monitoring activities will come under requirements imposed by the NPDES and Z-o-M programs. It is anticipated that the monitoring program proposed here will be incorporated into these requirements.

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APPENDIX A

COMMENTS AND CORRESPONDENCE

AECOS
970 N. Kalaheo Avenue, Suite C311 • Kailua, Hawaii 96734
Telephone: (808) 254-5884

September 18, 1992

(DISTRIBUTION LIST)

Dear Sirs:

This letter is to introduce your agency to a project at the Ko Olina Resort (West Beach, Oahu - TMK 9-1-57:1) for which an environmental assessment is now being prepared. When completed, a draft EA will be circulated for your information. However, the law requires that agencies and groups with an interest in the project, be consulted during the EA preparation period. This letter provides basic information about the project and invites your comments and/or recommendations to insure that the draft EA is as complete as possible when circulated.

Included on the grounds of the Ihilani Resort and Spa (now under construction) are a number of water features, including 22,000 square feet of salt water "lagoons" (concrete-lined ponds between 1.5 and 3.5 feet deep). Attempts to find a source of high quality salt water from wells drilled on the property have not been successful. Although a recirculating system is an alternative that has been considered, a flow-through system is deemed preferable for a variety of reasons.

The EA will encompass the salt water transmission system, consisting of intake structure, pipes, pumps, pump housing, and discharge structure. The intake is proposed for an area of large revetment stones just inside the north part of Ko Olina Lagoon No. 1. This area would not be used by swimmers and receives good quality coastal water from waves entering the lagoon. The outlet structure would be located immediately off the shoreline along the seaward face of the limestone bench about 600 feet north of the intake. All structures would be buried and not visible (or located below the low tide line). The pumps would be located in an underground housing, only the cover of which will be visible.

The residence time of water moving through the ponds is designed at 6 hours. For this EA, studies were conducted on similar decorative pond systems having high flow-rates in order to anticipate the water quality of the discharge. In general, changes in water quality were found to be small in these types of systems, indicating that the quality of the discharge is mostly a function of the quality of the intake water. A survey of the water quality off the West Beach area has been conducted, allowing for reasonable estimates of the quality of the discharge water to be made. Biological surveys have been conducted in the area of proposed and alternate discharge points. Because the quality of the discharge will not differ markedly from the receiving water, minimal environmental impact will occur if the outlet is not extended very far seaward from the shore.

This project will involve obtaining permits from the U.S. Army Corps, DLNR, and DLU because the 8" polyethylene pipes extend across the shoreline set-back and down into State and Federal jurisdictions seaward of the certified shoreline, and some trenching will be required in this area. Operation of the system will require an NPDES permit.

Please provide written comments to the following address:

AECOS, Inc.
970 N. Kalaheo Ave., Suite C311
Kailua, Hawaii 96734
ATTN: Eric Guinther

Concerns or recommendations regarding the EA may be transmitted verbally by calling me at (808) 254-5884. I will also be happy to answer any specific questions about the project.

Sincerely,

Eric B. Guinther

RECEIVED OCT 2 1992

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

October 1, 1992

REPLY TO
ATTENTION OF

Operations Division

Mr. Eric Guinther
AECOS, Inc.
970 North Kalaheo Avenue, Suite C311
Kailua, Hawaii 96734

Dear Mr. Guinther:

This is in response to your September 18, 1992 letter regarding the Ihilani Resort and Spa at Ko Olina Resort, Ewa, Oahu. We understand that a number of water features, including 22,000 square feet of salt water "lagoons" are proposed. The lagoons will be constructed inland of the shoreline and will not be physically connected to the ocean.

A flow-through salt water transmission system is planned and will involve installation of intake structures, pipes, pumps, pump housing, and a discharge structure. The intake and discharge structures, as well as any pump installation below the mean high water line would require a Department of the Army permit. Plans and typical sections of all in-water work should be coordinated with the Operations Division to confirm permit requirements and determine the applicability of nationwide authorizations for the outfall structures. File No. PO 92-211 has been assigned to this project. Please refer to it in future correspondence or inquiries.

Sincerely,

Warren Kanai

for Michael T. Lee
Chief, Operations Division

AECOS
970 N. Kalaheo Avenue, Suite C311 • Kailua, Hawaii 96734
Telephone: (808) 254-5884

October 26, 1992

Department of the Army
U.S. Army Engineer District, Honolulu
Ft. Shafter, Hawaii 96858-5440

Michael T. Lee
Chief, Operations Division

RE: **File No. PO 92-211** - Ihilani Resort and Spa Sea Water Intake/Discharge System

Dear Mr. Lee,

Enclosed is a completed copy of the Draft EA for the subject project. Included are plans and specifications of all in-water work as requested by your letter of October 1, 1992. Should you desire to see enlarged drawings, etc. we will be quite pleased to provide them. We would appreciate your review of the subject material for the purpose of determining the applicability to the nationwide authorization for the structures as proposed and to confirm any Federal permit requirements. We have submitted applications to the City and County of Honolulu, DLU as required for the SMA and this process will result in their distributing the draft EA to all interested parties and agencies. More than likely, they will be requesting comments on the environmental assessment from the Army Corps. Also, we are aware of the need to obtain an NPDES permit before operating the system, and will be applying to the State of Hawaii, DOH for this purpose in the near future.

Sincerely,

Eric B. Guinther

encl: Draft EA "Ihilani Resort and Spa, Environmental Assessment for a Flow-Through Sea Water System"

RECEIVED NOV 6 1992

JOHN WAIHEE
GOVERNOR OF HAWAII

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

JOHN C. LEWIN, M.D.
DIRECTOR OF HEALTH

In reply, please refer to:
92-354/epo

November 4, 1992

Mr. Eric B. Guinther
AECOS, Inc.
970 N. Kalaheo Avenue, Suite C311
Kailua, Hawaii

Dear Mr. Guinther:

Subject: Pre-Environmental Assessment
Ihilani Resort and Spa
Ko Olina Resort
West Beach, Oahu
TMK: 9-1-57: 1

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

Clean Water

1. Information regarding the water feature should be provided. For example: the types of planned uses, stocking of plants, fish or other aquatic life, and operation and maintenance activities.

2. Information regarding the quality and quantity of the discharge and any anticipated impacts should be provided.

3. The construction associated with the proposed water feature may require a Section 401 Water Quality Certification (WQC). The Army Corps of Engineers should be contacted as soon as possible in order to determine if a Section 401 WQC is applicable to this project.

If you should have any questions on this matter, please contact Mr. Mark Tomomitsu of the Clean Water Branch at 586-4309.

Very truly yours,

[signature] for
JOHN C. LEWIN, M.D.
Director of Health

c: Clean Water Branch

92-04827

DEPARTMENT OF PUBLIC WORKS

CITY AND COUNTY OF HONOLULU

650 SOUTH KING STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

C. MICHAEL STREET
DIRECTOR AND CHIEF ENGINEER

FELIX B. LIMTIACO
DEPUTY DIRECTOR

ENV 92-232

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DEPT OF LAND UTILIZATION
CITY & COUNTY OF HONOLULU

November 12, 1992

MEMORANDUM

TO: MR. DONALD A. CLEGG, DIRECTOR
DEPARTMENT OF LAND UTILIZATION

FROM: C. MICHAEL STREET, DIRECTOR AND CHIEF ENGINEER

SUBJECT: ENVIRONMENTAL ASSESSMENT (EA)
KO OLINA SALT WATER SYSTEM
TMK:9-1-57:1

We have reviewed the subject EA and have the following comments:

1. We have no objections to the proposed salt water system.
2. The EA should address the impact of storm water discharges associated with construction activities on water quality of the receiving waters.
3. The EA should also state what structural or non-structural best management (BMP) will be provided to control and reduce the discharge of pollutants as outlined in the National Pollutant Discharge Elimination System (NPDES) regulations (40 CFR Part 122, Subpart B for municipal separate storm sewer systems).

C Michael Street

C. MICHAEL STREET
Director and Chief Engineer

AECOS
970 N. Kalaheo Avenue, Suite C311 • Kailua, Hawaii 96734
Telephone: (808) 254-5884

January 13, 1993

Department of Public Works
City and County of Honolulu
650 So. King Street
Honolulu, Hawaii 96813

Re: ENV 92-292

Attn.: C. Michael Street, Director

Dear Sir,

Thank you for responding to the Environmental Assessment for a proposed sea water intake and discharge system at the Ihilani Hotel at Ko Olina circulated by DLU. Your comments will be used to guide revision of the draft EA. However, allow me to respond directly to the points raised in your letter dated November 12, 1992.

1) Impact of storm water runoff discharges associated with construction activities.

The period of construction of the intake and discharge systems (pipes and pump housing) will require trenching over a period of two to four weeks, after which time the ground surface will be restored to the preconstruction configuration. Aside from the fact that this part of Oahu is infrequently impacted by rainfall resulting in runoff, surface flow at the site is mostly directed into an area of boulder fill which effectively filters runoff water before runoff water reaches the ocean. Under conditions of exceptionally high rainfall, some runoff from the area where trenching would occur might flood across the beach areas north and/or south of the hotel site. Spoil material from the trenching will be covered in the event of unusual rain to prevent losing this soil, which must be used to refill the trench as placement of pipes progresses. Excess soil from the excavation for the pump housing will be removed from the area soon after excavation. The site is presently landscaped, and the project must be undertaken in a manner that will cause minimal impact on the surrounding grounds.

2) Structural or non-structural best management (BMP) for municipal separate storm sewer systems.

Although the decorative water feature discharge would not seem to be definable as a storm sewer, no need exists to control and/or reduce pollutants arising from the rain water that falls on surfaces drained by this system. Only minor runoff from areas immediately around the marine pond system will flow into the discharge line. Rain falling directly on the ponds may cause some depression of the salinity, but because of the high flow rate, the impact will not be significantly different from that of the rain falling directly on the nearby receiving water. However, the discharge may be subject to other provisions of the Clean Water Act and the NPDES regulations.

Sincerely,

E. B. Guinther

Eric B. Guinther

cc: DLU, attn.: Ardis Shaw-Kim

JOHN WAIHEE
GOVERNOR

REX D. JOHNSON
DIRECTOR

DEPUTY DIRECTORS
JOYCE T. OMINE
AL PANG
JEANNE K. SCHULTZ
CALVIN M. TSUDA

IN REPLY REFER TO:

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
HARBORS DIVISION
79 SO. NIMITZ HWY. • HONOLULU, HAWAII 96813-4898

November 12, 1992 HAR-EP 9206.93

RECEIVED NOV 16 1992

Mr. Eric Guinther
AECOS, Inc.
970 Kalaheo Avenue, Suite C311
Kailua, Hawaii 96734

Dear Mr. Guinther:

Subject: Ihilani Resort and Spa
Ko Olina Resort, Oahu

Thank you for your letter dated September 18, 1992 notifying us of the subject project.

Per your discussion with the Harbors Division Planning staff, we will withhold our comments until we receive a copy of the draft environmental assessment.

Very truly yours,

Calvin M. Tsuda
Deputy Director for Harbors

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

REPLY TO ATTENTION OF

November 13, 1992

Operations Division

Mr. Eric B. Guinther
AECOS
970 N. Kalaheo Avenue, Suite C311
Kailua, Hawaii 96734

Dear Mr. Guinther:

This is in response to your October 26, 1992 request for a determination of the applicability of Corps nationwide authorization for the proposed Ihilani Resort and Spa Sea Water Intake/Discharge System, Ko Olina, Oahu, Hawaii. The in-water work includes installation of an intake manifold and polyethylene pipes within an existing basalt boulder revetment and termination of a 15-inch PVC discharge pipe below the water line at a natural fissure located at the shoreline, further upcoast.

Placement of the intake system would involve temporary removal of revetment boulders. The intake system design is intended to insure that neither persons, fishes, nor other animals can be held against any openings by suction created from the pumping action. The discharge pipeline would be buried and the trench backfilled to pre-existing contours, terminating at the shoreline and discharging into a fractured limestone fissure. In-water work for the discharge pipe is therefore minimal.

Based on this understanding, the work may be authorized under Corps Nationwide Permit authority at 33 CFR 330, Appendix A, Paragraph B.7., for outfall and associated intake structures. Issuance of this authorization is contingent upon the effluent from the outfall being authorized, conditionally authorized, or specifically exempted, or otherwise in compliance with regulations issued under the National Pollutant Discharge Elimination System (NPDES) program. Once you have obtained the NPDES permit, you should follow the notification procedures described in Appendix A, Paragraph C.13 of the enclosed nationwide regulations.

In addition, you must also obtain a Section 401 water quality certification from State Health Department and a Coastal Zone Management Consistency Determination from the Office of State Planning as explained in the enclosed Public Notice dated February 7, 1992. Application forms for these certifications are enclosed for your use.

Finally, as noted on page 6 of the Environmental Assessment, consultation with the National Marine Fisheries Service under Section 7 of the Endangered Species Act may also be required. The assessment does not discuss the possible construction period or operation impacts of the project on the green sea turtle. This evaluation should be included when you submit your notification, in accordance with paragraph 13.(b)(5)(i) of the nationwide regulations.

If you have any questions, please contact the Operations Division at 438-9258. File no. NW 93-008 has been assigned to this activity. Please refer to this number in future inquiries or correspondence

Sincerely,

for Michael T. Lee
Chief, Operations Division

Enclosures

Copies Furnished (w/o enclosures):

Clean Water Branch, Environmental Management Division, Dept. of Health, State of Hawaii, P.O. Box 3378, Honolulu, Hawaii 96801
Office of State Planning, CZM Program Office, P.O. Box 3540, Honolulu Hawaii 96811-3540
National Marine Fisheries Service, Attn: Eugene Nitta, 2570 Dole Street, Room 106, Honolulu, Hawaii 96822-3496

c141

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P.O. BOX 621
HONOLULU, HAWAII 96809

WILLIAM W. PATY, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTIES
JOHN P. KEPPELER, II
DONA L. HANAIKE

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

REF:OCEA:SKK

NOV 17 1992

FILE NO.: OA-2608
DOC. NO.: 1764

RECEIVED NOV 18 1992

Mr. Eric B. Guinther
Aecos
970 N. Kalaheo Ave. Suite C311
Kailua, Oahu 96734

Dear Mr. Guinther:

We have received your Conservation District Use Application for a sea-water intake system at Ko-Olina Resort, Oahu, Hawaii.

Because the project involves the use of State land, we are reviewing the proposal in terms of our programs and policies. Upon completion of this review, we will be notifying you of its acceptability or non-acceptability for processing.

Should you have any questions, please feel free to contact our Office of Conservation and Environmental Affairs staff at 587-0377.

Very truly yours,

John P. Keppeler
for WILLIAM W. PATY

Attachment: receipt for
filing fee

92-05005

JOHN WAIHEE
GOVERNOR

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

REX D. JOHNSON
DIRECTOR

DEPUTY DIRECTORS
JOYCE T. OMINE
AL PANG
JEANNE K. SCHULTZ
CALVIN M. TSUDA

'92 NOV 25 AM 9 59
... OF LAND UTILIZATION
CITY & COUNTY OF HONOLULU

IN REPLY REFER TO:

November 20, 1992 HAR-EP 9231.93

Mr. Donald A. Clegg, Director
Department of Land Utilization
City and County of Honolulu
650 South King Street
Honolulu, Hawaii 96813

Dear Mr. Clegg:

Subject: Environmental Assessment for Ko Olina Salt Water System

Thank you for the opportunity to review the subject environmental assessment.

We have no comments to offer as this project should not impact maritime facilities or ocean vessel traffic.

Sincerely,

for

Rex D. Johnson
Director of Transportation

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

REPLY TO ATTENTION OF

November 27, 1992

'92 NOV 30 AM 9 22

Operations Division

Mr. Donald A. Clegg
Director
Department of Land Utilization
City and County of Honolulu
650 South King Street
Honolulu, Hawaii 96813

Dear Mr. Clegg:

In response to your November 10, 1992 request, I have reviewed the Environmental Assessment prepared for the Ihilani Resort and Spa, Flow-Through Sea Water System, Ko Olina, Oahu, Hawaii. The in-water work subject to Corps regulatory jurisdiction includes (1) installation of an intake manifold and polyethylene pipes within an existing basalt boulder revetment and (2) termination of a 15-inch PVC discharge pipe below the water line at a natural fissure along the coastline.

The applicant's consultant has coordinated the plans with our office and has been advised that the work may be authorized under Corps Nationwide Permit authority at 33 CFR 330, Appendix A, Paragraph B.7., for outfall and associate intake structures. Issuance of this authorization is contingent upon the effluent from the outfall being authorized, conditionally authorized, or specifically exempted or otherwise in compliance with regulations issued under the National Pollutant Discharge Elimination System (NPDES) program.

In addition, the applicant must obtain the Section 401 Water Quality Certification from the State Department of Health and a Coastal Zone Management Consistency Determination from the Office of State Planning. Finally, he must provide evidence of consultation with the National Marine Fisheries Service regarding the presence of any Federally listed endangered or threatened species or critical habitat that may be affected by the project.

File No. NW 93-008 has been assigned to this project. Please refer to this number in any future inquiries or correspondence.

Sincerely,

Michael T. Lee
Chief, Operations Division

92-03537

OFFICE OF STATE PLANNING

Office of the Governor

MAILING ADDRESS: P.O. BOX 3540, HONOLULU, HAWAII 96811-3540
STREET ADDRESS: 250 SOUTH HOTEL STREET, 4TH FLOOR
TELEPHONE: (808)587-2846, 587-2800

FAX: Director's Office 587-2848
Planning Division 587-2824

Ref. No. P-3866

December 10, 1992

'92 DEC 14 AM 10 11
DEPT OF LAND UTILIZATION
CITY & COUNTY OF HONOLULU

The Honorable Donald A. Clegg
Director
Department of Land Utilization
City and County of Honolulu
650 South King Street
Honolulu, Hawaii 96813

Dear Mr. Clegg:

Subject: Environmental Assessment--Ko Olina Saltwater System, Ewa Beach, Oahu, TMK 9-1-57:1

We have reviewed the referenced document and have the following comments to offer for your consideration.

Water quality is an important environmental concern. A relevant Chapter 205A, HRS, Coastal Zone Management (CZM) policy is to "promote water quantity and quality planning and management practices which reflect the tolerance of freshwater and marine ecosystems and prohibit land and water uses which violate State water quality standards."

The Ihilani Resort and Spa project proposes a series of water features designed to utilize seawater in a flow-through system. The proposed system would draw approximately 1,000 gallons per minute of seawater from the ocean, circulate it through water features on the hotel grounds, and return the water to the ocean through an effluent discharge pipe. A total of 3,000 saltwater fishes are anticipated to be maintained in the series of water features. We are concerned about elevated levels of ammonia and suspended solids comparable to marine aquaculture facilities that may be present in the saltwater system effluent. Elevated levels of ammonia may stimulate algal blooms and damage marine life, while suspended solids may reduce water clarity and settle onto coral reefs. We recommend that a pre-filter be installed at the outfall to prevent organic materials from entering the ocean.

Thank you for the opportunity to comment. If you have any questions, please contact Carolyn Stewart of the Coastal Zone Management Program at 587-2879.

Sincerely,

Dan T. Kochi
for Harold S. Masumoto
Director

AECOS
970 N. Kalaheo Avenue, Suite C311 • Kailua, Hawaii 96734
Telephone: (808) 254-5884

January 13, 1993

Office of State Planning
P.O. Box 3540
Honolulu, Hawaii 96811-3540

Attn.: Mr. Harold S. Masumoto, Director

Dear Sir,

Thank you for providing comments on the Environmental Assessment for a proposed sea water intake and discharge system at the Ihilani Hotel at Ko Olina circulated by DLU. We have since submitted an application for Coastal Zone Management Consistency Determination which more directly addresses the concerns of the Coastal Zone Management Program. With respect to your concerns about water quality impacts, I point out that the degree of similarity between the proposed decorative water features and aquaculture, particularly with reference to the levels of ammonia and suspended solids in the effluent, was addressed in a special study undertaken for the EA. This study was attached as Appendix B and summarized in Section IV.B.2 of the draft EA document. The study concluded that decorative marine pond systems are generally not similar to aquaculture systems.

We will request that the system designers consider what kinds of effluent treatments might be practical in this situation. However, the results of water quality sampling from two existing systems as presented in Appendix B of the EA indicate that little would be gained by treatment because of the low levels of suspended solids and ammonia (and other constituents) anticipated in the effluent. The Ihilani system is designed to maintain densities of organisms comparable to those found naturally in the marine environment and avoid water quality problems by replacing the water within the ponds at a rate comparable to well mixed natural environments. This approach provides good water quality for the decorative feature and avoids loading the receiving waters with constituents (although natural) that require some measurable area to assimilate. A monitoring program as proposed in our Section 401 Certification application to DOH will be used to substantiate this assessment of no impact on receiving water quality.

Sincerely,

E.B. Guinther

Eric B. Guinther

cc: DLU, attn.: Ardis Shaw-Kim

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P.O. BOX 621
HONOLULU, HAWAII 96809

WILLIAM W. PATY, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

REF:OCEA:SKK

DEC 24 1992

FILE NO.: 93-302
DOC. NO.: 1956

'92 DEC 29 AM 8 21
LAND UTILIZATION
HONOLULU

The Honorable Donald Clegg, Director
Department of Land Utilization
City and County of Honolulu
650 South King Street
Honolulu, Hawaii 96813

Dear Mr. Clegg:

SUBJECT: Environmental Assessment (EA) for the Ko Olina Salt Water Intake System, Ewa Beach, Oahu, TMK: 9-1-57: 1

Thank you for giving our Department the opportunity to review this matter.

We have already commented on a preparation notice submitted to us (comments of 10/12/92, attached), for this proposal. In it we have already expressed concerns regarding trenching and turbidity and impingement. With this document, the concern of impingement is lessened because of the multi-port intake proposed for use.

However, there are several concerns which should be addressed. One concern is maintenance of the waterway. As with all systems that utilize raw seawater, all exposed surfaces will begin to foul with sessile organisms and marine algae. The applicant should discuss cleaning procedures that might be used, and how loosened debris and fouling matter would be screened and removed from reaching the sea. Further, larger seawater-use systems such as the system at the Hyatt Waikaloa Resort should be used to compare to this proposed system and examined for current maintenance practices and problems associated with it as well as environmental impact, if any.

We would prefer that the applicant use saltwater wells on the applicant's fast lands as well as disposing of effluent through the use of injection wells. In this way, impacts to intertidal environments (from dredging) as well as suction intakes and possible impingement problems are avoided. The subject document states that such a system was not practical. We would suggest that Department engineers be allowed to examine the data to ensure that all possible options have been considered before resorting to the applicant's proposed design.

Another concern is with the mention of marine fishes being retained within the waterway for possible biological control. If the applicant intends to collect and maintain marine animals (fishes, crustaceans, and other invertebrates), collection and possession would be subject to existing state regulations on minimum sizes, bag limits, closed seasons, licensing, and so forth. This proposal should be reviewed from the enforcement standpoint when submitted as a CDUA which we understand is forthcoming.

Also, the environmental assessment does not determine the likely effect of the project on historic sites. The historic preservation development review process for Ko Olina is not yet complete because we have not received an acceptable report of the archaeological data recovery and paleontological excavations carried out by Paul H. Rosendahl Ph.D., Inc. at this parcel. We have reviewed a draft report that requires revisions and are awaiting a revised draft. The environmental assessment should clearly show the location of trenching in relation to known historic sites, so that we can determine the likely effect of the project on historic sites.

In addition, a Conservation District Use Application (CDUA) is currently being processed for the subject Salt Water Intake System.

Thank you for your cooperation in this matter. Please feel free to contact Don Horiuchi at our Office of Conservation and Environmental Affairs, at 587-0377, should you have any questions.

Very truly yours,

WILLIAM W. PATY

AECOS
970 N. Kalaheo Avenue, Suite C311 • Kailua, Hawaii 96734
Telephone: (808) 254-5884

April 21, 1993

Keith Ahue, Director
State Department of Land and Natural Resources
P.O. Box 621
Honolulu, Hawaii 96809

File No.:93-302

RE: Environmental Assessment (EA) for the Ihilani Resort and Spa sea water intake/discharge system, Ewa, Oahu, TMK: 9-1-57:1

Dear Mr. Ahue,

Sometime after the Department of Land and Natural Resources (DLNR) letter dated December 24, 1992 (Doc.No. 1956) was received at the Department of Land Utilization (DLU) the subject EA was transferred to your Office of Conservation and Resources Enforcement (OCEA) for processing under the CDUA permit process. As a consequence, the comments made in the December review by DLNR were not received by *AECOS* until much later, and a written response was not provided until now. Of course, the issues raised will be incorporated into the final EA for the project, but for completeness, we wish to respond to specific concerns raised by your letter.

(1) Maintenance of the waterway:
Fouling of pipes and pond surfaces is anticipated and provisions to clear the intake lines, for example, are designed into the system. The sea water will drain from the ponds as an overflow of surface water, with input jets tending to keep lighter particulates suspended to minimize accumulation of organic matter on the pond bottom. The overflow weirs will be outfitted with strainers. Floatables and particulates will tend to be removed constantly from the pond, and the larger items (e.g., leaves, masses of algae, etc.) will be caught in the strainer baskets and discarded. Smaller particulates will pass through and escape with the effluent. These particulates will not be in sufficient concentration to adversely impact the receiving waters and will consist of the same materials (fragments of marine plants and animals) that inhabit the shoreline at the discharge point.

Although initially some maintenance may be required to remove excess algae before a balance is achieved between algal growth and herbivore abundance, regular cleaning of the ponds is not anticipated. Algal material, if excessive, would be removed by hand and discarded on the land (possibly composted). Hand removal of algae is required approximately monthly at the Mauna Lani Resort ponds. Any "extensive" cleaning of submerged surfaces will be accomplished with provisions for removal of the bulk of loose material for disposal on land.

(2) Alternative of using on-site wells
The preference for using salt water wells and injection wells on the Ihilani Resort and Spa property is shared by the applicant but was found to be untenable. DLNR engineers may review the hydrologists report and discuss the matter with him if desired. The critical issue is whether an injection system will work since the intake system is designed to bne built into a man-made revetment not in the Conservation District and its impacts are absolutely minimal. Salt water injection wells are seldom practical unless considerable land is available or the geological formation highly porous. Raising both the hydrostatic head and the salinity of the ground water under the Ihilani Resort and Spa by injection of the pond outflow into the ground may not be a desirable option given the minimal impact of discharging this water into the nearshore waters.

(3) Collection of marine animals
The Ihilani Resort and Spa does intend to maintain a variety of marine life within the waterscapes receiving salt water from the proposed project. However, the Ihilani is not going to collect these animals from the nearby marine environment. Animals will be purchased from commercial sources in the aquaculture and aquarium fish trade. Presumably these sources will be in compliance with all existing State regulations. To the extent that permit requirements to maintain marine animals in ponds exist, the Ihilani Resort and Spa will comply.

(4) Impact on historic sites
The project will have no impact on historic sites. Information from surveys conducted for the Ko Olina Resort was reviewed, although we were unaware that a final report for the Ko Olina Resort including the Ihilani parcel was not completed. We have contacted your Historic

Preservation Office and reviewed the now completed documents. The surveys conducted in the immediate area of the proposed project reveal that skeletal remains were found in the coastal dunes nearby. However, these dunes no longer exist at the project site. The proposed sea water intake and discharge system involves trenching within lands that are now entirely of recent fill. The depth of trenching will, in most areas, not extend deeper than the fill layer. Where the intake line crosses the limestone bench, although a pre-development surface, no artifacts are likely to occur. The contractor will be informed to be aware of the remote possibility of encountering archaeological materials and to notify the State Historic Preservation Office in the event of anything unusual turning up.

Thank you for your review comments. Although our written response was delayed, the review comments were made part of the OCEA staff report presented to the Land Board for the project and will be incorporated into the final EA for the project.

Sincerely,

E.B. Guinther

Eric B. Guinther

JOHN WAIHEE
GOVERNOR OF HAWAII

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

JOHN C. LEWIN, M.D.
DIRECTOR OF HEALTH

In reply, please refer to:

January 9, 1993

92-354/epo

Mr. Donald A. Clegg
Director, Department of Land Utilization
City & County of Honolulu
650 South King Street
Honolulu, Hawaii 96813

Dear Mr. Clegg:

Subject: Draft Environmental Assessment
Ko Olina Salt Water System
91-001 Olani Street, Ewa Beach, Oahu
Tax Map Key: 9-1-57: 1

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

1. The construction associated with the proposed water feature may require a Section 401 Water Quality Certification (WQC). The Army Corps of Engineers should be contacted as soon as possible in order to determine if a Section 401 WQC is applicable to this project.

2. The construction of the sea water flow-through system potentially could involve dewatering from the excavated sites. Any construction activity dewatering should comply with Department of Health (DOH) Administrative Rules, Chapter 11-55, "Water Pollution Control."

3. The assessment should address any anticipated impacts to the marine environment associated with the construction activity of the project. The discussion should detail the best management practices (BMPs) to be applied to eliminate or minimize impacts to the marine environment.

4. Information pertaining to the operation and maintenance (O&M) of the facility should be provided. For example:

   a. The method(s) of fish feeding and the type of feed used. Also, any applicable BMPs or considerations to be applied.

   b. The method(s) applied for the maintenance cleaning of the lagoons. Of particular concern are the O&M practices pertaining to the removal of excessive algae growth and accumulated bottom sediments.

The discussion on the bottom sediments should address the following potential sources of sediment generation: 1) sea water that contains particulate matter (e.g., sand) which settles out in the lagoons; and 2) solid waste material produced by the fishes.

   c. Source water pumps O&M activities.

5. The assessment should clearly address any anticipated impacts to the marine environment associated with O&M activities. In addition, the assessment should provide qualitative and quantitative information to support the position that the effluent discharge will be diluted to background levels by the initial dilution.

If you should have any questions on this matter, please contact Mr. Mark Tomomitsu of the Clean Water Branch at 586-4309.

Very truly yours,

Bruce S. Anderson

FOR JOHN C. LEIWN, M.D.
Director of Health

c: Clean Water Branch

AECOS
970 N. Kalaheo Avenue, Suite C311 • Kailua, Hawaii 96734
Telephone: (808) 254-5884

January 28, 1993

State of Hawaii
Department of Health
P.O. Box 3376
Honolulu, Hawaii

Attn.: Dennis Lau
Clean Water Branch

ref: 92-354/cpo

Dear Mr. Lau,

Thank you for responding to the Environmental Assessment for a proposed sea water intake and discharge system at the Ihilani Hotel at Ko Olina circulated by DLU. We have made an application for a 401 WQC as indicated by the Corps of Engineers, and you should soon have the opportunity to review that document as well. Allow me to respond to some of your other comments (as numbered in 92-354/cpo):

(2) The excavations for the pipe systems and pump housing will not require any dewatering because of the elevation of the inverts above sea level (and ground water level). All of the work at the intake and discharge ends of the system will occur under water, with prefabricated concrete and PVC structures lowered into place.

(3) The draft environmental assessment (EA) includes a section on construction related impacts to the marine environment (IV.A.). Best management practices are discussed there and further elaborated in the application for a Section 401 Certification.

(4) We have not included much information on system maintenance in the draft EA, but will expand on this item. To respond specifically to each of your points, we offer the following:

(a) We have inquired the Mauna Lani concerning fish feeding practices. Purina Trout Chow is added daily to the ponds in an amount which leaves no visible residual. Once a week, chopped fish is feed to the predators in the system. Sea turtle are fed lettuce. The majority of fishes kept in these systems are herbivores and obtain food by cropping the algal growth on the sides and bottoms of the ponds. Because the outflow is via overflow weirs, only floating food would have much opportunity to exit the system before being eaten.

(b) Although initially some maintenance may be required to remove excess algae before a balance is achieved between algal growth and herbivore abundance, regular cleaning of the ponds is not anticipated. Algal material, if excessive, would be removed by hand and discarded on the land (possibly composted). Hand removal of algae is required approximately monthly at the Mauna Lani ponds.

Bottom sediments will not accumulate at the Ihilani. Water will enter the ponds through upwelling jets and exit through overflow weirs outfitted with strainers. Floatables and particulates will tend to be removed constantly from the pond, but only larger items (e.g., leaves) would be caught in the strainer baskets.

The point about possible accumulation of sand settling out in the lagoon is interesting, but not relevant to water quality. In general, sand accumulation on the pond bottoms would be tolerated (i.e., left in place) to provide a more natural appearance. Sand moving through the system (if any) is unlikely to be of amounts producing problems at the discharge end. If sand were to accumulate over time and then need to be removed from the pond, this material could be returned to Ko Olina Lagoon No. 1 without adverse environmental consequences.

(c) The system will have two pumps with separate intake lines to allow maintenance on one side while the other is in operation. Beyond the pump house, single lines feed into and out of the ponds. For the most part, maintenance will require some attention to removing fouling from the intake area. The intake manifold is designed to allow direct access to the intake line. Mechanical removal of fouling would have no adverse consequences on the environment. Scrapings of biological fouling would either become part of the sedimentary bottom near the intake or be carried into the pond, possibly requiring later removal by hand.

(5) No impacts of O&M on the marine environment off the discharge are anticipated. Maintenance would not involve use of chemical agents to

remove fouling. Substances accumulating in the pipes and ponds (whether particulates such as sand or fish waste, or attached algae) will mostly be removed by hand and discarded on the land. Given that all such material would be marine in origin and would be present in amounts equivalent to levels presently existing off the shore, any organic or inorganic particulates escaping into the discharge will be of no adverse consequence to the receiving water ecosystems. Larger particulates will be strained from the effluent prior to discharge.

The assessment does provide support for the contention that the effluent discharge will be diluted to background levels by the initial dilution. Predicting such dilution by computer model is difficult because of the more or less identical densities of the discharge plume and receiving water, and the fact that mixing and dilution will be largely determined by waves impinging on the shore. We are exploring the use of a mixing model which does not depend upon density differences, but doubt that any model adequately assess mixing by breaking waves. Based on measurements from very similar systems, incorporated as an appendix to the EA, an assessment was made of the quality of the discharge (Table III-9).

Thank You

E. B. Guinther

Eric B. Guinther

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P.O. BOX 621
HONOLULU, HAWAII 96809

WILLIAM W. PATY, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTIES
JOHN P. KEPPELER II
DONA L. HANAIKE

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

REF:OCEA:SKK

FILE NO.: OA-2608
180-Day Exp. Date: 6/6/93
DOC. NO.: 2050

JAN 28 1993

Pan Pacific Hoteliers, Inc.
1001 Bishop Street
Pauahi Tower, Suite 710
Honolulu, Hawaii 96813

Attn: John Bolner

Dear Mr. Bolner:

SUBJECT: Notice of Acceptance of Your Conservation District Use Application/Preliminary Environmental Determination

Your Conservation District Use Application for a sea water flow through a system at Ewa, Oahu, has been accepted for processing.

According to your application, you propose to construct a flow through sea water system as an integral part of the landscaping for the Ilihani Resort and Spa. The system will consist of an intake structure, pipes, pumps, pump housing, and discharge structure. All structures will be buried and not visible. The outlet will be located about 600 feet north of the mouth of Lagoon No. 1.

After our initial review, we have determined that:

1. The proposed use is a conditional use within the Resource subzone of the Conservation District according to Administrative Rules, Title 13, Chapter 2, as amended;

2. A public hearing pursuant to Section 183-41, Hawaii Revised Statutes (HRS), as amended, is required in the interest of the adjacent community; and

3. In conformance with Title 11, Chapter 200, of the Administrative Rules, and Act 241, SLH 1992, a negative declaration is anticipated based on the draft environmental assessment for the proposed action.

Your application is currently being reviewed by concerned State and County agencies. Following the review and the public hearing on this application, your application will be presented to the Board for disposition.

We understand that you have applied for a Special Management Area Permit for the project from the City and County of Honolulu's Department of Land Utilization. You should be aware that the Board would be prohibited by law (Section 205A-29(b), HRS) from approving your application if an SMA clearance for the project is not granted.

Please contact Don Horiuchi of our Office of Conservation and Environmental Affairs staff at 587-0381, if there are any questions regarding this process.

Very truly yours,

John P. Keppeler II

for WILLIAM W. PATY

Attachment (receipt)

cc: AECOS
C&C Dept. of General Planning
DOH/OHA/OSP

940

PLANNING DEPARTMENT

CITY AND COUNTY OF HONOLULU

650 SOUTH KING STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

ROBIN FOSTER
CHIEF PLANNING OFFICER

ROLANDO LIBBY, JR.
DEPUTY CHIEF PLANNING OFFICER

'93 FEB 24 AM 11 43

STATE OF HAWAII

MH 2/93-235

February 22, 1993

Honorable William W. Paty, Chairperson
Board of Land and Natural Resources
Department of Land and Natural Resources
State of Hawaii
P.O. Box 621
Honolulu, Hawaii 96809

Dear Mr. Paty:

Conservation District Use Application
for a Seawater Outlet at Ewa (Ko Olina), Oahu
File No.: OA-2608

In response to your department's request of January 28, 1993, we have reviewed the subject Conservation District Use Application and have the following comment to offer.

The Final Environmental Assessment should also disclose the relationship and consistency of the subject project to the following City plans and land use regulations:

A. General Plan
B. Ewa Development Plan Land Use Map
C. Ewa Development Plan Public Facilities Map
D. Ewa Development Plan Special Provisions
E. Land Use Ordinance

Should there be any questions, please contact Matthew Higashida of our staff at 527-6056.

Sincerely,

ROBIN FOSTER
Chief Planning Officer

RF:lh

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April 22, 1993

Robin Foster, Chief Planning Officer
Planning Department
City and County of Honolulu
650 South King Street
Honolulu, Hawaii 96813

File No.:93-235

RE: Environmental Assessment (EA) for the Ihilani Resort and Spa sea water intake/discharge system, Ewa, Oahu, TMK: 9-1-57:1

Dear Mr. Foster,

As per your recommendations we have expanded on the section of the subject EA to cover the project's relationships to the General Plan, Ewa Development Plan maps, and Ewa Development Plan Special Provisions. Please note that the project is proposed for lands designated resort and the intake and discharge lines extend across certain lands designated preservation (LUO P-2) in order to reach the submerged lands as required for obtaining and discharging of sea water.

All structures proposed will be buried underground, including the sea water pump house. Thus, the project is consistent with all of the pertinent provisions of the development plans: namely that public use and access to shoreline and coastal areas will be not be curtailed, and views of the ocean will not be impaired or lessened in any way.

Sincerely,

Eric B. Guinther

APPENDIX B

MEASUREMENTS OF THE QUALITY OF THE EFFLUENT FROM DECORATIVE SALT WATER POND SYSTEMS IN HAWAII

AECOS No. 645

MEASUREMENTS OF THE QUALITY OF THE EFFLUENT FROM DECORATIVE SALT WATER POND SYSTEMS IN HAWAII

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August 1992

INTRODUCTION

Because of actual and/or potential restrictions on the use of potable waters, most decorative waterscapes developed for resort and public areas utilize nonpotable, brackish or salt water sources. Supply wells drilled into strata containing salt water or sea water intake pipes laid off the shore can be practical sources of plentiful water for coastal projects. Drawing water from either source can be accomplished without harm to the marine environment, although geohydrological conditions may need to be considered to avoid or minimize impacts on ground waters where wells are to be located inland from the shore.

This paper addresses the water quality implications of the discharge from relatively high volume, salt water flow-through systems. The discharge of water at the "downstream" end of the water feature is of environmental concern because such discharges are effluents with a quality that may differ from that of the receiving water. Also, where such discharges are directed into the open waters of the State of Hawaii, a permit from the State of Hawaii, Department of Health (DOH) and the U.S. Environmental Protection Agency (EPA) under the National Pollutants Discharge Elimination System (NPDES) is necessary.

The water quality consequences of flowing water through a decorative water feature may be quite minor, but the quality of the effluent water will be assessed in terms of the receiving water quality and criteria values established as the State of Hawaii, water quality standards (DOH, 1989). Thus, the argument that the effluent cannot produce environmental harm because the system supports living creatures may provide strong indication of the absence of severely toxic substances, but really is of little value in meeting permit and certification requirements to avoid or minimize State water quality violations.

The subject of discharges from aquatic systems supporting abundant aquatic life (i.e, aquaculture facility effluents) has been addressed by the Center for Tropical and Subtropical Aquaculture (1990). Non-aquaculture systems with potentially similar characteristics include discharges from aquariums, permits for which have been issued in Hawaii.

Water features can be either static or dynamic. Dynamic features incorporate a constant flow of water, and to enhance the visual effects this flow will be substantial in terms of the total volume of the system. Static systems lack water flow, and therefore the discharge of water from such systems will be sporadic: either as part of a maintenance practice or as overflow resulting from rainfall or runoff inputs. Dynamic systems can be flow-through or recirculating. In the latter case, the discharge can be sporadic as in the case of a static system.

In flow-through systems, the discharge of an effluent is more or less constant. The degree of change in water quality between the supply point and the discharge point is partly a function of the residence time of the water (how long water remains in the system on average). Where residence time is short, water quality characteristics of the discharge may be more a function of the supply water quality than of processes taking place within the system. High flow rates and short residence times are usually designed into systems intended to support decorative fishes and other organisms as a means of insuring good water quality within the system. As a general rule, marine systems will require a higher turnover rate than fresh water systems.

Measurements of water quality in decorative water features located at the Mauna Lani Resort on the Island of Hawaii were made in June 1991 and May 1992 to provide a basis for assessing the water quality implications of discharges from these types of systems. The Mauna Lani systems support relatively large numbers of fishes and are typical of successful decorative marine pond features.

The Mauna Lani Resort

Bungalows Pond System

The outdoor salt water ponds system at the Mauna Lani Resort consists of a series of concrete-lined waterways separated by wiers and fed from waterfall structures and subsurface jets. The system source water is a deep well located on-site which provides saline ground water at a salinity of 33.5 ppt (measured by refractometer on May 24, 1991). The well pumps supply about 2400 to 2450 gpm of this saline ground water to the system. The Bungalows salt water well is included in a network of wells monitored regularly at the Mauna Lani Resort. Results of the testing of water from this well in 1992 are given in Table 1.

Table 1. Water chemistry measurements for the Bungalows salt water well at the Mauna Lani Resort, West Hawaii. January-May, 1992.

DATE:	TEMPERATURE °C	SALINITY ppt	TURBIDITY NTU	SILICATE mg Si/L
01/15	--	31.91	0.07	6.60
02/21	--	31.68	0.13	6.60
04/03	25.3	32.57	--	6.15
05/06	25.6	32.56	0.07	6.15

DATE:	NITRATE + NITRITE mg N/L	AMMONIA mg N/L	TOTAL N mg N/L	ORTHO-PHOSPHATE mg P/L	TOTAL P mg P/L
01/15	0.221	0.002	0.297	0.038	0.042
02/21	0.239	0.002	0.308	0.043	0.045
04/03	0.183	0.005	0.265	0.044	0.046
05/06	0.177	0.005	0.204	0.039	0.044

Data from Marine Research Consultants (1992).

Most of the water enters the interconnected channels after tumbling over wiers and boulders creating decorative waterfalls with a total initial drop of about 4 feet. The surface area of the system is estimated at 66,000 square feet and the average depth is 2.5 feet. Thus, the volume of the system is about 1.2 million gallons. In 1991 the number of fishes in the system channels and ponds was estimated at 11,000; in 1992, the estimated count provided was 8,000 fishes. These are a mixture of mostly herbivores and include manini and milkfish. A number of young, green sea turtles (*Chelonia midas*) were present in 1991.

All of the water flows towards a final pond and enters a single exit pipe at the far end of the system, which feeds into an unlined percolation pond or sump which feeds back into the ground near the shore. Based on the estimate volume of the system and the rate of water supply, the water residence time is thus between 8.1 to 8.7 hours.

On June 5, 1991 a series of water quality samples were collected to assess the changes in water quality that occur as water flows through the system. Conditions at the time of the 1991 survey varied from sunny to partly cloudy, becoming generally cloudy by 1540 in the afternoon. The survey was repeated on May 27-28, 1992. Conditions included generally clear skies. This survey covered 24 hours in order to provide a complete picture of the effluent characteristics.

Source water was sampled at the top of two of the five waterfall structures. Station IN(1) was located between the Canoe House Restuarant and the Mauna Lani Hotel; Station IN(2) was located north of the Mauna Lani Bungalows. The water from IN(2) flows a relatively short distance to the common drain, whereas the water from IN(1) follows a significantly longer path around the restuarant. Approximately one-fifth of the source water feeds into the shorter arm of the system and the residence time of the water here may be comparable to that in the physically longer system. Because of more difficult access to the top of the structure, some water action occurred at IN(2) between the input pipe and the actual sampling location. Thus, the dissolved oxygen values here were somewhat higher than at IN(1).

The two parts of the system join in a common "pond" area before exiting via a pipe into the unlined percolation pond. Water was sampled from the long leg just before entering the common "pond" at Station END(1). The short leg was sampled from the last pond above the weir before the common pond at Station END(2). Finally, samples were collected from the percolation pond itself (SUMP).

Mauna Lani Hotel Lobby System

Shallow marine ponds are an integral part of the "tropical garden" setting of Mauna Lani Hotel lobby. These ponds are fed from a well which inputs just outside on the north side of the building and exits outside the building on the south side. Most of the ponds are inside the atrium-like lobby of the hotel.

This system is older than the Bungalows system, and the shallower well provides water which is more brackish than that of the Bungalows system. The total volume of the Lobby system is about 23,000 gallons and water is supplied at 360 gpm (two wells with this rating are present, but ordinarily only one is in operation at a time). Residence time of the water in the system is thus about 1 hour. Total number of fishes was estimated at 10,000 individuals.

The Lobby system was sampled during the 24-hour survey of May 27-28, 1992. One sample (IN(1)) was collected from the pond on the north side of the lobby building just below the supply inlet waterfall. A second sample (END(1)) was collected from the pond on the south side of the lobby building just before the drain.

RESULTS

Results are reported here for each of the three "studies". Within each table is presented first the June 1991 measurements from the "Bungalows" pond system, followed by the May 1992 measurements from the same system, and finally the May 1992 measurements from the "Lobby" pond system.

Table 2.
TEMPERATURE
°C

	SAMPLE LOCATION				
TIME OF DAY	IN(1)	END(1)	IN(2)	END(2)	SUMP
JUNE 1991 BUNGALOWS					
0900	21.5	22.0	21.4	22.1	21.5
1130	21.9	23.2	21.9	23.6	22.8
1400	21.6	24.4	21.8	25.0	24.1
1530	22.1	23.8	21.6	24.9	24.0
MAY 1992 BUNGALOWS					
1200	25.3	28.7	26.5	29.6	28.8
1500	25.5	27.3	25.5	28.1	27.3
1800	24.9	24.7	24.9	26.8	26.9
2100	25.6	25.9	25.3	26.7	25.5
0000	24.4	24.9	24.9	25.7	24.7
0300	25.2	24.5	24.8	25.0	24.7
0600	24.7	24.4	24.5	24.0	23.8
0900	25.3	25.9	25.4	25.9	25.8
MAY 1992 LOBBY					
1200	27.4	29.6			
1500	26.3	26.6			
1800	25.8	25.8			
2100	25.2	25.4			
0000	25.2	25.3			
0300	24.9	24.8			
0600	24.8	24.7			
0900	25.6	25.5			

Temperature measurements (in °C) are provided in Table 2 above. The "Bungalows" system affects a slight increase in temperature of the water on the order of one to several celsius degrees during the daylight hours; the influent water may be cooled slightly during the early morning hours. The lobby system, being mostly indoors, appears to have little influence on water temperature, or the influence is only a fraction of a celsius degree.

In May 1991 the pH meter was damaged during the first round of sampling and only the following values were obtained in the field (0900 hrs): IN(1) 7.9; IN(2) 7.9; and END(1) 7.9. These values are somewhat low for marine waters, yet similar pH values (table below) were measured in May 1992. The salinity of the system was measured as 35.5 ppt (that is, sea water salinity) and the pH is expected to be in the range of 8.0 to 8.3. The pH values in all three "systems" measured in May 1992 hint at a tendency to rise during the day and to decline during the night. This result could follow as a consequence of the carbon dioxide (CO_2) balance: CO_2 dissolved in water forms a weak acid (carbonic acid), and less CO_2 would be present during daylight hours when it is actively taken up by algae in photosynthsis. Photosynthesis is a reductive process, causing a rise in pH; respiration is an oxidative process, causing a decline in pH.

Table 3.
pH

	SAMPLE LOCATION				
TIME OF DAY	IN(1)	END(1)	IN(2)	END(2)	SUMP
MAY 1992 BUNGALOWS					
1200	7.8	7.3	7.8	6.3	8.0
1500	7.8	8.0	7.8	8.1	8.1
1800	7.8	8.2	7.8	8.1	8.1
2100	7.7	7.7	7.7	7.9	7.9
0000	7.7	7.5	7.7	7.8	7.7
0300	7.8	7.6	7.7	7.8	7.7
0600	7.9	7.6	8.0	7.7	7.6
0900	7.7	7.6	7.8	7.8	7.7
MAY 1992 LOBBY					
1200	7.9	7.9			
1500	7.8	8.1			
1800	7.8	8.0			
2100	7.8	7.8			
0000	7.8	7.7			
0300	7.8	7.7			
0600	8.0	7.7			
0900	7.8	8.0			

Measurements of suspended solids or non-filterable residue (NFR) were only made on the samples collected from the ends of the Bungalows system in June 1991 because it was assumed that the well water would contain an insignificant amount of particulates.

Thus, any value measured at IN(1) or IN(2) might only represent particulate residues released from growth on the waterfall structure. While the source of particulates in the influent water is not known, measurements made in May 1992 near the influent points indicate that the particulate values are not insignificant, particularly if it is being assumed that the difference between the influent and effluent values represents the contributions of fishes, feed, and other sources of detritus generated within the pond system.

Table 4.
Non-filterable Residue
mg/L

	SAMPLE LOCATION				
TIME OF DAY	IN(1)	END(1)	IN(2)	END(2)	SUMP
JUNE 1991 BUNGALOWS					
0900	--	3.6	--	3.5	2.4
1130	--	5.4	--	8.8	8.0
1400	--	7.7	--	3.7	7.5
1530	--	7.1	--	8.7	2.8
MAY 1992 BUNGALOWS					
1200	2.2	2.0	0.3	6.4	2.4
1500	1.1	3.4	1.1	4.9	2.5
1800	1.4	2.6	0.5	6.3	3.8
2100	0.4	2.6	0.9	11.8	5.1
0000	0.9	5.5	1.1	3.6	5.5
0300	1.4	1.7	0.8	6.4	3.3
0600	0.5	2.2	0.6	4.2	4.8
0900	0.4	2.0	0.6	5.3	4.2
MAY 1992 LOBBY					
1200	1.3	2.4			
1500	1.0	8.7			
1800	2.1	2.8			
2100	2.8	1.7			
0000	1.2	2.5			
0300	0.7	1.3			
0600	1.1	1.7			
0900	0.3	2.2			

The weight of particulates is small for most samples but this parameter does show considerable variation from sample to sample. This result is expected because particles can range over considerable size and their movement up into the water will depend upon activities upstream of the sample point. Unlike substances dissolved in the water, particles tend not to become evenly mixed within the water moving through the system.

Measurements of dissolved oxygen are given in Table 5 below. The diurnal (daily) cycle of oxygen (O_2) production from plants (algae) is clearly demonstrated by the Bungalows systems as O_2 at the end of the flow stream reaches highest levels in the afternoon and drops to lowest levels in the early morning before sunrise. The lobby system shows the same pattern, but after dark values at the end of the system tend to be lower than the input water. This result could be simply a consequence of a greater density of fishes.

Table 5.
Dissolved Oxygen
mg O_2 / L

	SAMPLE LOCATION				
TIME OF DAY	IN(1)	END(1)	IN(2)	END(2)	SUMP
JUNE 1991 BUNGALOWS					
0900	3.5	5.4	6.0	6.1	7.3
1130	4.8	6.0	6.3	7.2	9.2
1400	5.5	6.7	6.5	7.9	10.7
1530	5.2	6.7	5.8	6.0	10.5
MAY 1992 BUNGALOWS					
1200	4.0	6.9	4.0	5.5	7.3
1500	3.4	7.7	3.5	8.2	7.6
1800	3.2	5.2	3.4	4.8	4.9
2100	3.1	4.8	3.7	4.1	5.2
0000	2.9	4.0	2.9	3.5	3.8
0300	4.2	4.1	3.6	4.2	4.2
0600	3.4	3.7	3.4	3.0	3.5
0900	3.2	5.0	3.4	4.8	4.2
MAY 1992 LOBBY					
1200	5.4	6.1			
1500	6.3	7.9			
1800	4.8	4.7			
2100	5.1	4.3			
0000	5.5	4.4			
0300	4.5	4.2			
0600	5.6	4.6			
0900	6.1	5.8			

Nutrient measurements from the pond systems were extensive because nutrients in the discharge would be of primary interest for an eflfuent directed into ocean waters of the State. Included were dissolved forms (nitrate, nitrite, ammonia, and orthophosphate) and dissolved plus particulate forms (total nitrogen and total phosphorus) of nitrogen and phosphorus.

Table 6.
Nitrate + Nitrite
mg $[NO_2+NO_3]$-N/L

TIME OF DAY	SAMPLE LOCATION IN(1)	END(1)	IN(2)	END(2)	SUMP
JUNE 1991					
0900	0.047	0.001	0.044	0.001	<0.001
1130	0.070	0.002	0.085	0.002	0.001
1400	0.135	0.001	0.124	0.006	0.001
1530	0.127	0.011	0.137	0.029	0.006
MAY 1992					
1200	0.101	0.088	0.134	0.056	0.088
1500	0.112	0.085	0.146	0.052	0.080
1800	0.130	0.088	0.151	0.062	0.084
2100	0.134	0.091	0.151	0.066	0.090
0000	0.134	0.106	0.154	0.076	0.090
0300	0.143	0.099	0.157	0.080	0.104
0600	0.140	0.108	0.157	0.080	0.108
0900	0.143	0.109	0.157	0.070	0.099
MAY 1992 LOBBY					
1200	0.624	0.591			
1500	0.638	0.591			
1800	0.666	0.610			
2100	0.675	0.610			
0000	0.675	0.647			
0300	0.666	0.647			
0600	0.704	0.647			
0900	0.666	0.657			

Measurements of nitrate plus nitrite are given in Table 6 above. Most of the nitrogen is probably present as nitrate because nitrite is rare in oxygen rich waters. Dissolved nitrate is an inorganic source of nitrogen readily utilized by plants and a decrease in nitrate as water flows through the ponds is expected. Nitrate in the water promotes algal growth. The pattern observed in June 1991 of a rising nitrate plus nitrite with time in the Bungalows supply well is not repeated in May 1992 and remains a curiousity. However, the difference in nitrate concentrations as a function of salinity is clearly demonstrated by comparing the Bungalows (35.5 ppt) and Lobby (21.0 ppt) supply wells. High nitrate concentrations are associated with fresh ground water. Concentrations in open ocean waters tend to be very low.

Ammonia is another inorganic form of nitrogen which can promote algal growth. In high concentrations ammonia can be toxic to fishes and other animals. Concentrations of ammonia in ground water are generally low, but ammonia is produced as a waste product by fishes in the pond system. Thus, ammonia tends to rise (Table 7) as the water flows through the ponds, particularly where the nitrogen requirements of the algae are readily met by the nitrate concentration.

Table 7.
Ammonia
mg NH_4-N/L

	SAMPLE LOCATION				
TIME OF DAY	IN(1)	END(1)	IN(2)	END(2)	SUMP
JUNE 1991					
0900	0.006	0.009	0.002	0.006	0.005
1130	0.005	0.008	0.001	0.005	0.007
1400	<0.001	0.006	0.001	0.010	0.006
1530	0.001	0.012	0.001	0.012	0.008
MAY 1992					
1200	0.004	0.025	0.007	0.024	0.007
1500	0.003	0.025	0.006	0.011	0.014
1800	0.005	0.011	0.003	0.021	0.021
2100	0.009	0.016	0.004	0.021	0.007
0000	0.003	0.021	0.003	0.003	0.015
0300	0.004	0.025	0.010	0.002	0.003
0600	0.006	0.013	0.027	0.002	0.003
0900	0.005	0.013	0.006	0.003	0.008
MAY 1992 LOBBY					
1200	0.005	0.017			
1500	0.008	0.005			
1800	0.011	0.009			
2100	0.013	0.017			
0000	0.006	0.012			
0300	0.005	0.007			
0600	0.006	0.006			
0900	0.002	0.008			

Total nitrogen (Table 8 below) is a measure of all the nitrogen compounds in the water sample, including the nitrogen in organic matter present as particulates. A little more than half of the nitrogen in these samples is accounted for by the nitrate, nitrite, and ammonia concentrations. The remainder is presumably dissolved organic nitrogen and particulate organic nitrogen.

Table 8.
Total Nitrogen
mg N/L

TIME OF DAY	IN(1)	END(1)	IN(2)	END(2)	SUMP
	SAMPLE LOCATION				
JUNE 1991					
0900	0.178	0.165	0.157	0.200	0.159
1130	0.222	0.185	0.135	0.201	0.177
1400	0.146	0.141	0.137	0.191	0.154
1530	0.180	0.173	0.185	0.215	0.154
MAY 1992					
1200	0.222	0.270	0.268	0.225	0.250
1500	0.273	0.258	0.242	0.254	0.186
1800	0.194	0.215	0.222	0.345	0.210
2100	0.198	0.187	0.242	0.264	0.177
0000	0.214	0.181	0.271	0.212	0.166
0300	0.156	0.219	0.225	0.208	0.190
0600	0.505	0.206	0.238	0.174	0.198
0900	0.203	0.217	0.233	0.162	0.176
MAY 1992 LOBBY					
1200	0.796	0.886			
1500	0.640	0.603			
1800	0.895	0.808			
2100	0.842	0.850			
0000	0.853	0.856			
0300	0.827	0.815			
0600	0.942	0.568			
0900	0.742	0.790			

A second important inorganic nutrient utilized by aquatic plants is phosphorus, which occurs naturally as orthophosphates. Concentrations of phosphorus in the supply wells tend to be moderately high by comparison with nearshore marine water, and is seen to be greater in the brackish, Lobby system supply well than in the more saline Bungalows salt water well (Table 9). Phosphorus concentration is reduced as water flows through the ponds, at least in the Bungalows system, a consequence of the algae removing orthophosphates from the flowing water. A low standing crop or low growth rate of algae in the more shaded Lobby system may explain the tendency for phosphorus to appear to increase between source and effluent sample locations here.

Total phosphorus (Table 10 below) includes the inorganic orthophosphates and other organic forms of phosphorus. In these samples the total phosphorus values are the same as the orthophosphate values, indicating that essentially all of the phosphorus present is as inorganic phosphates dissolved in the water.

Table 9.
Orthophosphate
mg PO_4-P/L

	SAMPLE LOCATION				
TIME OF DAY	IN(1)	END(1)	IN(2)	END(2)	SUMP
JUNE 1991					
0900	0.039	0.027	0.042	0.028	0.026
1130	0.033	0.027	0.043	0.028	0.024
1400	0.050	0.022	0.049	0.026	0.025
1530	0.043	0.020	0.050	0.024	0.020
MAY 1992					
1200	0.043	0.043	0.053	0.031	0.040
1500	0.047	0.047	0.050	0.031	0.034
1800	0.047	0.047	0.053	0.031	0.040
2100	0.050	0.043	0.081	0.031	0.043
0000	0.050	0.047	0.053	0.031	0.037
0300	0.050	0.047	0.053	0.031	0.043
0600	0.068	0.043	0.053	0.037	0.037
0900	0.060	0.043	0.053	0.031	0.037
MAY 1992 LOBBY					
1200	0.068	0.068			
1500	0.068	0.081			
1800	0.074	0.068			
2100	0.068	0.074			
0000	0.096	0.084			
0300	0.068	0.189			
0600	0.071	0.081			
0900	0.090	0.189			

Table 10.
Total Phosphorus
mg P/L

TIME OF DAY	IN(1)	END(1)	IN(2)	END(2)	SUMP
	SAMPLE LOCATION				
JUNE 1991					
0900	0.040	0.035	0.042	0.037	0.032
1130	0.033	0.034	0.043	0.041	0.034
1400	0.052	0.038	0.049	0.044	0.040
1530	0.043	0.035	0.050	0.042	0.032
MAY 1992					
1200	0.037	0.063	0.044	0.044	0.040
1500	0.044	0.047	0.050	0.054	0.040
1800	0.047	0.043	0.048	0.044	0.044
2100	0.053	0.048	0.055	0.049	0.045
0000	0.045	0.049	0.155	0.042	0.047
0300	0.044	0.049	0.045	0.047	0.043
0600	0.040	0.040	0.047	0.037	0.049
0900	0.044	0.047	0.046	0.044	0.034
MAY 1992 LOBBY					
1200	0.064	0.054			
1500	0.056	0.048			
1800	0.065	0.071			
2100	0.068	0.075			
0000	0.070	0.076			
0300	0.063	0.066			
0600	0.070	0.047			
0900	0.060	0.064			

Chlorophyll α measurements (Table 11) provide an indication of the concentration of microscopic algae in the water. No chlorophyll could be present in the source water (deep wells), so only the effluent chlorophyll α was measured. The values obtained are relatively high and exceedingly variable, indicating that the measurements probably are of or include) fragments of benthic algae carried as particulate matter. Residence time of the water in the ponds is probably too short for significant concentrations of phytoplankton to develop.

Table 11. Chlorophyll α µg/L					
	SAMPLE LOCATION				
TIME OF DAY	IN(1)	END(1)	IN(2)	END(2)	SUMP
JUNE 1991					
1130		1.78		2.84	3.40
MAY 1992					
1200	--	1.20	--	3.31	1.14
1500	--	3.42	--	4.29	2.44
1800	--	4.22	--	2.70	2.70
2100	--	3.14	--	5.13	1.62
0000	--	1.58	--	2.62	1.08
0300	--	2.45	--	2.10	0.94
0600	--	0.99	--	1.76	1.05
0900	--	4.43	--	2.53	1.44
MAY 1992 LOBBY					
1200	--	1.70			
1500	--	1.15			
1800	--	1.28			
2100	--	1.09			
0000	--	4.78			
0300	--	1.33			
0600	--	2.26			
0900	--	0.89			

Results Summary

The collection of samples over a 24-hour period gives a sense of the cyclical nature exhibited by at least some of the water quality parameters and provides a representative sample set. Comparison of the inlet and outlet values can be accomplished more efficiently by converting the data to average (mean or geometric mean) values (see Table 12 below). A geometric mean is used for some of these data in part because the State of Hawaii, water quality criteria are based upon the log-normal distribution.

Averaged numbers for the temperatures recorded at the inlet and outlet sides of the systems will combine both daytime heating and nightime cooling of the water as it flows through a system. The increase of nearly 2 C° between inlet and outlet seen in May 1991 is certainly influenced by the fact that measurements were made only during daylight hours. The results of the 24-hour sampling in 1992 suggests a smaller average increase in temperature occurs in the ponds. A curious result of the measurements is the higher average temperature of the well water in 1992 as compared with 1991.

Table 12
Data Summary Table
Mean and Geometric Mean Values

PARAMETER	SAMPLE LOCATION IN(1)	END(1)	IN(2)	END(2)	SUMP
JUNE 1991 BUNGALOWS (n=4)					
Temperature (°C)	21.8	23.4	21.7	23.9	23.1
NFR (mg/L)	—	5.7	—	5.6	4.5
DO (mg/L)	4.7	6.2	6.1	6.8	9.3
NO_3+NO_2 (mg N/L)	0.087	0.002	0.089	0.004	0.002
NH_4 (mg N/L)	0.002	0.008	0.001	0.008	0.006
Total N (mg N/L)	0.179	0.165	0.152	0.202	0.161
PO_4 (mg P/L)	0.041	0.024	0.046	0.026	0.024
Total P (mg P/L)	0.043	0.035	0.046	0.041	0.034
MAY 1992 BUNGALOWS (n=8)					
Temperature (°C)	25.1	25.8	25.2	26.5	25.9
pH	7.8	7.7	7.8	7.7	7.8
NFR (mg/L)	0.9	2.6	0.7	5.8	3.8
DO (mg/L)	3.4	5.0	3.5	4.6	4.9
NO_3+NO_2 (mg N/L)	0.129	0.096	0.151	0.067	0.092
NH_4 (mg N/L)	0.005	0.018	0.006	0.007	0.008
Total N (mg N/L)	0.230	0.217	0.242	0.224	0.193
PO_4 (mg P/L)	0.051	0.045	0.055	0.032	0.039
Total P (mg P/L)	0.044	0.048	0.055	0.045	0.042
Chlorophyll α (µg/L)	—	2.35	—	2.89	1.44
MAY 1992 LOBBY (n=8)					
Temperature (°C)	25.6	26.0			
pH	7.8	7.9			
NFR (mg/L)	1.1	2.4			
DO (mg/L)	5.4	5.1			
NO_3+NO_2 (mg N/L)	0.664	0.624			
NH_4 (mg N/L)	0.006	0.009			
Total N (mg N/L)	0.812	0.763			
PO_4 (mg P/L)	0.075	0.095			
Total P (mg P/L)	0.064	0.062			
Chlorophyll α (µg/L)	—	1.56			

Temperature values are means; pH values are means of log scale values (= geometric means); all other values are geometric means.

The pH of the water changed hardly at all between inflow and outflow when measurements are reduced to an average value. While both arms of the Bungalows system produced a pH 0.1 unit less than the inlet water, the sump value (just below the outlet measuring points) averaged the same as the inlet water. The Lobby system average was 0.1 unit higher at the outlet than at the inlet. Curiously, despite the difference in salinity of these two fishpond systems, the pH values were not very different and about 0.3 to 0.5 units below typical open ocean values. A desirable pH range (Spotte, 1979) for maintaining animals in both brackish and sea water systems is 8.0 to 8.3. The low pH in these systems is a consequence of chemical reactions within the ground water body and thus not easily remedied.

The suspended solids (NFR) did increase as the water flowed through the systems, but results were highly variable. Considering the nature of the systems, variation in suspended solids is expected. The release of particulates depends upon a number of managed and unmanaged factors, and "typical" values will probably be difficult to define for these systems.

Average oxygen in the water was increased across a diurnal cycle in the Bungalows system, but not in the Lobby system. The difference is probably related to the reduced photosynthetic activity in the indoor system as compared with the outdoor (Bungalows) system.

The nutrient results are interesting in several respects. The fairly substantial reduction in inorganic nitrates and phosphates observed in 1991 was not so great in 1992, presumably because of real differences in the dynamics of the primary producers (algae) in the systems. Owing to management practices, or "natural" cycles, the uptake of inorganic nutrients probably changes with time in these systems. Possibly contributing, was a greater concentration of nitrate plus nitrite in the well water in 1992 as compared with 1991. On the other hand, ammonia, a product of aquatic animal excretions, increased in all cases. The total N and total P results are variable, with slight average increases in some cases, and slight average decreases in all others. The 24-hour measurements suggest a decrease in total N as water flows through the system. About half of the total N is accounted for as inorganic nitrate, nitrite, and ammonia.

Changes in water quality between influent and effluent points can be expressed as the percent differences for comparative purposes (Table 13). Calculated as the effluent minus the influent values divided by the influent value, a large positive result indicates a contribution to the effluent by the system. A negative value indicates removal, uptake, or conversion; that is, the amount in the effluent is less than that supplied by the influent. For the ponds at the Mauna Lani on the days surveyed, most parameters were reduced in concentration by flow through the system. Not surprising, particulates (NFR) and ammonia were exceptions. These results compare in a general way with marine aquaculture facilities (Table 13; values after CTSA, 1990), where increases in ammonia and NFR are the most substantial changes effected on the supply water by the biomass of cultured organisms. In the latter, nitrate tends to be mostly unchanged (see also AECOS, 1987), but all other parameters show increases. Decorative pond systems resemble aquaculture to the extent that both share a common purpose of maintaining living aquatic organisms. Aquaculture management promotes the maximum, healthy growth of biomass of the cultured species as a primary purpose. Decorative pond management places a higher premium on water clarity, which is a goal consistent with minimizing effluent water quality impacts on receiving waters.

Table 13. Percent difference in the concentrations of parameters between influent and effluent waters.[1]

	BUNGALOWS 1991 (1)	BUNGALOWS 1991 (2)	BUNGALOWS 1992 (1)	BUNGALOWS 1992 (2)	LOBBY 1992	MARINE FISH AQUACULTURE[2]
NFR	--	--	189	728	118	350
NO_3+NO_2	-98	-96	-26	-56	-6	9
NH_4	300	700	260	17	50	831
Total Nitrogen	-8	33	-6	-7	-6	100
PO_4	-41	-43	-12	-42	27	92
Total Phosphorus	-19	-11	9	-18	-3	165

1 - Percent difference is calculated from: ((END-IN)/IN) × 100.
2 - Aquaculture values for Hawaii after CTSA (1990).

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