DRAFT

ENVIRONMENTAL IMPACT STATEMENT

FOR

SAND ISLAND SEWAGE TREATMENT PLANT

AND OUTFALL SEWER

By

Department of Public Works

City and County of Honolulu

March 1972

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I. GENERAL

A. PROJECT DESCRIPTION

The project consists of the construction of wastewater treatment and disposal facilities to eliminate the raw sewage discharge which has been occurring offshore of Sand Island since 1955. The location of this project is shown in Figure 1.

The proposed facilities will handle wastewaters from South and North Honolulu, being those portions of the City of Honolulu from Niu Valley to Nuuanu Stream and from Nuuanu Stream to Moanalua respectively. The total tributary drainage area, excluding unuseable and conservation lands, is about 22,870 acres, 15,720 acres located in South Honolulu and 7,150 acres in North Honolulu.

The major elements of the facilities include an advanced primary treatment plant located on Sand Island and a new ocean outfall sewer extending into deep water off Sand Island.

The proposed outfall will consist of a 9,000-foot long 84-inch pipe section and a 3,350-foot long diffuser section. It will lie westerly of the present outfall and terminate with the diffuser at depths varying from about 220 to 240 feet in water that has been designated as Class A by the State of Hawaii. The location of the outfall is shown in Figure 2.

Construction of the facilities will be undertaken in two phases. The first phase will consist of the construction of an

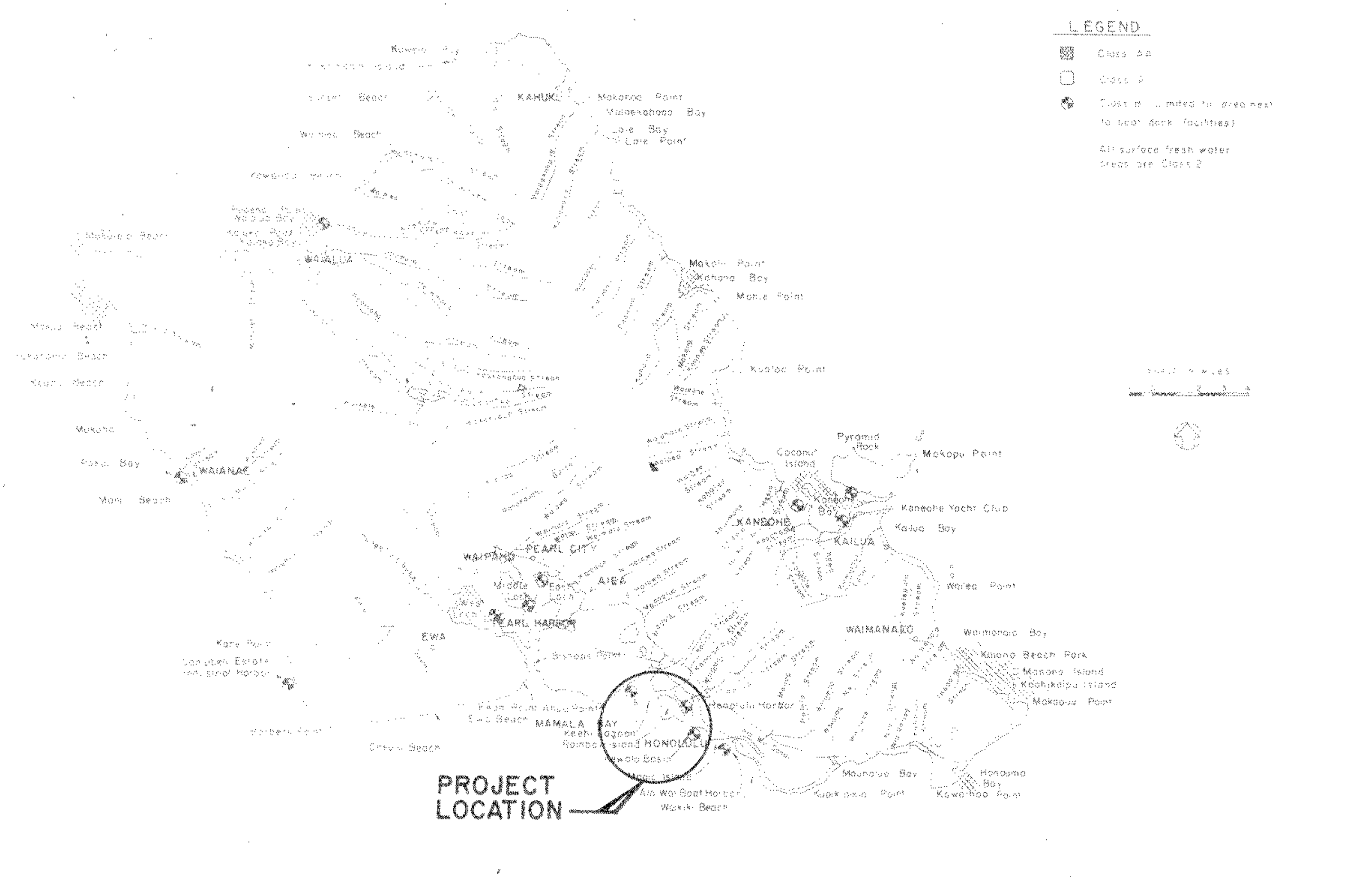
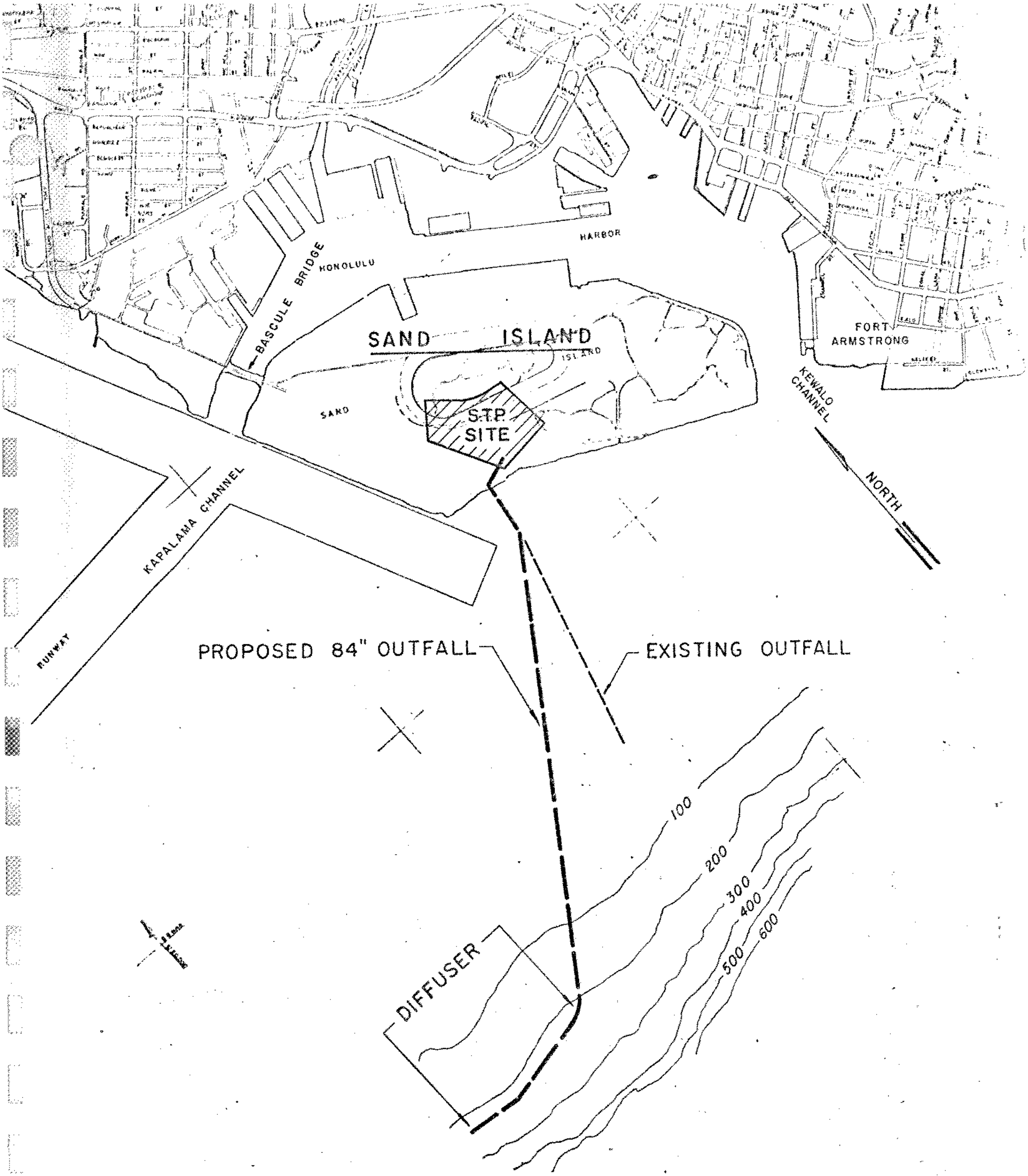

LEGEND
Class AA
All surface fresh water areas are Class 2
KAHUKU
Laie Bay
Laie Point
WAIALUA
WAIANAE
Kahana Bay
Kualoa Point
Pyramid Rock
Mokapu Point
Coconut Island
Kaneohe Yacht Club
Kailua Bay
KANEOHE
KAILUA
Waimanalo Bay
Kaiona Beach Park
Makapuu Point
WAIMANALO
WAIPAHU
PEARL CITY
AIEA
PEARL HARBOR
EWA
MAMALA BAY
Keehi Lagoon
HONOLULU
Kewalo Basin
Magic Island
Ala Wai Boat Harbor
Waikiki Beach
Maunalua Bay
Hanauma Bay
PROJECT LOCATION

Figure 1



SAND ISLAND STP & OUTFALL

MARCH 1972

Figure 2

82-mgd capacity plant with sludge handling facilities, an effluent pump station, and the ocean outfall sewer. The second phase, expected to occur between 1985 and 1990, will consist of additions and modifications to the plant to increase its capacity to 106 million gallons per day, the design flow for the year 2020.

B. NEED FOR PROJECT

The City of Honolulu presently discharges about 55 million gallons of raw sewage a day into Mamala Bay at a location approximately 3,600 feet offshore of Sand Island. This practice has limited the full use of the nearshore waters of and adjacent to the island and could cause more serious problems if allowed to continue. Immediate steps must be taken to eliminate the raw sewage discharge.

The proposed facilities will virtually eliminate or reduce the present pollutional effects, such as high bacteria counts, high turbidity and unsightly floating materials, to the shoreline waters and also eliminate the outcries of raw sewage pollution by the alarmists and conservationists of the Waikiki-Ala Moana Beach waters.

C. BACKGROUND INFORMATION

1. Existing Sewage Collection and Disposal System

The City's existing sewage collection system serves all developments within South and North Honolulu with the exception of a few isolated spots, including the Army facilities at Fort Shafter and Tripler Hospital. Waste flows from South Honolulu are presently conveyed to the existing Ala Moana Pumping Station located at 653 Ala Moana Boulevard through a network of sewers and pumping stations. The flows from North Honolulu are conveyed to the Hart Street Pumping Station located at 1031 Nimitz Highway. From these two focal stations, the waste flows are pumped to Sand Island through force mains which converge near the center of the island. The raw sewage from both mains, amounting to a combined annual average flow of 54.9 million gallons per day (1969-1970), is then discharged into the ocean through a common 78-inch outfall sewer which extends some 3,600 feet offshore of Sand Island to a depth of approximately 40 feet. Raw sewage from the Army facilities at Fort Shafter and Tripler Hospital is pumped from an existing pump station at Fort Shafter to a separate 36-inch outfall sewer located just east of the City's outfall sewer. The 36-inch outfall extends 1,250 feet into the ocean and terminates at a depth of about 18 feet. An average flow of about 1.4 million gallons per day is discharged through this outfall.

The construction of the proposed treatment and disposal facilities at Sand Island will affect the existing Ala Moana and Hart Street pumping systems. Determination of the actual effects and the modifications that will be necessary to convey sewage to the new facilities are being considered and are included as part of the design requirements of the Sand Island system.

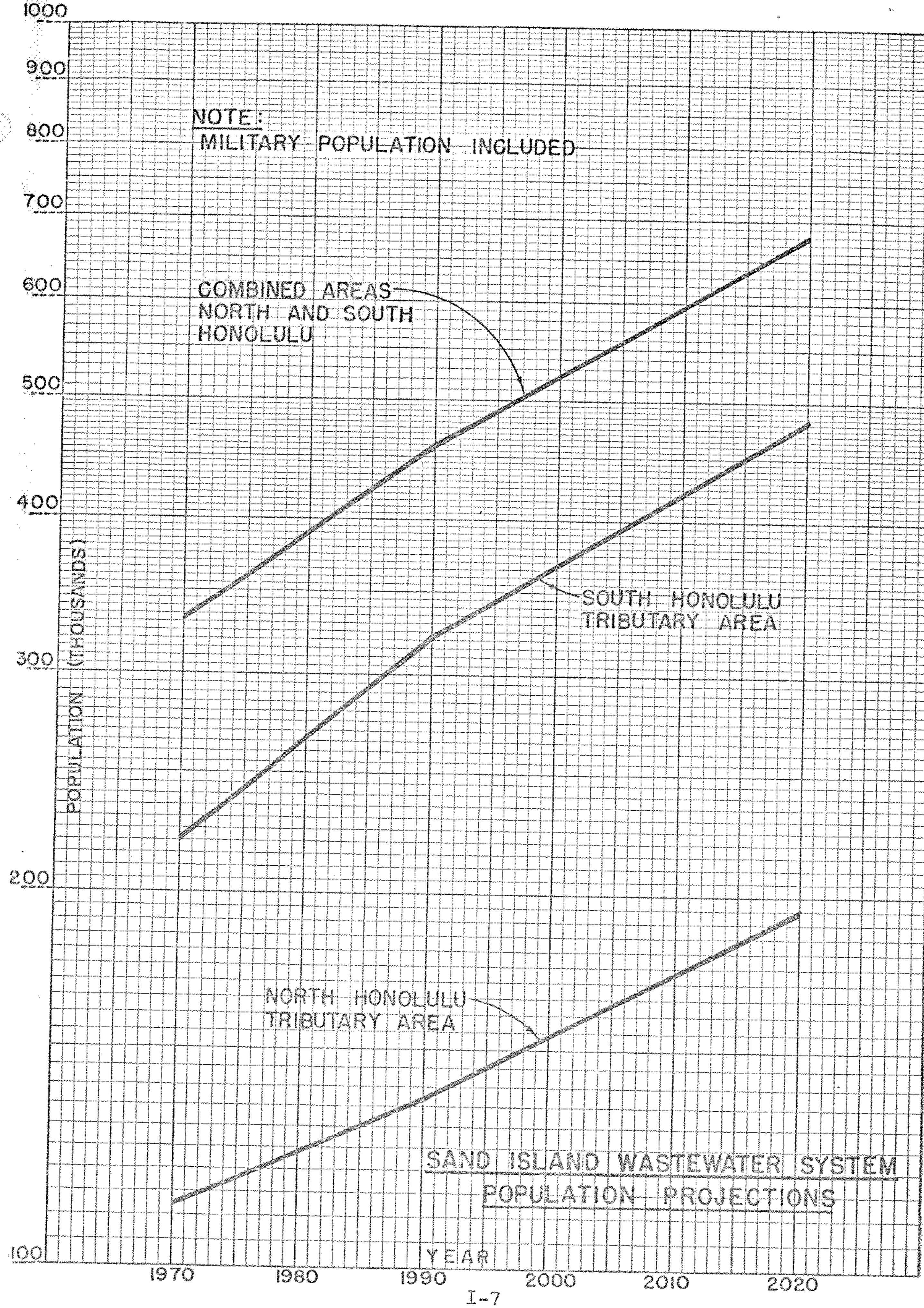
2. Population and Estimated Pollutant Loads

The capacities and related design requirements of the Sand Island treatment and disposal facilities were determined by the use of population, wastewater flow, and pollutant load estimates and projections developed under the Water Quality Program for Oahu with Special Emphasis on Waste Disposal (WQPO). These estimates and projections are discussed in the following sections.

a. Population

The present de facto populations of South and North Honolulu are 220,000 people and 112,000 people respectively, for a total of 332,000 people (Reference 2)*. Growth projections indicate that by year 2020, the populations within the two areas could possibly increase to 482,000 and 194,000 respectively, totalling 676,000 people. Figure 3 shows these projections.

* see attached Reference List



1000
900
800
700
600
500
400
300
200
100
POPULATION (THOUSANDS)
NOTE:
MILITARY POPULATION INCLUDED
COMBINED AREAS NORTH AND SOUTH HONOLULU
SOUTH HONOLULU TRIBUTARY AREA
NORTH HONOLULU TRIBUTARY AREA
SAND ISLAND WASTEWATER SYSTEM
POPULATION PROJECTIONS
YEAR
1970
1980
1990
2000
2010
2020
KEUFFEL & ESSER CO. MADE IN U.S.A.
1 CYCLE X 70 DIVISIONS

b. Wastewater Flows

Studies under the WQPO have determined that the present average waste flow per capita for South Honolulu is 87 gallons per day (gpd) and that of North Honolulu is 83 gpd. (Reference 3) It is estimated that these quantities may increase to 100 gpd and 90 gpd, respectively, by the year 2020. The present normal dry weather infiltration into the existing collection system has been determined to average 20 mgd for South Honolulu and 7 mgd for North Honolulu. It is anticipated that these relatively high infiltration rates would not increase appreciably in the future because (1) all available lands in the low lying areas where infiltration rates are the largest have been developed and required lengths of collection and transmission sewers have already been installed, and (2) continued maintenance and corrective action, including replacement of old sewers, should offset any additional infiltration from future developments. The normal dry weather infiltration is therefore assumed, for design purposes, to remain at existing levels through year 2020. Similarly the wet weather infiltration is not expected to change significantly.

The wastewaters from both South and North Honolulu are essentially domestic wastes, with the only significant contribution of industrial waste presently coming from the two pineapple canneries, Dole and Del Monte, in North Honolulu. The amount and nature of the existing flows are shown in Table 1. A summary of industrial flows is shown in Table 2.

The projected design waste flows are summarized in Table 3. Flows from Fort Shafter and Tripler Hospital are included in the projections. The present total flow from these installations is estimated to be 1.4 mgd with an anticipated increase to 2.0 mgd by year 2020. Waste flows from the pineapple canneries are also included in the projections. The design flows for the Sand Island Treatment Plant are as follows:

	1970	1990	2020
Average (mgd)	62.8	81.3	106
Peak (mgd)	151	173	202

c. Solids Loads

The total solids loads, which include floatable and settleable solids, are estimated to provide a basis for the sludge handling system. The average quantity of total suspended solids in sewage flows for both South and North Honolulu can be expected to be 0.17 lbs/capita/day (Reference 3). The total solids load

TABLE I

PRESENT WASTE DISCHARGES FROM MUNICIPAL AND MILITARY FACILITIES

Study Area	Collection Point	Type of Treatment	1969-70 Flow (mgd)	WASTEWATER CHARACTERISTICS (C=mg/l and MER=lbs/day)										Receiving Waters
				BOD		S S		Total-N		Total-P		Grease		
				c	MER	c	MER	c	MER	c	MER	c	MER	
1	Ala Moana SPS	Raw	39.2 38.9(a)	132	43,000 40,500	110	36,000 33,000	20 -	6,500	5.6 -	1,800	66 -	21,500 20,700	Ocean, off Sand Island
	Sub-total				43,000		36,000		5,100		1,800		21,500	
2	Hart St. SPS	Raw	14.2 20.6(b)	183 915	22,000 157,000	160 307	19,000 53,000	38.8 62	4,600 10,700	8.1 3.7	960 650	49 45	5,800 7,000	Ocean, off Sand Island
	*Ft. Shafter incl. Tripler Hospital	Raw	1.4	169	1,975	143	1,667	28	322	7.1	83	36	416	Ocean, off Sand Island
	*Aliamanu Crater STP	Trickling Filter	0.03	50	12	45	11	21	5	10	2	20	5	Salt Lake
	Sub-total				23,987		20,678		4,927		1,045		6,221	

(a) Without tuna cannery waste.
(b) At time of peak seasonal flow from pineapple cannery.

MER

TABLE 2

SUMMARY OF INDUSTRIAL WASTE DISCHARGES

Study Area	Industry	FLOW, CONCENTRATION (mg/l)									MASS EMISSION RATE (lbs/day)							Method of Disposal
		mgd	n(c)	BOD	SS	NH_3-N	Org N	NO_3-N	Total P	Grease	BOD	SS	NH_3-N	Org N	NO_3-N	Total P	Grease	
1	Tuna Cannery	0.33	5	895	1091	-	609	-	-	287	2500	3000	-	1700	-	-	800	To Municipal Sewer (Ala Moana SPS) & Sand Island outfall
	Others	1.4	-	-	-	-	-	-	-	-			-	-	-	-	-	
2	Pineapple Canneries																	
	a. Sewers	6.22	6	3170	956	85	113	0.46	3.7	-	165000	49600	4415	5870	24	191	-	To Municipal Sewer (Hart St SPS) & Sand Island outfall
	b. Kapalama Canal	10.31	3	339	76	6.0	9.0	0.26	0.8	-	29000	6500	540	815	21	65	-	To Kapalama Canal and Honolulu Harbor
	Hawaii Meat	0.71	1	650	344	3.5	61	0.4	0.7	193	3800	2000	21	360	2	4	1100	
	United Meat	0.12	1	440	606	6.0	293	0.6	0.8	120	440	600	6	290	0.6	0.8	120	
	Others	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

TABLE 3

ESTIMATED POLLUTANT LOADS

DESCRIPTION	1970			1990			2020		
	SOUTH HONOLULU	NORTH HONOLULU	Total	SOUTH HONOLULU	NORTH HONOLULU	Total	SOUTH HONOLULU	NORTH HONOLULU	Total
Population (thousands)	220	105[1]	325	321	130	451	482	187	669
Average Per Capita Flows (gpd)	87	83		92	86		100	90	
Average Sewage Flow (mgd)	19.2	8.7	27.9	29.5	11.2	40.7	48.2	16.8	65.0
Dry Weather Infiltration (mgd)	20	7	27	20	7	27	20	7	27
Cannery Flows During Peak Season (gpd)		6.5	6.5		12	12		12	12
Fort Shafter and Tripler (mgd)		1.4	1.4		1.6	1.6		2.0	2.0
Design Average Flow (mgd)	39.2	23.6	62.8	49.5	31.8	81.3	68.2	37.8	106
Design Max Hourly Flow (mgd)	53	33	79	67	43	101	90	52	130
Wet Weather Infiltration (mgd)	40	32	72	40	32	72	40	32	72
Design Peak Flow (mgd)	93	65	151	107	75	173	130	84	202
Average Per Capita SS (lbs/day)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Total SS in Municipal Sewage (1,000 lbs/day)	37	18	55	55	22	77	82	32	114
Total SS from Military Flows (1,000 lbs/day)		2	2		3	3		3	3
Design Peak Seasonal Cannery SS[2] (1,000 lbs/day)		21	21		23	23		23	23
SS w/Design Peak Seasonal Cannery Load (1,000 lbs/day)	37	41	78	55	48	103	82	58	140

NOTES: 1. Population does not include the military of 7,000 people

2. Design peak seasonal cannery load based on Dole removing 65% and Del Monte removing 50% of solids from their flows prior to discharge into city sewers.

from the pineapple industry during peak season includes an estimated 32,000 lbs/day from Dole and 24,000 lbs/day from Del Monte. The design loads for the Sand Island Treatment Plant are shown in Table 3.

It should be noted that the suspended solids contribution by the pineapple canneries during peak seasonal operations can amount to 56,000 lbs/day. These cannery loads, if not reduced by the canneries prior to discharge of waste flows into the municipal system, would require at Sand Island, sludge handling facilities with capacities substantially larger than would be feasible.

The City has met with representatives from the canneries and has agreed to permit the canneries to discharge their wastewaters into the municipal system only under certain conditions. The conditions include a minimum of 50 per cent reduction of suspended solids by mechanical screening devices and pH control (neutralization). Reduction of cannery solids will result in less maintenance problems for the collection system and will reduce capital expenditures, and operation and maintenance costs for sludge handling at the Sand Island plant.

in terms of flow rate or total load?

3. Joint City-Military Use of Municipal Sewerage Facilities

The President's Executive Order of February 4, 1970 for the Prevention, Control, and Abatement of Air and Water Pollution at Federal Facilities states under Section 4 (3) that "The use of municipal or regional waste collection or disposal systems shall be the preferred method of disposal of wastes from Federal facilities." Further, under Section 5 (a), it is required that pollution abatement actions at existing facilities be completed or be underway no later than December 31, 1972. Full justification as to the extraordinary circumstances necessitating any extension of the time specified under Section 5 (a) shall be required of any request for such extension.

The military agencies have constructed and are currently operating a considerable number of separate wastewater collection, treatment and disposal facilities within their establishments on Oahu. The U. S. Navy has in recent years undertaken a vigorous construction program of waste treatment facilities, particularly in the Pearl Harbor area, to comply with pollution abatement requirements.

Use of the municipal sewerage facilities by Federal agencies has been a long established precedent within metropolitan Honolulu. Wastewater flows from the Federal Building, U. S. Immigration Building, Punchbowl Cemetary, Coast Guard Headquarters at Pier 11, the U. S. Naval Reservation opposite Pier 4, Camp Catlin and Radford Terrace Housing, Fort Armstrong, Fort Ruger, Fort DeRussy and the Army Honolulu Port enter the City's sewer system and are discharged into the ocean through the Sand Island Ocean Outfall.

During the past five years, numerous discussions and negotiations regarding increased joint use of municipal sewerage facilities by military agencies have developed. The City has taken a deliberately cautious position in these negotiations because of financial considerations and capacity limitations of the existing facilities. While the City has been able to negotiate reimbursements for capital construction costs, it is apparently restrained from recovering full operation and maintenance costs of the facilities shared with the Federal Agencies since no public sewer service charge exists. Recent negotiations with the Federal Agencies are discussed below.

a. U. S. Coast Guard (14th District)

In conjuction with its proposed Housing project at Red Hill, the Coast Guard considered two alternatives for its waste flow disposal: (1) construction of its own waste treatment facility with discharge of the effluent into Halawa Stream or (2) connection to the City's sewerage system via the Moanalua Trunk Sewer. Following successful negotiations with the City in 1968, the Coast Guard elected to utilize the City's system and agreed to paying a connection charge of $212,000.

There is a Coast Guard facility on Sand Island which is connected to a local pump station operated by the State of Hawaii. This station which is located on the proposed plant site pumps the local sewage into the Army's outfall. Flows from this station will be diverted into the proposed treatment plant. Preliminary discussions with the Coast Guard indicates that a satisfactory agreement can be reached for this connection.

b. U. S. Army

The Army's immediate concern is the disposition of its sewage from Fort Shafter and Tripler Hospital. Under its present system, raw sewage is pumped to Sand Island for disposal through a 36-inch diameter ocean outfall. Since 1965, the Army authorities have discussed the possibility of joint use of the City's proposed treatment plant at Sand Island. In the intervening years, the Army was ready to embark on a separate course to construct its own treatment facility at Fort Shafter Flats.

By letter dated February 12, 1970, Headquarters United States Army Hawaii requested that the City consider the inclusion of the Fort Shafter and Tripler Hospital waste flows with municipal flows for treatment at the proposed Honolulu (Sand Island) Wastewater Treatment Plant and indicated its willingness to pay its share of capital costs as well as an equitable operation and maintenance costs. By letter dated March 12, 1970, the Mayor of the City and County of Honolulu replied that the City would consider the Army's request provided the Army conveys its sewage directly to the treatment plant site. The financial arrangement is to include an equitable share of the operation and maintenance costs for the treatment of the wastes. Reasonable capital charges for the initial treatment works and outfall sewer and any future improvements to the facilities as may be imposed by State and Federal requirements will also be included.

Another Armyinstallation which will be considered by the City for connection to the municipal sewerage system is the Aliamanu Military Reservation. The reservation's existing trickling filter plant has a capacity for 3000 men, with effluent discharge into Salt Lake. The use of Salt Lake as the receiving water may be terminated in the future due to the rapid urbanization of the peripheral area.

The Army's existing 24-inch force main from Fort Shafter presently connects to a 36-inch outfall at Sand Island. This force main will be connected to the screening building of the City's proposed Sand Island Treatment Plant. The portion of the force main after the connection and the ocean outfall will be abandoned. The Army's connection at the treatment plant is being designed and will be made by the City; however, any other work necessary for the diversion of their waste flows, including the modification of the Fort Shafter pumping station, has to be borne by the Army. The City has furnished the Army with engineering data needed to design their improvements.

4. Oceanographic Studies

a. Introduction

Coastal waters, estuaries, and the open ocean have been the recipients of most of man's liquid-borne waste materials, as well as some of the atmospheric-borne and solid wastes. Because of its insularity, topographical features, and tourist-oriented economy, wastewater disposal into all marine waters has special significance for the Island of Oahu.

The concept of marine disposal necessitates a thorough knowledge of near-shore oceanography as related to the dispersal capability of the receiving waters, the physical placement of the pipeline on the ocean bottom, and other factors that influence transport, decay, and reduction of the deleterious components of wastewaters. In addition, a critical need exists for the determination of baseline water quality conditions in the waters of Oahu.

b. Ocean Survey Program

A wide variety of information has been accumulated in the past by government agencies, the University of Hawaii, private organizations and individuals.

Data available from the above sources were evaluated as to applicability to the proposed project and the City's water quality program. Based on this evaluation, an ocean survey program was developed to provide the maximum amount of useful data with the available funds.

Sampling and Survey Stations were selected to provide coverage of the entire island with special emphasis on potential ocean outfall sites and areas under stress or presumed to be under stress.

The ocean cruises and sampling were spaced chronologically to allow delineation of seasonal variations in the parameters sought. Ocean cruises were made in a 16-foot Boston Whaler (Dillingham Environmental Company) or an 18-foot Glasspar (City and County of Honolulu).

Water samples were obtained with a Van Dorn sampler and sediment samples with a Petersen dredge. Major oceanographic gear included in situ recording current meters (Savonius rotor), in situ salinometer, relative irradiance meter, transmissometer, fathometer, winches, underwater television monitor and videorecorder, and in situ wave and tide recorder.

The analyses of water samples were made in accordance with the methods outlined by Strickland and Parsons (Reference 11). Chlorinated pesticides, arsenic, and heavy metals in sediment samples were analyzed by a commercial laboratory* which reported utilizing electron capture chromatography for chlorinated pesticides, atomic absorption spectrometry for heavy metals, and the method of AOAC (Association of Official Agricultural Chemists) for arsenic.

Water samples were analyzed for parameters which included:

(1) Temperature;

(2) Secchi Disc Transparency;

(3) pH;

(4) Dissolved Oxygen;

(5) BOD;

(6) Nitrate Nitrogen;

(7) Nitrite Nitrogen;

(8) Ammonia Nitrogen;

(9) Total Organic Nitrogen;

(10) Reactive Phosphorus;

(11) Total Phosphorus;

(12) Total Coliform Bacteria;

(13) Fecal Coliform Bacteria;

(14) Salinity; and

(15) Phytoplankton (Periphyton).

* Stoner Laboratory, Inc., Campbell, Calif.

Sediment analyses included:

(1) Particle Size Distribution;

(2) Mineralogical;

(3) Bicarbonate Extractable Phosphorus;

(4) Ammonia Nitrogen;

(5) Total Organic Nitrogen;

(6) Sulfides;

(7) BOD (Index of Putrescibility);

(8) Chlorinated Pesticides;

(9) Arsenic;

(10) Heavy Metals; and

(11) Benthic Organisms (biomass and diversity).

Oceanographic measuresments included:

(1) Ocean Currents and Circulation;

(2) Density Stratification;

(3) Bathymetric Profiles and Bottom Configuration;

(4) Wind, Sea, and Wave Characteristics; and

(5) Optical Properties (Light Attenuation and Transmission)

In addition, special investigative efforts included;

(1) Bacterial decay (T-90) studies;

(2) Monitoring TV tapes for numbers and types of benthic biota;

(3) Observation of biota by SCUBA divers; and

(4) Artificial substrates for chlorophyll and biomass.

Data listings for the analyses and measurements can be found in Reference 8.

c. General Offshore Circulation

The results of the field program have shown that the offshore circulation and the resultant net transports vary seasonally, vary remarkably from location to location around Oahu, and are strongly under the influence of the tides or wind, depending upon the location. A transport chart for the North Pacific Ocean was proposed by Sverdrup (Reference 12), showing the Pacific North Equatorial Current and a large anti-cyclonic (clockwise in S. Hemisphere, counter-clockwise in N. Hemisphere) grye around the Hawaiian Archipelago. Additional evidence of its existence has been advanced by others (References 13, 14, 15 and 16).

Based upon the present evidence, it appears that an East Pacific Gyre exists and that the position of this gyre changes seasonally. During the late spring, summer, and early fall months, the East Pacific Gyre is probably centered south-southeast of the island of Hawaii. If so, this gyre would produce a general north or northwest flow in the area of the Hawaiian Archipelago. Though the Hawaii Islands would break up this basic flow into more complex patterns around the islands, the water would generally approach the island of Oahu from the southeast. The northern portion of this flow moves around Makapuu Point, flows parallel to the shore across Waimanalo Bay, across Kailua Bay, and is deflected to the north by Mokapu

Point. Once around Mokapu Point, this flow probably deflects northwestward to Kahuku Point. At Kahuku Point, it begins flowing to the north again slowly shifting to the west far offshore. The southern portion of the flow dividing at Makapuu Point moves along the entire south coast of Oahu into Mamala Bay, resulting in a southwest transport leaving the bay during the summer months. At Barbers Point, a portion of this flow probably meets water moving southeastward along the Waianae coast. The possible result is a formation of cyclonic eddies off Barbers Point and off the Waianae coast primarily during the late spring and early fall. Eddies would more likely occur with the changing tide during the periods when the tradewinds are strong (Reference 17). The configuration of the coastline off both the windward side of Oahu and the leeward side from Makapuu Point to Barbers Point strongly influences the flow throughout the year in the shallow areas (less than 30-feet deep) close to the shoreline. Behind prominent points, such as Kawaihoa Point (Koko Head), eddy patterns may develop and change with each changing tide.

During the winter months, the location of the East Pacific Gyre probably moves southward. This would allow the westward drift north of the Hawaiian Archipelago to also move slightly southward. The result would be that the flow approaching the Hawaiian

Archipelago would be basically from the northeast and, therefore, the flow would reach Oahu from the north or northeast. This flow is divided off Kaneohe Bay. The northern portion moves northwest toward Kahuku Point. The southern portion is diverted around the east coast of Oahu, flows parallel to the east coast of Oahu, Maunaloa Bay, and continues moving around Diamond Head into Mamala Bay. This flow becomes increasingly influenced by the tides and less influenced by the wind as it moves toward Mamala Bay. Once in the bay, the net westward transport decreases and the influence of the coastline configuration (bathymetry) deflects this flow to the southwest. During both the winter and summer months (except during Kona storms) a southwest transport would be expected in Mamala Bay from off Kewalo Basin to Keehi Lagoon. The southwest transport off Barbers Point turns westward offshore and moves toward Kaena Point. The result is that weak anti-cyclonic eddies may form off the southern portion of the Waianae coast.

Figure 4 has been developed from past information supplemented by the results of the field program conducted and presents the general circulation patterns around the Island of Oahu.

GENERAL CIRCULATION PATTERNS AROUND OAHU

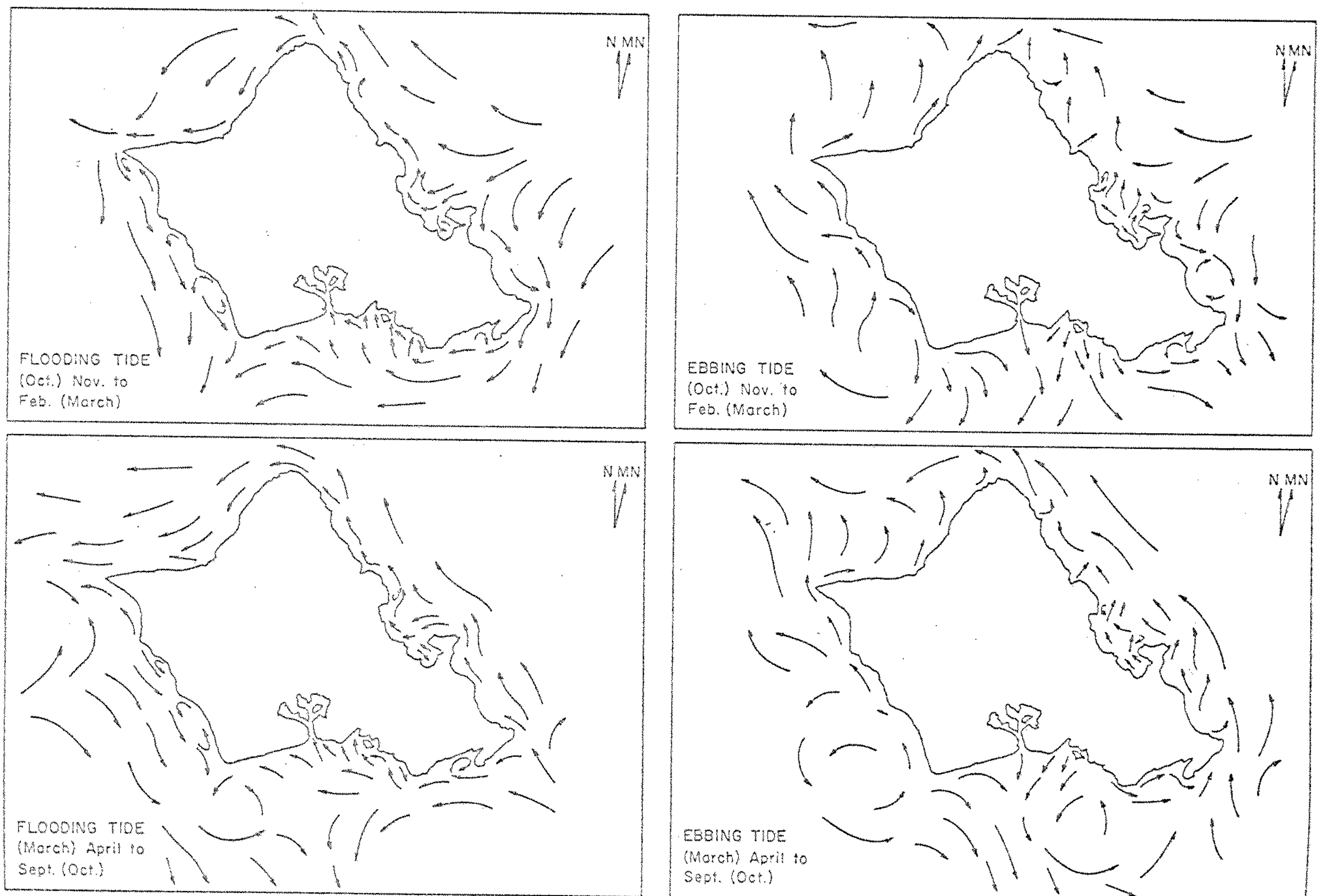


Figure 4

d. Nearshore Circulation

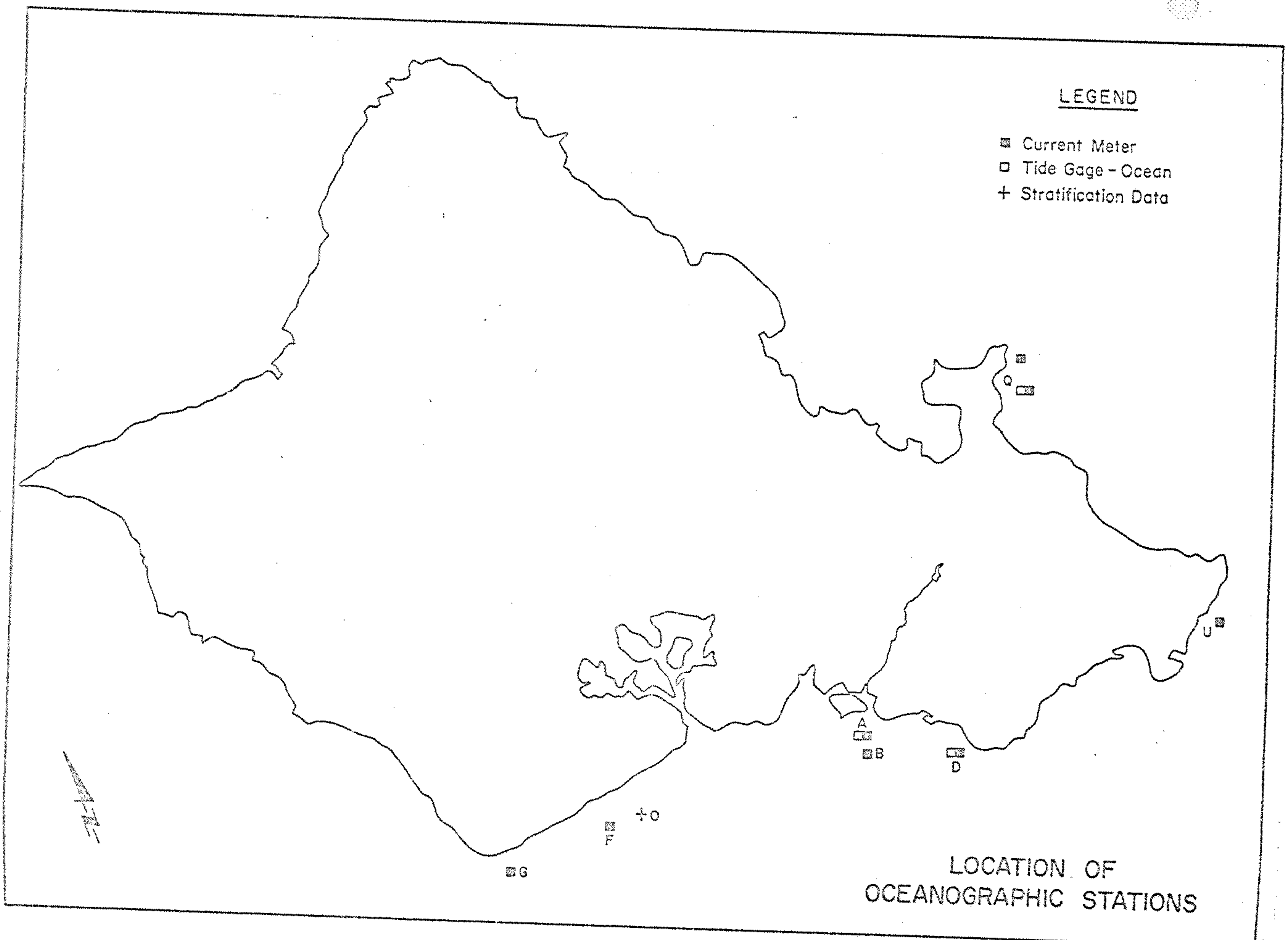
The direction of the net transport in the inshore waters (less than 400-feet deep) varies seasonally, particularly on the windward side of Oahu. During the late spring, summer, and early fall months (tradewind conditions), the transport along the entire windward coast of Oahu appears to be to the northwest. During the winter months, the direction of the transport is northwest along the coastline north of Kaneohe Bay, but is southeast between Kaneohe Bay and Makapuu Point. During February, when the observed winds changed from Kona winds to strong tradewinds, the net transport in Kailua Bay was observed to change from the southeast to the north. In Mamala Bay, the direction of the net transport is consistently away from the coast of Oahu during most of the year. Data taken during December, January, and February off Sand Island shows that the influence of strong Kona storms during this period shifts the direction of the net transport to the east-southeast, but just for the duration of the Kona storms. During this time, the velocity of the net transport is very weak and the flow moves slowly toward Diamond Head paralleling the shoreline. When the Kona storms cease, the net transport quickly shifts back to a net southwest transport. In all cases the daily transport is strongly under the influence of the changing tides.

The direction of the net transport in the surface layer (0 to 100-foot depth) in Mamala Bay is determined predominantly by the winds and configuration of the coastline. The subsurface daily transports (100 to 400-foot depth) follow the depth contours and the tidal influence predominates. The subsurface net transport, however, is weaker, flowing at approximately one-half that found in the surface layer.

The influence of the tides in changing the direction of flow and the velocity of currents varies with the location around Oahu. The tidal influence is weakest off the windward coast of Oahu and off East Oahu. The influence is strongest in Mamala Bay, particularly at Diamond Head and Barbers Point, and somewhat weaker along the Waianae coast and north coast of Oahu. In general, the tidal influence on the circulation off the leeward coasts increases with decreasing depth.

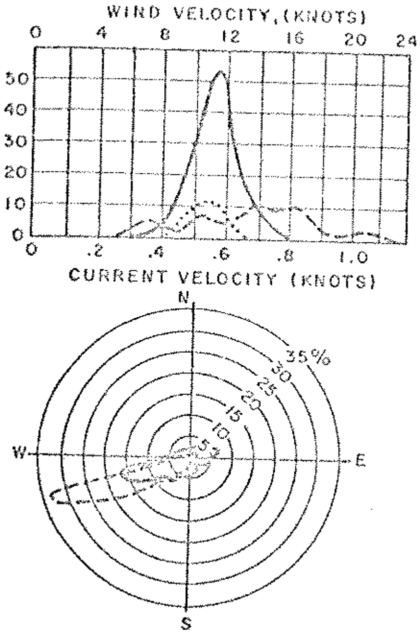
e. Currents in Mamala Bay

Extensive current measurements were made at several locations (see Figure 5) in Mamala Bay. Frequency diagrams of the speeds and directions of the measured currents are shown in Figures 6 and 7. Based on these studies, (Reference 8) two potential discharge sites were selected, one off Sand Island and the other off Ewa Beach.

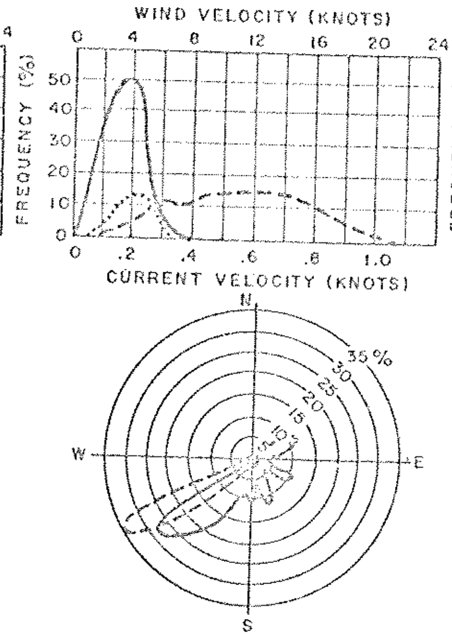


LOCATION OF
OCEANOGRAPHIC STATIONS

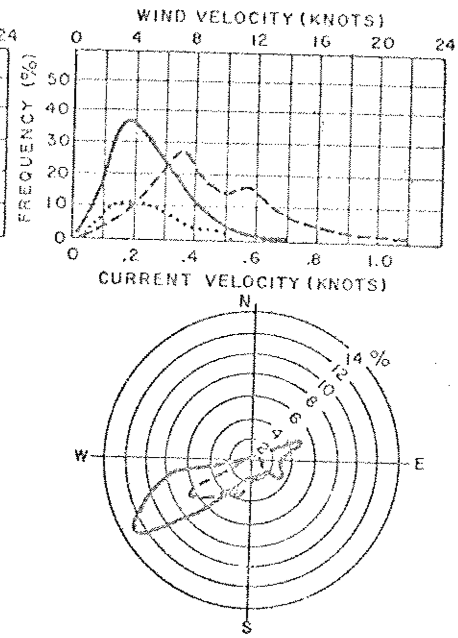
CURRENT VELOCITY AND DIRECTION FREQUENCY DIAGRAMS FOR SAND ISLAND



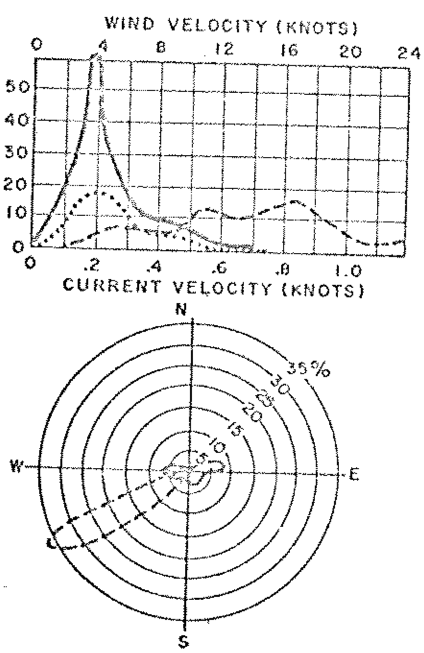
STATION A, DEPTH 18 FEET
JUNE 25 TO
JULY 9, 1970



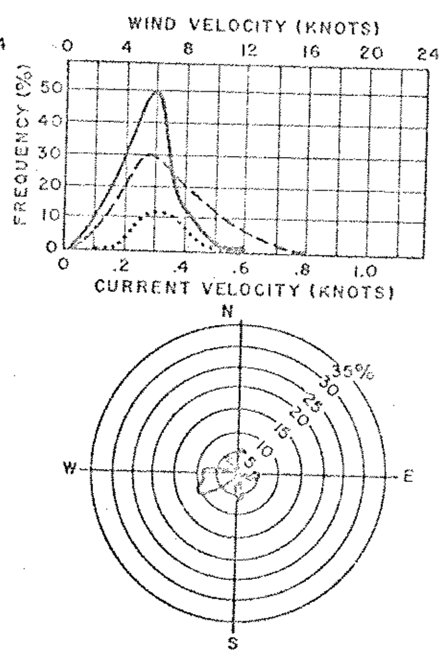
STATION B, DEPTH 200 FEET
SEPTEMBER 4 TO
SEPTEMBER 14, 1970



STATION B, DEPTH 200 FEET
NOVEMBER 6 TO
NOVEMBER 23, 1970



STATION B, DEPTH 275 FEET
DECEMBER 18 TO
JANUARY 4, 1971

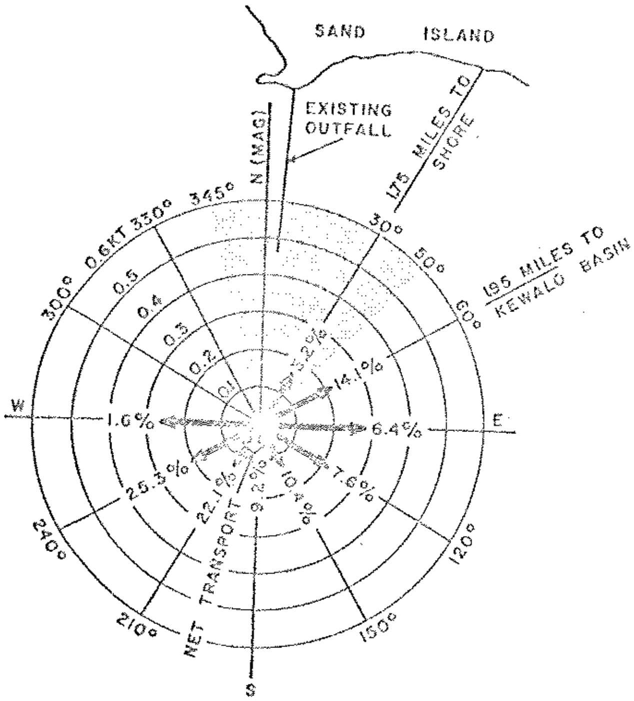


STATION B, DEPTH 275 FEET
JANUARY 22 TO
FEBRUARY 5, 1971

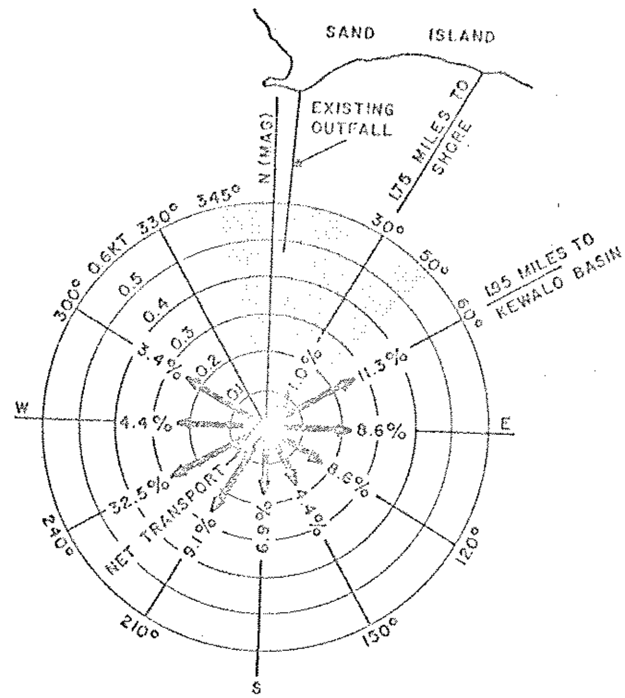
LEGEND

- (solid line) CURRENT (all directions)
- (dotted line) CURRENT (shoreward components)
- (dashed line) WIND (all directions)

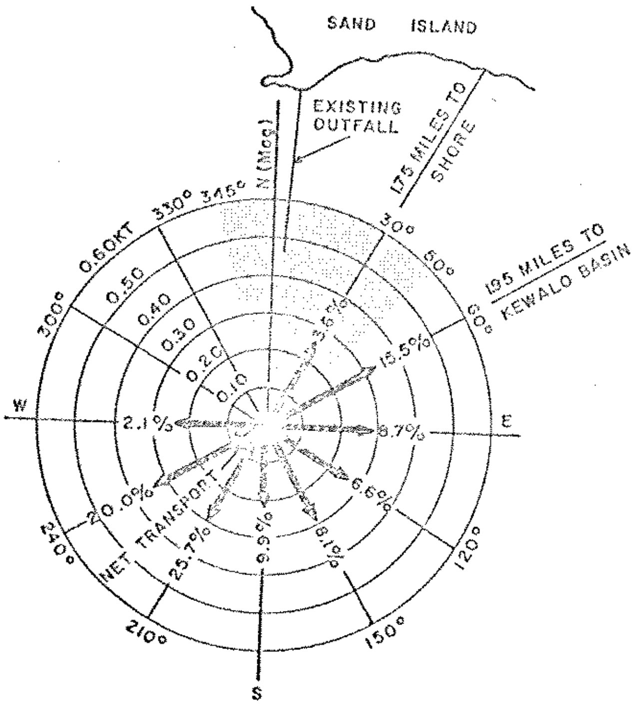
CURRENT ROSES, DEEP CURRENTS, SAND ISLAND, STATION B



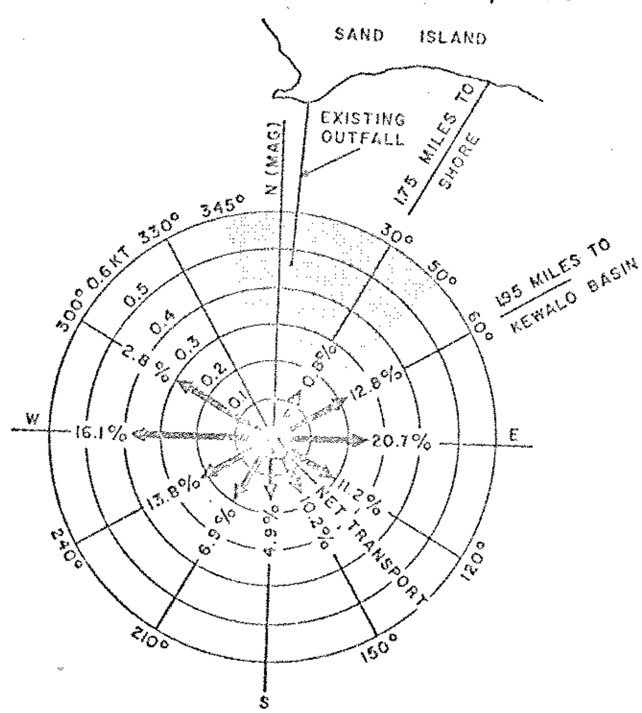
DEEP CURRENTS
SAND ISLAND - STATION B
SEPTEMBER 4, to SEPTEMBER 19, 1970



DEEP CURRENTS
SAND ISLAND - STATION B
NOVEMBER 6, to NOVEMBER 22, 1970



DEEP CURRENTS
SAND ISLAND - STATION B
JANUARY 22, to FEBRUARY 5, 1971



DEEP CURRENTS
SAND ISLAND - STATION B
DECEMBER 8, 1970 to JANUARY 4, 1971

Off Sand Island, deep currents (200-foot) were measured at a station located at the 300-foot depth along an extension of the existing outfall alignment. Current readings were made during four different periods between September 1970 and February 1971. The speeds ranged from 0 to 0.7 knot with modes ranging from 0.2 to 0.3 knot. Figure 7 shows current roses of the total observations with the given directions representing 30° sectors. Currents in the "critical" direction towards Sand Island (345° clockwise to 45°) occurred less than four percent of the time and the speeds were less than 0.3 knot. The distance to Sand Island is about 1.5 nautical mile (NM) so that a sustained current of 0.3 knot involves a travel time of about five hours.

Net transport velocities off Sand Island were calculated at less than 0.12 knot in a sector described by 149° to 249° magnetic azimuths (from SW to SE).

The second station selected in Mamala Bay was off Ewa Beach at a depth of 300 feet. Currents were recorded over a 14-day period in November 1970. The current directions represent all currents within a 30° sector. In the "critical" zone from 290° clockwise to 30°, no currents were observed. Currents with average speeds of about 0.30 knot were observed in the sector from 30° to 50°. In this direction, the nearest land is over 2.2 NM and would require travel times of about seven hours. The net transport velocity for this series of observations was 0.25 knot in the ESE direction (117° magnetic azimuth).

f. Net Transport

The net transport calculated from the current meter readings at various locations around Mamala Bay are summarized below:

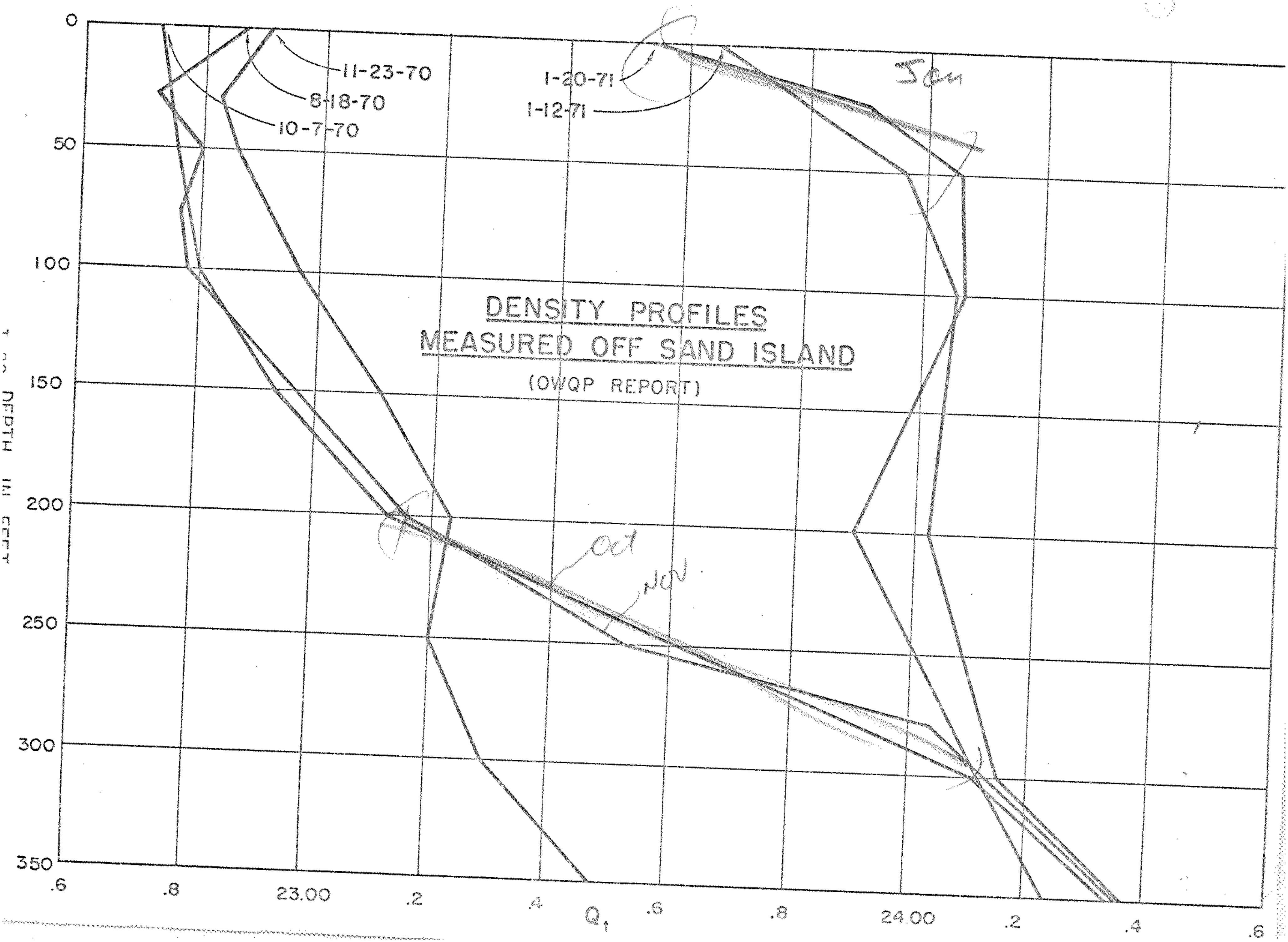
NET TRANSPORT - VELOCITY AND DIRECTION

Location	Date	Depth of Obser. (ft.)	Velocity (Knots)	Direction (° Mag)
Mamala Bay				
Barbers Pt.	Aug. 13 - Sept. 1, 1970	10	0.34	180
Ewa Beach	Nov. 4-13, 1970	200	0.28	121
Pearl Harbor Ent.	Nov. 30 - Dec. 11, 1970	60	0.38	200
Sand Island	June 25 - July 9,1970	18	0.25	199
" "	Sept. 4-19, 1970	200	0.08	185
" "	Nov. 6-23, 1970	200	0.10	219
" "	Dec. 18 - Jan.4, 1971	275	0.04	149
" "	Jan. 22 - Feb. 5,1971	275	0.11	211
Waikiki	July 14-23, 1970	10	0.41	115

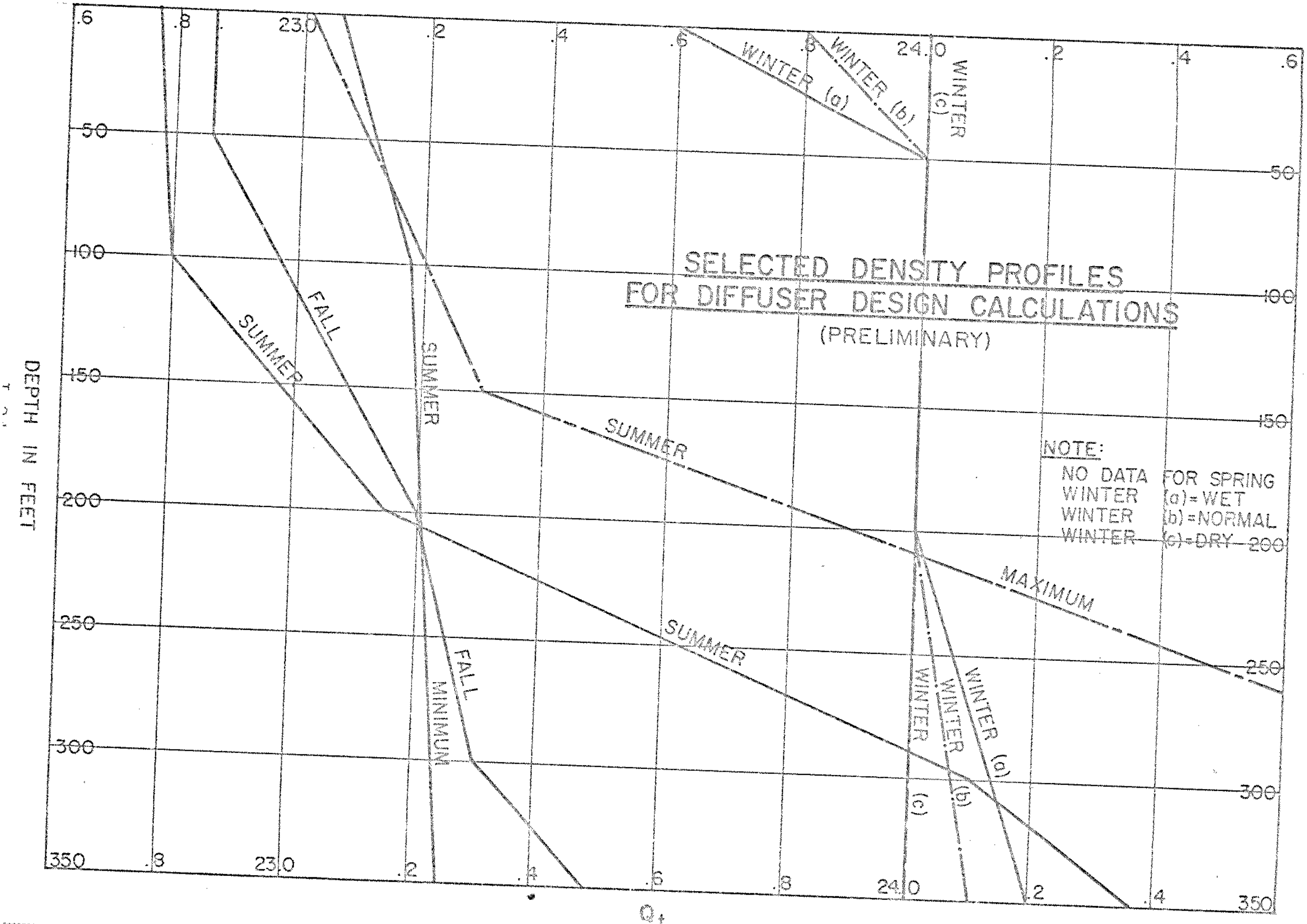
g. Offshore Stratification

The variation of water density with depth is an important characteristic when considering marine wastewater discharge. It determines to a large extent whether or not the discharge will remain submerged. Density stratification profiles were constructed from temperature and salinity data collected during the WQPO field surveys. These are reproduced here in Figure 8. Additional data were collected by R. M. Towill Corporation (RMT), the City's consultant for the design of the Sand Island Treatment Plant and Outfall Sewer. They report that the minimum density stratification occurs most probably in February, the maximum occurs most probably from July through October, and the density stratifications from July through October are virtually identical.

Data collected by the OWQP (WQPO consultants) and RMT (design consultants) were used to illustrate seven density profile conditions as shown in Figure 9, designated Summer, Summer Max, Summer Min, Fall and Winter (a), (b) and (c). These profiles will be used in estimating the submergence and dilution for various diffuser lengths and depths. The Winter (a) profile was measured by the OWQP during January 1971. Since the winter of 1970-71 was a relatively wet one, it was decided to include Alternate profiles (b) and (c),



DENSITY PROFILES
MEASURED OFF SAND ISLAND
(OWQP REPORT)
11-23-70
8-18-70
10-7-70
1-20-71
1-12-71
Jan
Oct
Nov
0
50
100
150
200
250
300
350
DEPTH IN FEET
.6
.8
23.00
.2
.4
.6
.8
24.00
.2
.4
.6


SELECTED DENSITY PROFILES
FOR DIFFUSER DESIGN CALCULATIONS
(PRELIMINARY)
NOTE:
NO DATA FOR SPRING
WINTER (a) = WET
WINTER (b) = NORMAL
WINTER (c) = DRY
WINTER (a)
WINTER (b)
WINTER (c)
SUMMER
FALL
MAXIMUM
MINIMUM
DEPTH IN FEET
σ_t
.6
.8
23.0
.2
.4
24.0
50
100
150
200
250
300
350

representing normal and dry winter profiles, respectively. The profiles below a depth of 200 feet are also divided into three alternates representing possible deep thermoclines.

D. ALTERNATIVES CONSIDERED

1. Alternatives

There are normally several possible alternatives for meeting the water quality objectives for a basin or plan area. These include -

a. treatment of wastewaters,

b. relocation of discharge points,

c. diversion of flows from basin,

d. flow regulation,

e. in-stream modification

f. water reuse,

g. control of wastewater quantities through zoning and/or planned growth both for type and amount of expansion, and

h. combinations of the above.

2. Discussion of Alternatives

The area in question, Honolulu, is a sub-area of the Mamala Bay drainage basin and has been plagued for the past 17 years with a raw sewage discharge off Sand Island. Discussions on the various alternatives available to alleviate this undesirable problem are presented in the following paragraphs. The continued discharge of raw sewage through a longer and deeper outfall was also considered and is also discussed.

a. Treatment of Wastewaters

The Mamala Bay drainage basin consists of the Honolulu and Honouliuli sub-areas. Treatment of wastewaters is believed to be the most feasible alternative for the Honolulu area. For the Honouliuli (Pearl Harbor-Ewa-Barbers Point) area, in addition to treatment, reuse of treated wastewater also appears to be feasible.

(1) Honolulu Area (Sand Island System)

The Honolulu area sewer system extends from Niu Valley to Moanalua. Wastewaters requiring treatment include municipal sewage, the U. S. Army's wastewaters from the Tripler-Fort Shafter area and "bland" wastes presently being discharged into the Kapalama Canal by Dole and Del Monte pineapple canneries.

Under this alternative, wastewaters, including pre-treated industrial wastes, would be conveyed to facilities for treatment and disposal. The Army's outfall sewer at Sand Island would be abandoned and their wastewaters diverted to the City's proposed treatment and disposal facilities. The Navy-Air Force flows from Hickam AFB and adjacent military areas will continue to be treated at the Navy's Fort Kamehameha treatment plant. This plant will be retained by the Navy throughout the design period and will not be considered further.

Based on studies conducted during the development of the WQPO (Reference 9), the City's consultants have recommended that an advanced primary facility designed with special emphasis on the removal of floating materials and a long outfall extended into deep waters where effluent field submergence can be achieved be adopted as the treatment and disposal system. This system will provide the treatment required for meeting the water quality and water use objectives of the receiving waters.

Cost comparisons between an advanced primary plant with a long outfall (depths greater than 200 feet) and a secondary plant with a shorter outfall (depths between 80-100 feet) show that it is more feasible to build a primary treatment system. Secondary and tertiary treatment with long outfalls were considered but not adopted for obvious reasons even though the results would be excellent.

The comparisons indicate that capitalized costs and annual operation and maintenance costs of the advanced primary system are much less than the secondary system. The figures, which include 30 percent of the estimated construction cost for administration, engineering and contingencies, are shown below and are based on an 82 mgd plant.

	Advanced Primary System	Secondary System
Capitalized cost	$ 32,000,000	$ 43,000,000
Annual O & M Cost	965,000	1,508,000

Besides cost differences in the treatment systems, there are other reasons for going to a primary treatment system with a long ocean outfall. It has been conclusively demonstrated elsewhere that systems incorporating primary treatment and properly designed ocean dispersion facilities have, in fact, accomplished what is desired; that is, a total system which does not impose undue stress on the ocean ecology. In addition, contrary to certain beliefs, a disposal system which can be designed on the basis of primary sewage treatment and an associated long ocean outfall provides a higher margin of public health and aesthetic safety than is provided by a system embodying secondary treatment and a shorter outfall. The reasons are as follows:

(a) Secondary (biological) sewage treatment processes are susceptible to normal process "upsets" which can result in insufficiently treated effluent; whereas, primary (physical) processes are not so affected.

(b) Secondary processes can be seriously affected by industrial waste discharges, particularly those which are seasonal and contain large amounts of organic material, such as pineapple cannery wastes.

(c) In the event of an emergency due to operational "upsets" or equipment breakdown, the discharge of settled sewage into a short outfall could pollute the adjacent beaches; whereas, little affect would result in the primary long outfall alternate because the discharge would occur substantially further away from the beaches and the process would be less susceptible to these upsets.

(2) Honouliuli Area (Honouliuli or Pearl Harbor-Ewa-Barbers Point System)

A secondary treatment facility with wastewater reclamation for cane irrigation is the recommended alternative for the Honouliuli Area. Studies (Reference 4) regarding potential reclamation of wastewaters indicate that wastewater reclamation for irrigation is feasible and desirable for this area. An ocean outfall sewer located east of Barbers Point NAS would be required during periods when irrigation is not required and when process "upsets" are experienced.

b. Relocation of Discharge Points

The relocation of the discharge point from Sand Island to the Ewa-Barbers Point area for treatment and disposal was given much consideration. This alternative included a single major treatment and disposal facility for handling wastewaters from the entire Mamala Bay area, except those from somewhat isolated areas, with an option of also handling flows from the Pearl Harbor Naval Base. The advantage of this system is that the operation and maintenance of only one major treatment and disposal facility is more economical than multiple plants. However, the system would require a longer construction period; hence, it would take longer to eliminate the raw sewage discharge problem offshore of Sand Island. In addition, a present worth analysis of the alternative systems considered indicate that this system would cost $16,000,000 more than a two-plant system. This alternative was not adopted by the City.

c. Diversion of Flows from Basin

A diversion of wastewaters from the drainage basin to an area outside of it was not seriously considered. The two best discharge points on Oahu from the standpoint of ocean disposal are at Kaena Point and Kahuku Point. These locations are across the mountain ranges at straight line distances of about 32 and 29 miles respectively. It was not given much consideration because of the high cost and the excessively long time required for implementation.

d. Flow Regulation

Flow regulation is not an applicable alternative.

e. In-stream Modification

In-stream modification is not an applicable alternative.

f. Water Reuse

Water reclamation and reuse were given serious consideration. Studies (Reference 4) indicate that reclamation of wastewaters from the Honolulu (Sand Island) system is not now feasible nor desirable because of the high chloride content of the tributary flows. The studies, however, indicate that the potentials for wastewater reclamation in the Honouliuli area are good. Further, they also indicate that a secondary treatment facility will be required in this area. Based on an average requirement of 10,000 gallons per acre per day of water for irrigation of cane fields in the Ewa plains, a considerable amount of the effluent from the Honouliuli plant can be utilized. There are some considerations, however, which must be resolved before the reclamation scheme can be a reality.

g. Control of Wastewater Quantities

Control of wastewater quantities is not an applicable alternative since the plant is needed now and the plant can be designed to accommodate the population of Honolulu within the study period (up to year 2020). Control of flow by the use of better materials, methods and technology is a continuing process. Control of the number of people in an area is a municipal planning function which is inter-related with complex social forces which are beyond the capability of any single body and is governed by the existing democratic process.

h. Combinations of Alternatives a to g

The wastewater tributary areas of Mamala Bay extend from Niu Valley to Barbers Point and encompass a major portion of Oahu's population. Based on combinations of alternatives, four basic concepts on alternative wastewater management systems(Reference 9) for the drainage basin were formulated. The concepts are -

(1) a single primary treatment and ocean disposal facility located in Honouliuli,

(2) two separate primary treatment and ocean disposal facilities, one at Sand Island and a second in Honouliuli,

(3) a primary treatment and ocean disposal facility at Sand Island and a separate treatment facility in Honouliuli with an ocean outfall off Barbers Point NAS. The latter facility would have provisions for reclamation of effluent for irrigation of sugar cane in the Ewa district, and

(4) a system similar to Alternate Scheme (3), with an additional secondary treatment facility at Pearl City.

i. Continue to Discharge Untreated Wastewaters

An alternative consisting of a deep water outfall sewer (depth in excess of 300 foot) for the continued discharge of raw sewage was considered. This alternative would permit the abandonment of the existing shallow outfall and improve the poor water quality conditions off Sand Island, Honolulu Harbor and Keehi Lagoon. Aesthetically, the existing sewage "boil" would be eliminated and replaced by a discharge with sewage field submergence attainable most of the time. Toxicity should not be a problem since studies performed under the WQPO indicate that the Sand Island raw sewage is less toxic than treated effluent from other areas (Reference 7) and adequate dilution in excess of 200:1 can be provided by design.

However, there are some problems associated with the discharge of raw sewage through a deep water outfall. During some period of time when the density stratification is weak, the sewage field would surface and be noticeable. Buoyant (persistent) floatable materials will also be a problem. These floating materials may not be held in suspension within the water column even with adequate density stratification and will appear on the water surface. We can also expect an area almost equal to the present "affected area" around the existing outfall to be degraded similarly at the new discharge site.

Special studies were made of the benthic community structure off Sand Island during the development of the WQPO. The diversity index of the benthic communities at the existing outfall was noticeably depressed; however, it appeared normal within about 500 yards northeast (upwind) or southwest of the outfall.

The most meaningful but yet rather surprising conclusion to be drawn from these studies of benthic animal communities near the present Sand Island Outfall is that measurable effects of the discharge on benthic communities are limited to an area of about 300 acres (Reference 7). The surprising feature of this conclusion is that we are dealing with a raw sewage discharge which is expected to have significant wide range effects on these communities. Yet based on two independent methods of analysis, it has been shown that the effects are limited to a rather small area.

In spite of the fact that considerable sums of money could be saved with this alternative, it was not seriously considered and was not adopted because:

(1) The discharge of raw sewage into nearshore waters is not considered a practicable treatment or control.

(2) The basic water quality standards applicable to all waters would be violated since substantial amounts of materials that could settle and form objectionable deposits would not be removed. (Reference 18)

(3) The discharge of raw sewage is not in comformance with the non-degradation policy statement of the State. (Reference 19)

3. Considerations and Evaluations

Alternatives were compared and evaluated with proper consideration of all other factors and constraints that relate to or affect each alternative. Based on these comparisons and evaluations, alternative h, Combinations of Alternatives, a to g, was determined to be the most feasible. General conclusions of the concepts under this alternative are as follows:

a. Concept 1, hereinafter called Alternative 1, with a single treatment and disposal facility in the Ewa-Barbers Point area, would be the most costly. The system has the advantage of operating and maintaining a single treatment and disposal facility. However, it requires a long pressure main (64,000 lineal feet, 96 inch diameter) to convey the large flows from the Ala Moana and Hart Street pumping stations to the treatment facility. Utilization of this long pressure main is also costly from the standpoint of operation and maintenance. Further, the extended time required for sewage to reach the treatment plant is undesirable when considering treatability and probable odor nuisances. Of vital concern is the fact that this alternative would require appreciably more time to implement. A solution to the priority disposal problem of Sand Island (flows from North and South Honolulu) would be delayed because of the greater time necessary to coordinate design, and construct this large regional system.

b. Concept 2 (Alternative 2) was the most economical of the four alternatives. It considered the feasibility of two separate primary treatment and ocean disposal facilities, one at Sand Island to serve North and South Honolulu and another in the Ewa-Barbers Point area to serve the Pearl Harbor tributaries, which extend from Halawa to Ewa.

Oceanographic studies (Reference 8) conducted within Mamala Bay conclude that ocean disposal of primary treated effluent into deep waters off Sand Island is feasible. The deep ocean disposal site off Barbers Point is also feasible.

c. Concept 3 (Alternative 3) also included a primary treatment and ocean disposal facility at Sand Island. A separate treatment facility would be located in the Ewa-Honouliuli area, with ocean disposal of effluent into deep waters east of Barbers Point. Originally, the latter facility was planned to initially provide primary treatment of wastewater with provisions to incorporate secondary treatment when the use of effluent for irrigation of cane is needed and arrangements for its delivery concluded with the plantations. Plans now reflect the construction of a plant to provide secondary treatment from the beginning.

The potential for reclamation of wastewater has been studied and found to be feasible in the Ewa caprock area. This is a major consideration in the evaluation of alternative schemes. It is concluded that Alternative 3 (concept 3), the system with a treatment facility located in the Ewa-Honouliuli area, would be advantageously suited for potential reclamation of wastewaters for irrigation of cane. However, even with the inclusion of reclamation, the ocean outfall proposed off Barbers Point would still be required as a backup means of disposal since irrigation of cane fields is dependent upon crop phase and rainfall.

Effluent disposal would be effected via the outfall during periods when irrigation water is not required or desirable and when process "upsets" are experienced. Since the discharge of wastes off the Waianae Coast at Barbers Point is not advisable, the same ocean outfall could also provide for the discharge of treated industrial wastes from the Campbell Industrial Park.

d. Concept 4 (Alternative 4) is similar to 3, except for a third treatment facility to handle the flows from Halawa to Pearl City. This alternative proposes upgrading the existing Pearl City treatment plant to a secondary process with possible reuse of wastewater for irrigation of cane lands in the Waiawa area. While this scheme enables retention of existing facilities and could be implemented immediately, it poses several contingent factors. Potential reuse of the effluent for irrigating the Waiawa cane lands is speculative, since this agricultural land could be converted to urban use; further, the Board of Water Supply has reservations over the reuse of treated wastewater with respect to adverse effects to the underlying basal water supply. The need for a positive back-up means of effluent disposal with this facility is therefore apparent. Sustained discharge of secondary effluent into Middle Loch of Pearl Harbor is not advisable, except as an interim solution. Tertiary treatment prior to discharge into Middle Loch is also not advisable as an ultimate solution because of high costs.

4. Conclusions

General conclusions are that it is feasible and more economical to handle wastewaters from the Mamala Bay tributaries with two separate treatment and disposal facilities, one at Sand Island and the other in the Ewa-Honouliuli area.

It is recommended that wastewater from Honolulu be conveyed to a primary treatment facility on Sand Island with ocean disposal of effluent into deeper offshore waters. Sand Island is considered to be the most suitable site for such a facility because of the following reasons:

a. Design and construction of the treatment and disposal system at this site will entail the least delay.

b. The island is the present terminal point for all of the Honolulu waste flows and is physically separated from the City by Honolulu Harbor and the industrial belt extending from Fort Armstrong through Iwilei to Kapalama peninsula (Kapalama military shipping area).

c. No present or future residential areas are planned for the island. Planned usage is for industrial and park purposes.

d. The plant site will have adequate buffer areas to adjacent industrial and park developments. The plant may be made odor free by covering of the treatment units. Proper landscaping will ensure maximum compatibility with the park.

The second treatment facility, located in the Honouliuli area, would be provided to serve the Pearl Harbor tributaries which extend from Halawa to Ewa. This facility will provide secondary treatment. Effluent will be discharged into the ocean via an ocean outfall into deep waters off Barbers Point and/or reclaimed and reused for sugar cane irrigation.

E. PROVISIONS FOR SECONDARY TREATMENT

Provisions for secondary and advanced treatment facilities have been incorporated in the plant layout. These include space and connection provisions for aeration tanks (activated sludge), final settling tanks and advanced treatment units. Functional units are to be grouped together to facilitate process flow and placed to avoid future conflicts with major in-plant lines.

Approximately fifty percent of the land area in the southeast portion of the site is being reserved for secondary units.

A hydraulic allowance of 4-1/2 feet has been reserved for losses through secondary units. The effluent pumping station has been sited to facilitate both the initial primary facilities and possible future expansion to the secondary level. The distribution conduits have been designed for direct extension for additional primary units and effluent conduits have been designed for direct feed to secondary components.

II. ENVIRONMENTAL ASSESSMENT OF WASTEWATER DISPOSAL OFF SAND ISLAND HONOLULU, HAWAII

A. INTRODUCTION

1. Project Identification

Name of Applicant: City and County of Honolulu, Hawaii

Address: 520 South King Street, Honolulu, Hawaii

Project Number: WPC-HAWAII-46

Location of Project: Mamala Bay off the Southern coast of Oahu, Hawaii(See Figure 1).

2. Brief Description of Project

This project resulted from recommendations submitted to the City and County of Honolulu by a group of scientists and experts from three engineering firms, collectively referred to as the Oahu Water Quality Program (OWQP), who were given the task of formulating a wastewater management program for the Island of Oahu. Their studies (see References 1 to 10) began in April 1970 and have covered all aspects of wastewater management, i.e., oceanography, ecology, demography, sanitary engineering, etc. The State Health Department, the Federal Environmental Protection Agency, and other interested agencies have received copies of their reports.

The OWQP proposed route of the outfall pipe and location and depth of the diffuser system were altered during the design phase of the project. This project now consists of the construction of a new ocean outfall pipe and diffuser system to handle the discharge of a primary treated sewage effluent at a mean depth of 230 feet and at an offshore distance of approximately 9,000 feet (see Figure 10) instead of an extension of the existing outfall to a depth of about 300 feet. The final design of the outfall system provides for a greater dilution at the lesser depth at about the same frequency of submergence, i.e. submerged field most of the time. This outfall and diffuser system will replace an inadequate shallow water outfall through which raw sewage is presently being discharged.

3. Applicable Final Design Parameters

Applicable final design parameters for the sewerage and ocean disposal systems follow.

a. Ocean Outfall System:

(1) Capacity: Ultimate peak wet-weather Q = 202 mgd.
Present minimum Q = 32 mgd.
Diffuser designed to operate at maximum efficiency in Q range of 65 - 130 mgd.

(2) Dilution: Initial dilution of 200 to 1 when field is submerged and about 400 to 1 when plume surfaces.

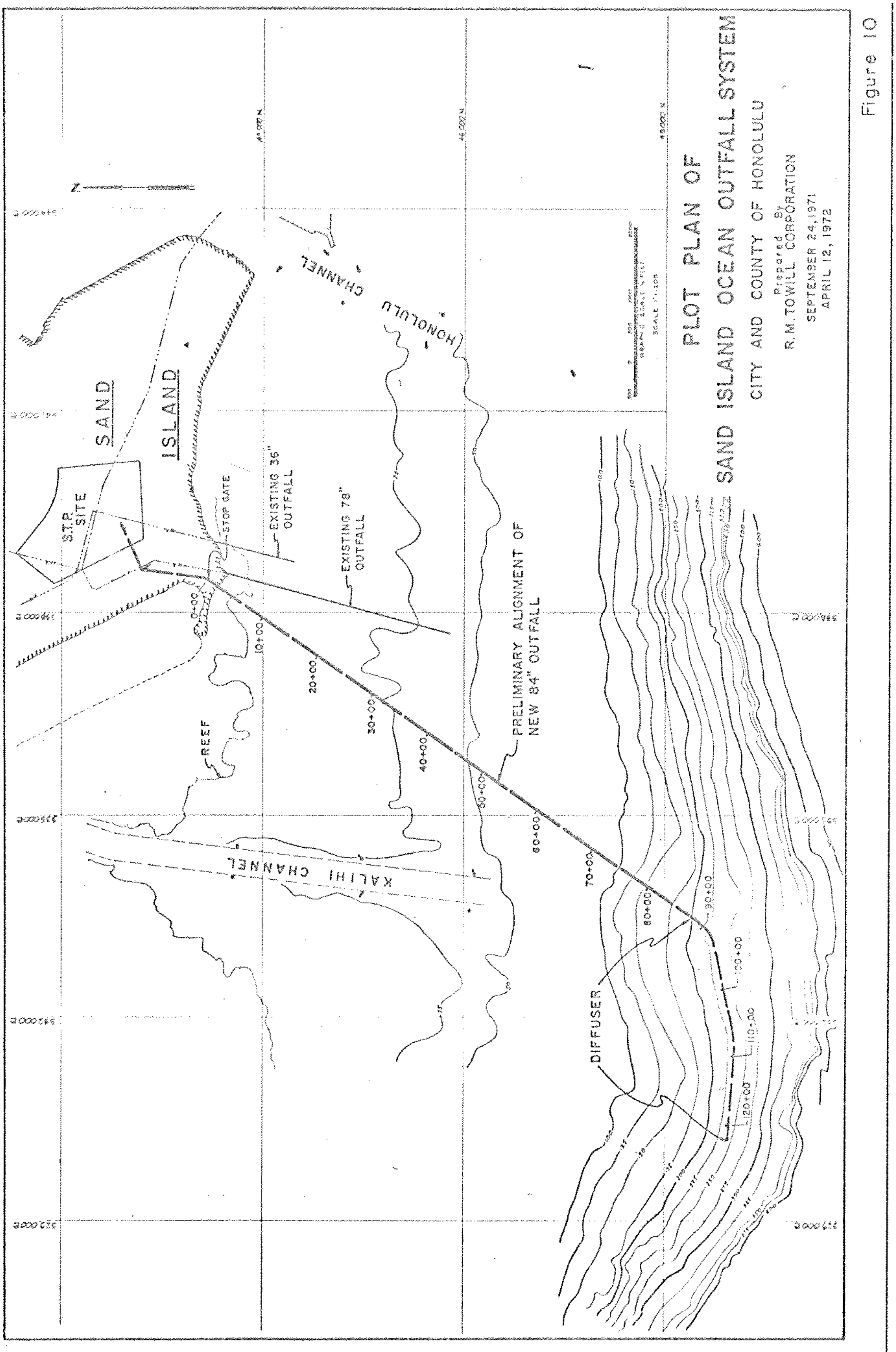

PLOT PLAN OF
SAND ISLAND OCEAN OUTFALL SYSTEM
CITY AND COUNTY OF HONOLULU
Prepared By
R.M. TOWILL CORPORATION
SEPTEMBER 24, 1971
APRIL 12, 1972
SAND
ISLAND
S.T.P. SITE
STOP GATE
EXISTING 36" OUTFALL
EXISTING 78" OUTFALL
PRELIMINARY ALIGNMENT OF NEW 84" OUTFALL
HONOLULU CHANNEL
KALIHI CHANNEL
REEF
DIFFUSER
0+00
10+00
20+00
30+00
40+00
50+00
60+00
70+00
80+00
90+00
100+00
110+00
120+00
N
Figure 10

Figure 10

Initial dilution is defined as that dilution resulting from the jet action of the outfall diffuser ports prior to and independent of subsequent dilution caused by ocean currents.

(3) Submergence: Sewage field is to remain submerged most of the time when operating at 130 mgd.

(4) Length, including a 3,350 feet long diffuser, will be 12,350 feet.

b. Treatment Facility

(1) Bar-screens/grit removal

(2) Sedimentation/Flotation

(a) Settleables: Substantially complete ($\geqq$95%) removal of settleable materials.

(b) Floatables: Overall removal (60%) of floatable materials with particular attention given to achieving complete removal of persistent buoyant floatable materials ($\geqq$95%).

(3) Fine-screen: Further removal of particulate materials.

(4) Sludge Handling: Incineration preceded thickening by heat treatment, and dewatering by centrifuges. Centrate disposal by return to sedimentation/ floatation units. Ash disposal by hauling to landfill.

(5) Chlorination facilities for odor control and other in-plant purposes and effluent disinfection, when required.

4. Anticipated Effluent Characteristics

The anticipated effluent characteristics from the advanced primary treatment facilities before initial dilution are presented below. Average characteristic values (except for Parameters G, H, I and M) of the submerged field inside the proposed zone of mixing after initial dilution can be derived by dividing these values by 200, the design initial dilution factor established under the Water Quality Program for Oahu for a submerged field. If the plume surfaces, average values within the zone can be derived by dividing the values by 400. 400 is the dilution factor established for an surfacing field.

Parameters		Anticipated Effluent Characteristic
a.	Settleable solids	0.1 - 1.0 mg/l
b.	Floatables	3 ppm
c.	BOD, median non-canning	100 mg/l
d.	BOD, median canning	200 mg/l
e.	Total Coliform, median	200,000/ml (est.)
f.	Fecal Coliform, median	50,000/ml (est.)
g.	pH	6.7 - 7.5
h.	Total dissolved solids	2,500 mg/l
i.	Turbidity	20 - 30 JTU
j.	Suspended solids, median	50 mg/l

	Parameters	Anticipated Effluent Characteristics
k.	Total phosphorus, average	5 mg/l
l.	Total nitrogen, average	22 mg/l
m.	Temperature	71 - 79 Deg.Fah.

B. PROBABLE IMPACT OF THE PROJECT ON ENVIRONMENT

It is anticipated that the proposed project and wastewater discharge will have a negligible effect on the ecology of Mamala Bay.

1. Effects on Benthic Animal Communities

Studies of the benthic animal communities near the present Sand Island raw sewage discharge have shown fairly conclusively that the severely affected area is roughly 10 acres and measurable effects attributable to the discharge are limited to an area of slightly less than 300 acres (Reference 7). These effects are reflected by increased invertebrate productivity, decreased community diversity, and a preponderance of detritus feeding organisms. These studies also indicated that most effects could be attributed to settleable materials in the raw sewage discharge. The area significantly affected by the proposed discharge should therefore be substantially less than the area affected by the present discharge because over 90 percent of the settleable materials will be removed by treatment prior to discharge.

Underwater television surveys, submersible surveys and inspection of bottom samples near and from the proposed discharge site did not indicate any biological communities of major ecological or economical importance that might be degraded or destroyed. The macro-fauna in this area is sparce, consisting of a few starfish, molluscus, and gastropods. In places, however, there are large colonies of pinna clams with densities ranging as high as 200 organisms per square meter. These clams were also found in large numbers near the present raw sewage discharge which suggests that they would not be adversely affected by the proposed discharge. No live corals were found

2. Biostimulatory Effects

Biostimulatory effects of the proposed discharge should be minimal. No adverse conditions such as undesirable algae blooms have been noted near the present outfall and none are anticipated due to the proposed discharge. Water currents are of sufficient magnitude ($\overline{X} \sim 0.1$ knot) and are in a direction (185° magnetic; offshore) to prevent excessive accumulations of nutrients which might stimulate undesirable algae blooms. A slight increase in primary productivity may occur, but it is anticipated that this increase will be quickly cycled through to the next trophic level thereby preventing an accumulation of plant biomass.

3. Effects Due to Heavy Metals and Pesticides

Accumulations of heavy metals and pesticides in sediments near the proposed discharge are not expected. Analyses of sediments samples taken from near the present discharge indicated low concentrations of heavy metals as follows (concentrations as ppm dry weight):

Location	Hq	As_2O_3	Cu	Zn
500 yds upwind (northeast) of outfall	0.01	5.2	3.1	7.1
A+ outfall	0.01	9.5	7.8	25.
500 yds downwind(southwest) of outfall	0.00	2.8	0.9	5.7

Total chlorinated hydrocarbons in the same samples were barely detectable upwind from the outfall, 4.4 ppm at the outfall, and 0.06 ppm downwind from the outfall. Chlorinated hydrocarbons at and downwind from the outfall could not be identified (Reference 7).

4. Effects Due to Construction of Outfall

Construction of the outfall and diffuser system may impose a certain amount of stress on the ecosystem, but this stress will be temporary and minimal. Underwater television and submersible surveys near and along the proposed outfall route have shown that the bottom is relatively smooth except for a few coral heads and major excavations or fillings probably will not be required. There are no coral beds or other such biological communities of significance in the proposed path of the outfall that would be destroyed or degraded during construction.

5. Effects Due to Floatable Material

No objectional accumulations of wastewater floatables are expected to occur in Mamala Bay as a result of this outfall. There appears to be a large number of factors involved which govern concentrations of wastewater materials on a receiving water surface. Of importance are quantity, quality and emission rate of floatables in the discharge, currents, including eddy diffusivity, density stratification of the receiving waters, and wind. Large persistent floatables probably rise rapidly from the discharge port (s) to the water surface without being influenced greatly by the character of the receiving water. However, the smaller particles are significantly affected by the character of the receiving water and may remain suspended within the water column because of turbulence and density factors, much as are plankton.

Observations of floatable concentrations over the present raw sewage discharge off Sand Island indicated that a major portion of the materials in the discharge that were defined as floatables by measurement were not persistent enough to accumulate and remain at the surface of the receiving water. This was borne out by observations of what appeared to be small sewage floatables suspended within the water column. Thus, it appears that most of our attention should be directed towards removal by treatment of the large persistent particles in waste streams.

A treatment design parameter for 60 percent removal of the total floatable mass appears to be reasonable in that it gives satisfactory assurance for substantially complete removal of the large persistent floatables. For the purpose of this discussion, floatables are classified into three general groups: large persistent, small persistent, and non-persistent particles. The large persistent particles comprise an estimated 35 percent of the total floatable mass in untreated waste flows and the small persistent and non-persistent particles make up about 40 and 25 percent, respectively. If one assumes that the efficiency of floatable removal by standard treatment processes follows the general trend that large persistent particles are easier to remove than the small persistent ones which in turn are easier to remove than the non-persistent particles, then it can be shown that a 60 percent total removal objective will provide for about 95 percent removal of the first group and about 65 and 0 percent of the second and third classes, respectively.

By removing 95 percent of the large persistent particles and a substantial portion of the smaller persistent particles through treatment, aesthetic problems associated with these materials in the receiving waters should be eliminated or at least greatly reduced. Because the design of the outfall system calls for field submergence, it is highly possible that once the large persistent floatables are removed by treatment, most of the remaining materials would have densities approaching that of the effluent and remain submerged with the general sewage plume where they would be subjected to great dilution by subsurface movement of the sewage field prior to any appearance at the ocean surface. Experiences at other locations where sewage fields are submerged most of the year suggest this probability. For example, at San Diego, where sewage field submergence is experienced at all times, tests for coliform bacteria in the surface waters above the outfall are generally negative indicating no rapid transport of sewage materials from the outfall diffusers to the ocean surface.

Primary treatment removal efficiency of floatables is about 52 percent, estimated by pooling data from the Waianae and Pearl City treatment facilities, compared with a slightly higher efficiency of about 65 percent for the Kailua and Kaneohe secondary plants. A 50 percent reduction of floatables was also recorded for a Richmond, California primary treatment plant.

A well designed primary treatment facility can obtain a 60 percent removal of total floatables as long as special attention is given to floatables removal. The initial treatment given to floatables and suspended solids as raw sewage enters the Sand Island plant is the removal of coarse solids by mechanical screening devices. As the sewage passes on its way to the floatator-clarifier units, it will be injected with high pressure water that has been saturated with air. Air will be distributed uniformly throughout the total flow. In the flotation units, the physical separation of the finer particles will be accomplished, either as "float" or scum for the low specific gravity particles or as sludge for the higher specific gravity particles, including grit. Before the effluent enters the effluent pumping station, it will pass through fine screens (1/4 inch) for removal of any solid carryover from the clarifier weirs. The expected treatment efficiencies for solids are:

Type of Solids	Percent Removal
Suspended	70
Settleable	95
Floatable	60
Floatable (persistent)	95

In summary, floatable materials should not create an aesthetic problem in the receiving waters due to (1) special attention given at the treatment plant for floatable removal, (2) favorable offshore ocean current and wind patterns, and (3) submergence of the effluent field.

6. Effects on Beneficial Uses of Area

The proposed discharge will have no significant deleterious effect on the beneficial uses of this area. These uses include shipping, boating, fishing, and aesthetics. Water contact sports generally do not occur in this area, but even if they did, no health hazard would be anticipated because the design provides for sewage field submergence. The special attention to be given to floatable material removal in the treatment process combined with favorable winds and currents should prevent accumulation of objectionable amounts of these materials on the surface of the receiving water. The submerged field should also prevent significant changes in the natural clarity of the surface waters as well as to prevent the occurrence of objectionable odors.

If the sewage field surfaced, odors would not be detectable and the increase in turbidity probably would not be noticed by casual observers. It is anticipated that if the field did surface, the turbidity (20-30 JTU) would approach normal sea water. Temperature of the effluent (71-79^{o}F) will approach normal sea water within 0.1^{o}F.

No significant deviations from the State Water Quality Standards are anticipated although a "zone of mixing" will have to be established for coliform bacteria. The median total and fecal coliform counts after initial dilution are estimated to be 1000/ml and 250/ml respectively. The zone of mixing for these parameters probably would begin at the ocean bottom and extend upwards only so far as the sewage field rises. The initial and subsequent dilution of the wastewaters should eliminate the necessity for a large zone of mixing, however.

It should be pointed out that the present nutrient standards for these waters are not realistic because even under ambient conditions these waters appear to violate the Standards. Water quality data collected over a 7-month period from Mamala Bay including a station off Diamond Head, which presumably represents a "pristine" area, are listed below (Reference 8):

	Total Phosphorus, mg/l		Total Nitrogen, mg/l	
Location	Mean	Range	Mean	Range
Sand Island	0.013	0.001-0.026	0.145	0.037-0.315
Ewa Beach	0.035	0.008-0.229	0.225	0.010-0.612
Diamond Head	0.035	0.003-0.152	0.184	0.032-0.562

Total permissible concentration specified by the standards for Class A waters are: total phosphorus - not greater than .025 mg/l; and total nitrogen - not greater than 0.015 mg/l (Reference 18).

From these data it is obvious that the nutrient standards are not met most of the time. It should be clearly understood, however, that these deviations from specified levels appear to be purely a natural phenomenon and that there is no evidence to suggest that these waters are polluted.

C. ANY PROBABLE ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED

There can be little doubt that the wastewater discharge will have some effect upon the ecology of its receiving waters. One of the basic principles of physical chemistry is that for a system in equilibrium, such as a natural ecosystem, any change in any one of the factors upon which that equilibrium depends, such as nutrient concentrations, will cause the equilibrium to shift in such a way as to diminish the effect of the change (Le Chatelier's Principle). The question to be answered then is whether or not this change and subsequent shift in equilibrium caused by the proposed discharge will be detrimental to the ecology of Mamala Bay. Based on all of the data gathered from this area, it appears that any effects resulting from this proposed discharge will be insignificant and certainly far less detrimental than the effects produced by the present raw sewage discharge. A slight increase in community metabolism may be expected in areas influenced by the discharge, but this increase should not cause significant changes in the natural biota. Significant changes in the biota and in the productivity of the biota can be expected to occur in relatively small areas near the proposed outfall, however.

D. ALTERNATIVES CONSIDERED WITH EVALUATION OF EACH

As with any comprehensive wastewater management program, a large number of alternatives were considered and evaluated. The possible alternatives for meeting the water quality objective for Mamala Bay have been discussed previously. Only the more significant of these alternatives will be considered here. The first alternative would be to forego construction of the outfall and simply to consider treating the wastewaters by a secondary or advanced treatment process before discharging effluent into the ocean. Neither of these processes appear to offer significant advantages over primary treatment with deepwater disposal especially when one considers the fact that we are dealing with a municipal-type waste which is not ladened with toxic industrial substances. Secondary and tertiary sewage treatment processes are susceptible to normal process "upsets" which can result in insufficiently treated effluents whereas primary (gravity) processes are not so affected. Secondary and tertiary processes can be seriously affected by waste discharges that are seasonal and contain large amounts of organic material such as pineapple cannery wastes. A power outage or equipment breakdown in a secondary or tertiary treatment plant could result in an emergency discharge of settled sewage into the short outfall which might pollute nearby beaches and recreational areas thus creating a potential health hazard. Secondary or tertiary treatment combined with a long deepwater outfall system could conceivably provide better results, but such systems are extremely expensive, and therefore would curtail expenditures of monies needed for solving pollution problems elsewhere.

The proposed treatment facility will have sufficient flexibility in design so that if the character of the wastewaters changes or if it is determined that the discharge is having a detrimental effect on the receiving waters, the treatment process can be upgraded and/or modified to meet the needs. Present indications are that the advanced primary treatment plant will meet substantially all of the objectives being sought.

Other alternatives considered disposal of the treated effluent at some other point in Mamala Bay. None of these alternatives were more attractive than the selected alternate when compared on the basis of water quality, currents, stratification, bathymetry, and ecological considerations.

E. RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF THE ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The implementation of the proposed wastewater treatment and disposal system will greatly enhance the aesthetics and recreational potential of Mamala Bay. The proposed system will replace an inadequate and antiquated disposal system which consists of a raw sewage discharge into 40 feet of water 3,600 feet offshore. Because of the high coliform levels in nearby waters, State Health Department officials have been forced to post and close certain recreational areas along

Sand Island and in Keehi Lagoon. The proposed treatment and disposal system will allow for the development of a much needed water-oriented recreational area on Sand Island which would be impossible under existing conditions.

The proposed discharge into deep offshore waters will have no significant adverse effect on the beneficial uses of these waters and could conceivably benefit some of these uses by providing a diffused source of basic raw materials for phyto-plankton. A sustained increase in algal production should be reflected by a concomitant increase in fish production, although realistically these increases probably will not be of any significance due to the net transport out to sea.

F. ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Except for the ocean bottom on which the outfall pipe and diffuser system will lie, there does not appear to be any irreversible and irretrievable commitment of the resource. There are no important biological communities such as coral reefs in the vicinity of the proposed outfall site that might be destroyed or degraded. Although not expected, adverse changes in the ecosystem probably could be rectified quickly by upgrading the treatment process and then relying on ocean currents to dilute out the earlier effects.

G. PUBLIC OBJECTION TO PROJECT, IF ANY, AND THEIR RESOLUTION

A great deal of effort has gone into getting information about this proposed project to the public by means of television, radio, and newspaper coverage and public and professional meetings. In general, the project appears to have had overwhelming acceptance although as with any proposed wastewater disposal project there have been a few dissenters. Efforts are being continued to resolve points of dissension.

H. ECONOMIC AND SOCIAL COST ANALYSIS

1. Definition of Beneficial Uses

The State of Hawaii took positive steps to define, and in some cases to evaluate, the beneficial uses of its waters by holding public hearings for this purpose in 1966 and 1967. These hearings provided the basis upon which the State Water Quality Standards were established. A classification system composed of distinct classes of waters with each of the water classes designed to provide protection for specific beneficial uses was developed (Reference 18). For marine waters, these classes included Class AA waters, established to protect oceanographic research, propagation of shell fish and marine life, conservation of coral reefs and wilderness areas, and aesthetic enjoyment; Class A waters, established to protect recreational, including fishing, swimming, bathing, and other water-contact sports, and aesthetic enjoyment; and Class B waters which were to provide protection for small boat harbors, commercial, shipping and industrial, bait fishing and aesthetic enjoyment. All waters around Oahu were placed into these use-based classes.

2. Beneficial Uses

The coastal and inland waters of Oahu serve a wide variety of uses which provide immeasurable benefits, both economic and social, to the people of Oahu, the State, and to the nation. These benefits include water-oriented recreation, aquatic life propagation and sustenance, commercial fishing, industrial water supply, ocean-going water transport, and in general, an environment for pleasant living and enjoyment of aesthetic values. All of these benefits depend to some degree upon the maintenance of waters of suitable quality.

Evaluation of beneficial uses is perhaps the more difficult portion of the procedures leading to the establishment of adequate water quality standards to insure the greatest net economical and social return to the people. The easiest and most direct approach is probably an economic evaluation of the obvious uses of a water resource. To the industrialist and agriculturist, this approach is often preferred since their uses of the waters have very specific monetary worths. To the small independent merchant and businessman either directly or indirectly dependent on the water resources of an area, an approach which only considers large obvious monetary worths could be disastrous. For example, how many fewer gallons of gasoline would be sold by a local independent service station owner if the number of vacationers in an area declined because a section of coral reef had been destroyed by thermal pollution? How much of an economic loss would a sightseeing guide suffer if oil slicks were allowed to develop in boat harbors? These are social-economical questions that are often difficult, if not impossible, to answer based on present technology and knowledge. Nevertheless, benefits from and rights to natural resources by all society must be protected in order to insure a continued strong economic growth.

The water areas in Mamala Bay that are affected directly or indirectly by the Sand Island discharge are listed in Table 4. The current uses of these water areas are also indicated in this table.

3. Communities or Areas Which Would Benefit

Communities or areas which will benefit by the elimination of the raw sewage discharge off Sand Island include Kalihi-Palama, Honolulu Harbor, Kapalama Canal, Keehi Lagoon, Sand Island, Kewalo Basin, Waikiki and Ewa Beach. At these communities or areas, the value of the water ecosystem will be enhanced. At Waikiki and Ala Moana beaches where exist Class A waters of high value, a wastewater discharge off Sand Island which has not received the best practicable

TABLE 4
COASTAL AREAS, BENEFICIAL USES
DICTATING RECOMMENDED WATER QUALITY OBJECTIVES

WATER AREA	USES DICTATING RECOMMENDED WATER QUALITY OBJECTIVES	HAWAII WATER AREA CLASSIFICATION
Campbell Estate Industrial Harbor	Boat harbor, baitfish propagation	B
Barber Point) Oneula Beach) Ewa Beach)	Recreation (whole-body-contact), marine life propagation (oceanic), aesthetics	A
Pearl Harbor, West Loch	Shellfish and marine life propagation, baitfish propagation, aesthetics, waterfowl	AA,*B
Pearl Harbor, Middle Loch	Baitfish propagation, aesthetics, recreation, aesthetics	A,*B
Pearl Harbor, East Loch	Baitfish propagation; aesthetics, recreation, aesthetics	A,*B
Hickam Harbor	Boat harbor, baitfish propagation, aesthetics	B
Keehi Lagoon	Recreation (whole-body-contact), bait-fish propagation, marine life propagation (oceanic), aesthetics	A
Keehi Marinas	Marinas, baitfish propagation, aesthetics	B
Kapalama Basin	Marinas, baitfish propagation, aesthetics	B
Honolulu Harbor	Baitfish propagation, boat harbor, aesthetics	B
Kewalo Basin	Baitfish propagation, marinas, aesthetics	B
Ala Wai Yacht Harbor	Marinas, baitfish propagation, aesthetics	B
Waikiki - Ala Moana Beaches	Recreation (whole-body-contact), marine life propagation (oceanic), aesthetics	A
Maunalua Bay	Recreation (whole-body-contact), marine life propagation (oceanic), aesthetics	A

*B - Class B designation apply only to a limited area next to boat docking facilities in bays and harbors.

treatment or control could seriously jeopardize the tourist industry.

4. Aesthetics and Recreation

Aesthetics is clearly an important use of all waters. From all available evidence, the social well-being and orderly growth of our society appear to depend to a great extent upon the quality of the environment in which we live. Environmental degradation implies a concomitant social degradation. Protection of aesthetics qualities of all surface water resources is as important as the protection of all other beneficial uses.

Another important use of the waters of Oahu is recreation. People are drawn worldwide to the shores of Oahu to experience and take part in water-based recreational activities. These activities range from swimming through bathing, surfing, SCUBA diving, skin diving, boating, and fishing to simply sightseeing. Most of this recreational demand is due to the high quality of most coastal waters together with a warm and constant tropical climate.

The most significant deterrent to the aesthetics and recreational uses of coastal waters appears to be the raw sewage discharge off Sand Island. From all available evidence, however, this discharge does not appear to be directly affecting established beach areas such as Waikiki and/or Ala Moana Beach Park. However, just the knowledge that near these areas exists a raw sewage discharge which is visible from aircraft, from high rise buildings, and from ships and boats passing nearby, is enough to detract from the recreational quality of these waters.

5. Demographic and Economic Forces

The area served by the Sand Island sewer system is subject to the same major economic forces as are present throughout the State of Hawaii; i.e., defense expenditures, visitor expenditures, sugar production, and pineapple production. Within the area exists the famous Waikiki Beach complex, military facilities, pineapple canneries and financial and business offices that serve the entire state.

The residents and visitors pay a premium to live in or visit Hawaii. The cost of living in Hawaii is often quoted to be the highest in the nation. The compensation for this high cost of living is the high quality of the environment which exists within the State. People choose to live or visit Hawaii in order to enjoy the benefits gained from a clean and healthful natural environment. It should be noted that this is not necessarily the driving force that determines residency throughout the rest of the United States. A downgrading of the environment, particularly water quality, would result in economic as well as demographic upheaval in Hawaii. Management of wastes from domestic, industrial, agricultural, and natural sources to protect and enhance water quality is vital to insure economic and demographic stability.

A summary of economic and demographic statistics (1961-1971) from an overall State view is shown in Table 5.

6. Specific Benefits

The most important commercial fish of the State is the Skipjack tuna (aku) fishing with landings valued at about $3 million. The nehu which is used as baitfish are taken in significant numbers from Keehi Lagoon, Honolulu Harbor, Pearl Harbor and also Kaneohe Bay. One of the limiting constraints in the growth of this industry has been the availability of the baitfish. Thus, the enhancement of water quality may directly stimulate the industry by increasing the yield of baitfish. This aspect must be further studied for difinitive conclusions.

A vital part of the economy of Oahu is tourism. It accounts for much of the activities related to construction, air travel, and hostelries which in turn provide employment for a significant part of the population. The lure of the Islands is in part due to salubrious climate, scenic beauty, and its water-oriented recreation. Visitor expenditure in Hawaii have steadily increased from about $25 million in 1950 to over $510 million in 1969. In order to maintain the growth rate of this vital part of the economy, it appears that enhancement of water quality in Mamala Bay and other areas is essential.

Table 5

*A Decade Of Change**

(Statistical Summary of Growth Since 1961 with Preliminary Estimates for 1971)*

		1961	1970	1971	Annual Rate of Change: Average 1961-71	1969-70 (Percent)	1970-71
POPULATION (As of July 1)							
Total Resident Population		658,684	773,667	789,225	1.8	3.1	2.0
Civilian		597,872	719,864	737,559	2.1	2.6	2.5
Military		60,812	53,803	51,666	— 1.6	11.0	— 4.0
EMPLOYMENT							
Average		232,910	335,450	341,000	3.9	5.5	1.7
INCOME							
Total Personal Income	$ Millions	1,598	3,445	3,760	8.9	13.0	9.1
AGRICULTURE							
Sugar	$ Millions	78.6	110.6	115.9	10.6	5.4	4.8
Pineapple	$ Millions	34.8	38.7	39.1	1.2	7.5	1.0
Diversified Agriculture	$ Millions	46.9	63.5	65.4	3.4	6.9	3.0
MANUFACTURING SALES							
Sugar	$ Millions	146.4	196.7	209.0	3.6	4.0	6.3
Pineapple	$ Millions	117.5	135.0	135.0	1.4	7.7	—
Diversified Manufacturing	$ Millions	203.0	420.0	440.0	8.0	5.0	4.8
CONSTRUCTION							
Completions	$ Millions	268.5	783.8	675.0	9.7	25.3	—13.9
Authorizations	$ Millions	157.4	483.2	370.0	8.9	— 4.4	—23.4
VISITOR INDUSTRY							
Visitor Arrivals	Number	319,807	1,798,591	1,775,000	18.7	17.8	— 1.3
Visitor Expenditures	$ Millions	137.0	570.0	625.0	16.4	8.6	9.7
Hotel Room Inventory	Number	10,193	32,289	35,699	13.4	19.9	10.6
TRADE							
Retail Trade	$ Millions	949.0	2,024.7	2,200.0	8.8	14.8	8.7
Foreign Trade	$ Millions	80.4	223.8	270.0	12.9	2.9	20.6
TRANSPORTATION (FY Ending June 30)							
Interisland Air Passenger Trips	Thousands	925.8	2,796.1	2,954.6	12.3	9.8	5.7
Interisland Air Cargo	Tons-Thousands	12.9	25.6	24.4	6.6	30.6	— 4.7
FINANCE (As of June 30)							
Deposits of All Financial Institutions	$ Millions	979.7	2,182.6	2,607.8	10.3	5.8	19.5
Loans of All Financial Institutions	$ Millions	688.2	1,978.8	2,271.7	12.7	13.8	14.8
GOVERNMENT							
Defense Expenditures	$ Millions	401.9	683.4	720.0	6.0	3.5	5.4
UTILITIES							
Telephones In Use	Thousands	221.6	414.2	441.7	7.2	8.4	6.6
Volume of Electricity Sold	Million KWH	1,518.2	3,275.7	3,620.0	9.1	9.0	10.5
Volume of Gas Sold	Million Therms.	20.8	37.7	42.0	7.3	9.9	11.4
Volume of Water Sold	Billions Gallons	21.8	36.9	39.0	6.0	9.8	5.7

* Bank of Hawaii Monthly Review December 1971

III. CONSTRUCTION IMPACT

A. GENERAL

Construction activities will have definite effects on the environment. Various construction activities, processes and methods and their effects will be discussed in this section. Construction is expected to begin during the Summer of 1972 and should be completed by the end of 1973.

B. CLEARING AND GRUBBING

The sewage treatment plant (STP) site shall be cleared of native vegetation which consists mainly of weeds, small shrubs, and small algaroba (kiawe) and opiuma trees. The larger of these trees are approximately 25 feet tall with 12± inch thick trunks. The majority of the trees are approximately 10 to 15 feet tall with trunks approximately 3 to 6 inches thick. It is anticipated that land clearing will be accomplished by cutting of trees and bulldozing of shrubs and weeds. Vegetation spoil will be disposed of by presently acceptable means such as land fill or incineration. The use of herbicides is not anticipated. Any on-site burning will comply with all applicable laws, rules and regulations. There are several buildings on the site which will be demolished. The disposal of these buildings will be by conventional means.

The land portion of the outfall will require some clearing of weeds, shrubs, and small algaroba trees. This vegetation will be disposed of as discussed previously.

The ocean portion of the outfall will not require any clearing and no work of this nature is anticipated.

There are no major streams or drainage structures on Sand Island. The STP Site is approximately 1700 feet from Honolulu Harbor at the closest point and is approximately 800-1000 feet from the ocean along its southerly and southwesterly boundaries. A portion of the STP site drains into the moat defining the old Quarantine Island. This moat empties into Honolulu Harbor via a drain passing through the Coast Guard property. The remainder of the STP site drains into the ocean. There appears to be no defined drainage ditch passing through the STP site other than the moat mentioned above. A drainage plan is being developed as a part of the STP construction plan. Drainage patterns during construction has not been determined and their development will be made the responsibility of the contractor. The relatively small area (50 acres) of the plant, the flat terrain of the area and the relatively dry climate indicates that surface runoff and erosion will not be a major problem during construction.

C. GRADING AND EXCAVATIONS

The STP site will be graded to conform to an overall grading plan. The plant will be graded to provide maximum utility of the site and to blend the STP with the environment. Visual emphasis in the overall site is being given to the landscaping rather than to individual buildings. Landscaped berms will be used along the periphery to obscure the facility from outside view. All excess excavated material and spoil will be incorporated into these berms.

Deep trenches, foundations and structures will require dewatering. The contractor is required to control the discharge from these operations to comply with existing regulations. These operations are therefore not expected to have any significant effect on the environment.

The underwater excavations, on the other hand, will be difficult to control. Any disturbance of the bottom will release sediments and will increase the turbidity of the water. The overall effect, however, is expected to be small since only a relatively small area will be exposed or be disturbed at any given time. Also, the prevailing currents and dispersal pattern will localize this effect.

Hard materials may be encountered during construction and may require blasting. Such blasting, if employed, will be done in accordance with all applicable industrial safety regulations. The safety of the public and the working force will be protected at all times. Such blasting is not expected to have any effect on wildlife on shore. Similarly, only localized effect on marine life is expected.

Excess excavation on shore will be incorporated into the plant construction. Excess excavated material from the ocean portion will be deposited along the trench. No further handling is anticipated and no nuisances are expected from placing the excess excavated material along the pipeline.

D. SITE ACQUISITION

Except for the U. S. Coast Guard Honolulu Base, control and ownership of Sand Island is with the State government. The entire 50 acre site for the STP is owned by the State of Hawaii and will be leased to the City and County of Honolulu for a 65-year period. Portions of the STP site are being used as base yards by contractors, storage firms, auto wreckers, and other light industries on a month-to-month lease basis. The leases can be terminated by the State at any time. By letter dated March 2, 1972, the State informed the leaseholders(13) that their leases will be cancelled and that relocation assistance from the City was available. Also located on the site is the "Half Way House", a facility used for the treatment and rehabilitation of male alcoholics. The major portion of the 50-acre site is unused at present. The area is currently zoned at R-6 (Single family residential, 5000 sq ft minimum area) and I-2 (Heavy Industrial): The City's General Plan designates most of Sand Island for Industrial use and a portion along the shore is shown for park use. The STP site is wholly within the area designated for industrial use.

The "Half Way House", an independent, nonprofit organization functioning under the Hawaii Alcoholics Foundation for the treatment and rehabilitation of alcoholics, has a facility within the plant site. According to information received from that organization, approximately 120 people are serviced by this facility during a year. They have bed space for approximately

29 people with an average residence of approximately 25 persons. The facility is recognized and approved by the State Department of Health and is partially funded by the State Department of Social Services. Their staff consists of unpaid volunteers. They have been on the present site for approximately 10 years in facilities provided by the State.

There is also a raw sewage lift station on the site. This lift station receives all of the local Sand Island sewage and discharges it into the Army outfall. This facility is operated by the State Department of Land and Natural Resources. The function of this lift station will be retained within the STP site. The effluent line will be connected to the treatment facility upon its completion.

The outfall pipeline traverses land that is owned by the State of Hawaii. It will be buried to depths between 3 and 8 feet and will not interfere with any planned structures. The land is presently undeveloped and is not being used. Portions of these lands will be developed as a park by the State. Easements will be required for the outfall.

Relocation payment as mandated by Act 166, SLH 1970 will be provided in accordance with the act.

E. AIR QUALITY

Construction activities may affect the quality of the air. This effect is expected to be minimal.

Dust may be generated and could affect the area downwind of the construction site. The specifications require that the contractor control dust by watering, applying dust palliatives, or other methods acceptable to the City.

Burning of excess material such as scrap lumber could be accomplished. Such burning will comply with all applicable laws and regulations and no nuisances or difficulties are expected as a result of such burning.

Use of chemical sprays such as insecticides or herbicides are not expected.

Exhaust fumes from construction equipment are not expected to become a problem. Only conventional construction equipment are expected to be used.

F. WATER QUALITY

Construction activities will have temporary effects on water quality.

Water from dewatering of trenches, excavations, and other construction activities must be disposed of without creating nuisances or unusually restricting usage of the surrounding waters. Preliminary soils information indicates that the subsurface materials are generally porous and recharge into the ground may be possible. If such recharge is unsuccessful, silting basins will be utilized with the overflow being discharged into the harbor or the ocean.

Construction actitivies on the ocean portion may cause localized water pollution in the form of increased turbidity from suspended materials. This will occur during excavation, placement or gravel cushion, concrete placement, and backfill placement. The fine materials in the bottom, sand, gravel, and cement from freshly placed concrete will be washed out and will be transported away by the prevailing ocean currents. Control of this turbidity may not be possible. The overall effect, however, is not expected to be significant in that the total particulate matter under consideration is not large and the net transport of this water is away from shore. The effect of this pollution is expected to be of a very short duration and no long term effects are anticipated.

The sewage flow through the existing waste disposal systems will not be affected during construction and no diversion or bypassing of sewage is anticipated.

G. NOISE

Some noise will be generated by construction activity. They will come from internal combustion engines, compressors, jackhammers, saws, pile drivers, explosives (blasting), and other construction equipment and processes.

There are no residences in the immediate vicinity. The U. S. Coast Guard station barracks housing approximately 150 persons (mostly transients) is approximately 1500 feet from the construction site. The closest permanent business, the Seatrain Lines Terminal, is approximately 500 feet from the

STP site. There are some temporary tenants (contractors, etc.) on State lands (presently on month-to-month lease) within a distance of 500 feet from the Plant site. Permanent civilian homes are approximately 1 mile from the construction site across the harbor.

The industrial character of the area and its distance from residences and businesses indicate that construction noise and vibrations will not have any significant effect on them. No special noise control measures are required for this work.

There are no know major wildlife in the construction area to be affected by construction noise. Fish and marine life in the construction area will be affected by the construction activities but this effect will be temporary.

H. NIGHTWORK

This project is a critical construction project required to reduce pollution in Mamala Bay and a minimum construction period is required. Construction must be completed by November 1973, according to the State approved implementation plan. The contractor may be required to perform some of his work at night to conform to the tight schedule imposed by the contract.

Lights or Noise are not expected to have any significant effect on the environment due to the industrial character of the area and the distance from residences and businesses.

I. TRAFFIC

The STP and outfall sites are generally undeveloped and construction activity is not expected to have any effect on vehicular or pedestrian traffic. Public access to park areas, beaches, etc. will not be affected. An exception is the ocean outfall construction which will require the closing of a section of the shoreline and public access to this area will not be allowed during construction.

J. PUBLIC SAFETY

The public will be protected from construction hazards. The contractor will be required to provide barriers, guards, lights, warnings and other safeguards as may be necessary to prevent injury to persons and property. Public access to causeways, trestles and floating equipment will not be permitted.

IV. LONG - TERM IMPACT STATEMENT

A. LAND COMMITMENT

The proposed Sand Island treatment plant will be located on a 50-acre site near the center of the island. The 50 acres represent the ultimate (2020) land area required for advanced primary treatment and sludge handling facilities, as well as land reserved for potential secondary treatment facilities. A strip park of 140 acres, extending from the Diamond Head end of the island along the ocean and towards the Bascule bridge, has been proposed. The exact configuration of the park which will be constructed and maintained by the State has already been delineated. The first increment of the State park, consisting of approximately 35 acres adjacentto the southeast boundary of the plant site, is scheduled for construction during 1972. Whether the 140-acre park will be expanded to 250 acres as some groups have advocated is uncertain at this time; however, in no case will the location of the treatment plant deter the creation of a 250 acre park complex. Present indication (March 1972) is that the park will be limited to 210 acres.

Light industrial and harbor facilities uses are existing and proposed for the Ewa-mauka part of Sand Island. In addition, a site of 11 acres not far from the western boundary of the plant has been reserved for bulk fuel storage by Governor's Executive Order (EO) No. 2405; however, this site is expected to be relocated. Adjacent to this boundary is the area leased for break bulk containerization activity (G. L. S. 4258). By Governor's Executive Order No. 2462, the northwestern part of the island has been set aside for the State Department of Transportation for container yards and a marginal wharf. Of the 53.3 acres set aside, 21 acres are used by Seatrain as a container yard.

Other maritime activities proposed mauka of the plant site include those related to ship repair and foreign trade zone and trans-shipment. The determination of the final use of this area lies with the State Board of Land and Natural Resources.

The U. S. Coast Guard Honolulu Base on Sand Island is located on a 48.6-acre site along Kapalama Channel. The base has docking berths, a galley, barracks and numerous industrial shops. On the Waikiki boundary of the Coast Guard facility is an existing bait station operated by the State Division of Fish and Game.

The State strip park will be approximately 600 feet wide and will begin, as stated earlier, from the fishery site and extend to the Bascule bridge. The Board of Land and Natural Resources has agreed that the State park will play a predominant role on Sand Island but does not wish to preclude maritime connected industries in areas mauka (north) of the park. The Board intends to retain a park planning consultant firm to assure the development of a park of high standards.

In order to assure compatibility with the development of the park, any leasing agreement issued by the Board for the use of any portion of Sand Island will contain conditions relating to aesthetics and landscaping. Construction plans must be approved by the Board before any work can proceed, in order that landscaping of high standards is maintained.

In addition, the 65- year lease of the treatment plant site to the City will contain a stipulation that the plant must provide odor control devices. The City has fully agreed to this condition and has incorporated this requirement in the design of the treatment plant.

The treatment plant will serve as a buffer between the industrial uses on the harbor side of the island and the recreational oriented ocean side. This inland location therefore represents the least physical intrusion into the planned beach front development. Approximately one half of the plant site, the half adjacent to the industrial areas, will be utilized initially by the primary and sludge handling facilities. The remaining half of the site will be held in reserve for secondary treatment facilities if they are required in the future. Therefore, this area will initially serve as an additional buffer zone between the first increment of the plant and the park. Interim use of the vacant area has not as yet been determined.

The decision to locate the treatment plant on Sand Island was not a hasty decision. Since 1947, a site of 12.2 acres was reserved for treatment plant uses by EO No. 1188. A 50-mgd primary plant was designed in 1947, but the City fathers at that time deferred the construction of the plant after receiving a report which concluded that the proposed 78-inch outfall would be adequate from a public health standpoint as long as the flows are less than 50 mgd. If the discharge greatly exceeded 50 mgd, the report recommended an extension of the outfall to a 100-foot depth rather than the construction of a primary treatment plant.

The makai boundary of the present treatment plant site bisects the 12-acre site provided by EO No. 1188. Since this new 50-acre site can accomodate the ultimate sewage treatment facilities, EO No. 1188 will be cancelled.

Access to the site will be through the proposed extension of the existing Sand Island Access Road.

B. AESTHETICS

The aesthetic goals in the development of the sewage treatment plant site plan were threefold:

1. To relate the various parts of the plant to each other in a functional and economical way.

2. To insure that the presence of the project does not encumber recreational development of adjoining sites.

3. To maintain the above mentioned functional and environmental qualities as phased expansion of the plant proceeds.

With these goals in mind, design and layout have been developed. Control and maintenance facilities are located to facilitate optimum utilization of staff and equipment. Grouped between and adjacent to these facilities are flotation-clarification units, and spaces for future activated sludge, final settling and advanced treatment units. Process flow is direct and concise. In addition, these elements are located to allow for use of the existing major lines. The plant layout is shown in Figure 11.

The incinerator and maintenance areas are in proximity to the administration and control center; yet the major service areas are out of sight of visitors.

The landscaped entrance roadway and parking area combine with the interior courtyard to enrich the environment in the plant, both for staff and visitors.

Berms will be utilized to partially screen the plant units from view, especially from the park. The berm on the makai side will have a top elevation of about 16 feet. One end of the berm will terminate at the project limits for initial construction. This dike berm will be extended in future stages of construction for full perimeter screening and protection of the site.

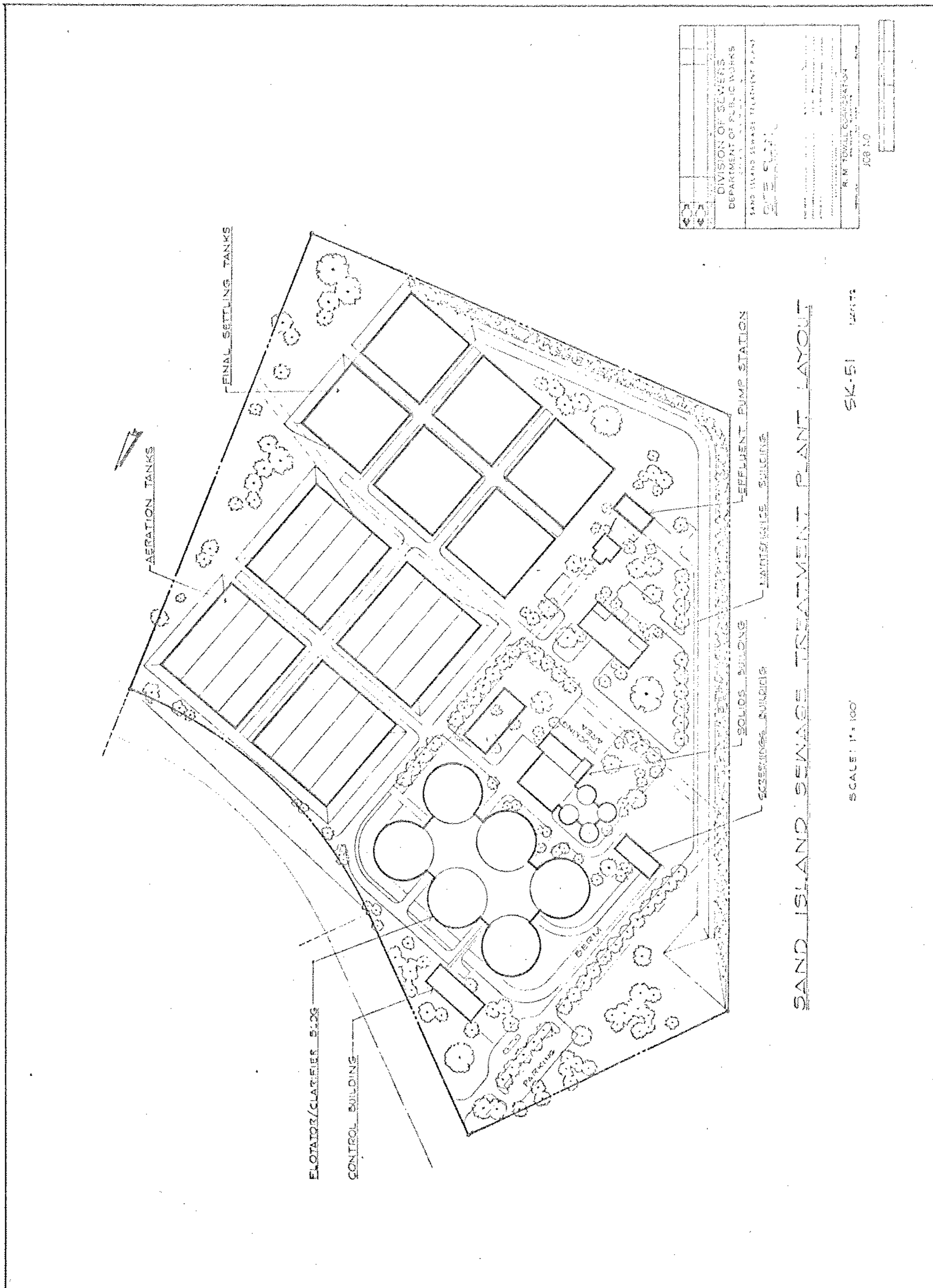


Figure 11

Figure 11

The berm will create an entrapment of surface water runoff. Therefore, well designed drainage slopes, catchments, channels and conduits will be of prime importance in storm flow planning.

The berm's primary function will be to screen the plant from view. In addition, it will also provide a reasonable degree of tsunami protection when completed around the perimeter, but will not be especially designed for heavy wave action. All berm slopes will be landscaped for erosion protection.

Visual emphasis in the overall site plan has been given to the landscape rather than to individual buildings. The elevations of the major structures are: screening building - 49 feet, control building - 38 feet, maintenance building - 36 feet, effluent pump station - 42 feet, flotator-clarifier - 33 feet and incinerator - 83 feet. Process tanks, will be neutral in appearance and low in profile. Their profile will be further reduced by utilization of landscaped berms along all tank perimeters. Whenever possible, trees will be provided in front and on top of these berms to further obscure the architecture of the project. This landscape treatment is to be used along the major roadway and adjacent parklands.

The incinerator has been located as far away as possible from both the main roadway and adjacent parklands. Thus only a small portion of the structure will be visible. It will be seen over the tops of trees. The form of the equipment will be enclosed by an architectural facade, enabling it to blend with the Honolulu skyline which is readily visible from Sand Island.

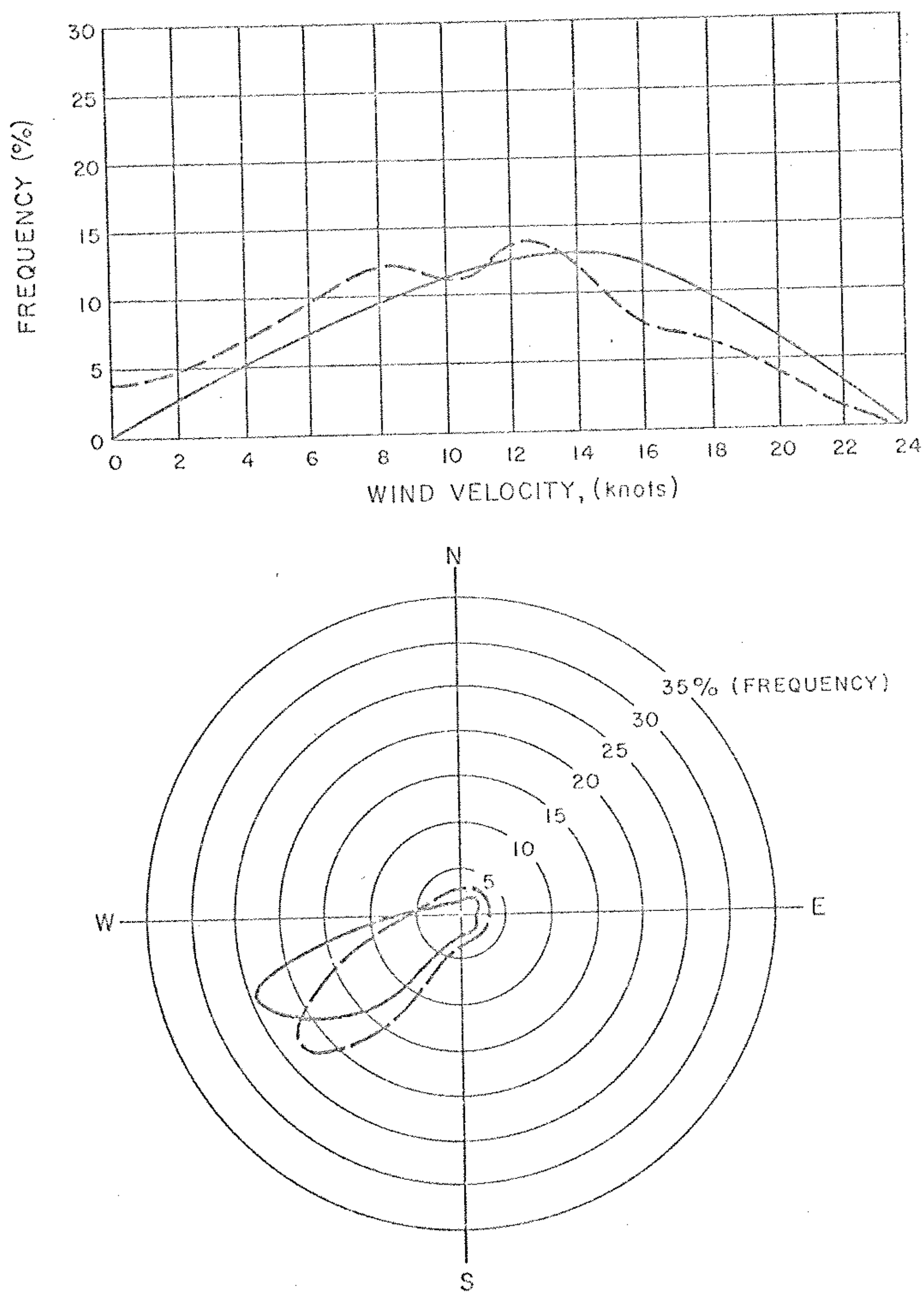
C. AIR QUALITY

1. General

Oahu is slightly south of the Tropic of Cancer in the tropical region and within the belt of northeast trade winds. The prevailing winds are of an anticyclonic pattern from the east-north-east at an average velocity of 12 miles per hour. The reverse pattern of winds is associated with major storms of cyclonic circulation. These cyclonic patterns can occur throughout the year; however, they are generally prevalent during the period of November to April. Anticyclonic winds are trade winds while cyclonic winds are called "Kona winds" and blow from a southerly direction (south to southwest).

Wind and rainfall conditions as recorded at the Honolulu International Airport apply to this area. The summary prepared by the U. S. Weather Bureau for the period of 1950 to 1960 shows that an annual frequency of 73 percent of the winds are from the north to east sector. Maximum velocities of strong trade winds reached 29 mph. The southerly quadrant of south to west, where "Kona winds" originate, shows winds blowing 7 percent of the year at an average of 12 mph. Maximum gusts have reached 70 mph. Figure 12 shows an annual average wind frequency diagram.

ANNUAL AVERAGE WIND FREQUENCY DIAGRAM



——— Data taken on the Leeward Side of Oahu from 1951 to 1960

— — — Data taken on the Windward Side of Oahu from 1966 to 1967 (after Bathen, 1968)

Figure 12

The "Kona wind" condition is cited by various sources as prevailing on the average of 15 days to 30 days a year. During some years no "Kona storms" occur. During summer months, local southerly winds are common, although weak, and occur when trade winds cease and local heating effects cause breezes to blow onshore during the day.

Sand Island is physically separated from the City by Honolulu Harbor and the industrial belt extending from Fort Armstrong through Iwilei to Kapalama Peninsula. No residential areas presently exist or are planned for the island. Planned usage is for park and maritime related light industrial purposes. The U. S. Coast Guard Honolulu Base is located east (upwind) of the plant site approximately 1,500 feet from the treatment facilities. Industrial areas are adjacent to the plant site, to the north and the east, but upwind.

Located near Sand Island are Honolulu Harbor and port facilities at Fort Armstrong, Iwilei, Waiakamilo and Mokauea. Approximate straight line distances from the plant site to the boundaries of the port facilities are as follows: Fort Armstrong, 6000 ft.; Central Business, 6,000 ft.; Iwilei (Pier 30), 4,000 ft.; Iwilei (Pier 40), 5,000 ft.; and Mokauea, 6,000 ft. The nearest residences are located mauka of Pier 40, approximately 4,400 feet away, in an area presently utilized for every land use breakdown considered.

The area is presently zoned for industrial use. All of these areas mentioned are located upwind of the prevailing northeasterly trade winds. Only the ocean and portion of the strip beach park are located downwind of the plant site.

2. Odor Control

Sand Island is essentially free from sewage odors since the sewage is totally enclosed between the Ala Moana and Hart Street pumping stations and the outfall terminus except at the outfall junction box where odors are usually noticeable. Odors are also usually noted offshore in the vicinity of the sewage "boil". Both of these sources of odors will be eliminated by the treatment and disposal facilities now under design. The junction box will be demolished upon the completion of the new outfall sewer.

The WQPO (Reference 7) evaluated the effect of waste discharges on the odor of receiving waters and determined the usefulness of odor as a criterion for protection of aesthetic uses. The odor parameter was quantified on the basis of threshold odor measures applied to effluent samples. Threshold odor is defined as the number of times an odor-bearing effluent sample has to be diluted with "odor-free" water for the odor to be just detectable.

According to the results of the study, treatment appeared to have a pronounced effect on odor with raw sewage being roughly five times more odoriferous than primary treated sewage, which in turn was two to four times more odoriferous than trickling filter effluents. The recommended initial dilutions of effluents which will prevent "objectionable odor" in the receiving waters are: raw sewage, 130:1; primary treatment, 28:1; and secondary treatment (trickling filter), 13:1. There should be no odor problem in the new discharge area off Sand Island because of the (1) treatment provided, (2) submerged field and (3) dilution provided (200:1).

a. Basic Design Criteria

All facilities are being designed to eliminate, destroy or minimize odors because the treatment facilites are located in a prime recreational area, and in close proximity to downtown Honolulu.

b. Liquid Treatment Units of Plant

All process units are totally enclosed for odor and sound suppression. These units include the screening and flotator-clarifier buildings. Work areas will be continuously ventilated with the exhaust gases treated with ozone for odor destruction. Chlorine will be applied in the force mains at their entry to the plant to oxidize hydrogen sulfide and to control the decomposition of organic materials, thus preventing further septicity of sewage.

Potential coliform aerosols emission in the flotator-clarifier tank should not be a problem since it will be under a partial vacuum and "bubbles" will not escape to the outside of the building. The air pumped out would be treated with ozone prior to release to the atmosphere.

c. Solids Treatment Units of Plant

Positive odor control will be accomplished by covering all of the tanks and odor-emitting equipment in the system. A forced draft system will be used to collect the odor-laden air and pass it on through the incineration and scrubbing system to remove the odors. Chlorine will be applied in the sludge thickening process for odor control during the holding period. It can also be applied to the incoming sludge, as necessary.

3. Incinerator Emissions

The specifications for the incinerators require that the performance of the equipment must meet the latest Federal and State standards (at the time of bidding) concerning air pollution. This procedure is necessary since revisions to the standards are beinq proposed.

To comply with the air pollution standards, a wet type scrubber will be used to cleanse and cool off the furnace gases. The scrubber employs an impingement baffle plate section and a water spray section. The spray section cools and humidifies the entering gases while simultaneously removing larger particulate matters. The underplate spray action keeps the plate and walls clean and prevents buildup of particles. Actual scrubbing is accomplished by the jet-swirl interaction of gases and liquids produced by a uniquely designed impingement baffle plate. This turbulent effect assures thorough wetting of particles, even those of sub-micron size.

D. SURFACE WATER QUALITY

1. Predicted Water Quality Changes at Proposed Disposal Site

Any sewage discharge, even though highly treated, will have some effect on the quality of its receiving water. This is particularly true if a waste effluent, with its load of biostimulants and toxicants, is discharged into an oligotrophic receiving water as would be the case with the proposed marine disposal systems for Oahu. The questions needing answers are: (1) Will the effects be detrimental? and (2) What will their magnitudes be?

Primary treated sewage effluents from the proposed Sand Island disposal system should have little effect on the ecology, sanitary quality, or aesthetics of the receiving water. The diffuser system of the outfall sewer is proposed to be emplaced in 220 to 240 feet of water in areas where the ocean floor is relatively free of biological communities having important economical or ecological values.

In a few areas, there are large colonies of pinna clams which may be influenced by the discharge; however, these same type of clams were found in large numbers near the present Sand Island raw sewage discharge which suggests that they would not be affected adversely by the proposed discharge. No adverse biostimulatory effects on plankton communities is expected at the discharge site although a slight increase in primary (algal) productivity may occur. It is anticipated that any increase in energy fixation at the primary trophic level will be transmitted rapidly through the higher trophic levels (zooplankton, fish, etc.) thereby preventing objectionable accumulations of plant biomass. Submergence of the sewage field will protect the aesthetic quality of the receiving water at the surface. Should the field surface, the high dilution anticipated (about 400 to 1) would prevent the field from being noticed by casual observers.

2. Water Quality Standards

The Department of Health, State of Hawaii has classified the water area offshore of Sand Island as Class A (see Figure 1). The water uses to be protected and water quality standards that are applicable to the treated effluent to be discharged into the water area are as follows:

a. Water Uses To Be Protected (Chapter 37A, Section 3, Classification of Water Uses; Paragraph A-2, Class A Waters)

The uses to be protected in this class of waters are recreational, including fishing, swimming, bathing and other water contact sports and aesthetic enjoyment. It is the objective for this class of waters that their use for recreational purposes and aesthetic enjoyment not be limited in any way. Such waters shall be kept clean of any trash, solid materials or oils and shall not act as receiving waters for any effluent which has not received the best practicable treatment or control compatible with the standards established for this class.

b. Applicable Water Quality Standards (Chapter 37A, Section 6, Water Quality Standards; Paragraph B)

(1) Microbioligical Requirements:

The median coliform bacteria shall not exceed 1,000 per 100 ml nor shall more than 10% of the samples exceed 2,400 per 100 ml. Fecal coliform content shall not exceed an arithmetic average of 200 per 100 ml during any 30-day period nor shall more than 10% of the samples exceed 400 per 100 ml in the same period.

(2) pH - Units:

Not more than 1/2 unit difference from natural conditions but not lower than 7.0 nor higher than 8.5 from other than natural causes.

(3) Nutrient Materials:

Total phosphorus, not greater than 0.025 mg/l.

Total nitrogen, not greather than 0.15 mg/l.

(4) Dissolved Oxygen (except from natural causes):

Not less than 5.0 mg/l.

(5) Temperature:

Temperature of receiving waters shall not change more than 1.5 degrees Fahrenheit from natural conditions.

(6) Turbidity:

Secchi disc or secchi disc equivalent shall not be altered from natural conditions more than 10%.

(7) Radionuclides:

The concentration of radioactivity in water shall not exceed 1/30th of the MPC_w values given for continuous occupational exposure in National Bureau of Standards Handbook No. 69. The concentration of radioactive materials present in marine waters shall be less than those that would require restrictions on the use of organisms harvested from the area in order to meet the Radiation Protection Guides recommended by the Federal Radiation Council.

These water quality criteria ware based upon the best currently available data (1968). The Health Department recognized that studies planned to be made in connection with the implementation program may prove them to be either inadequate or unattainable. For this reason, the criteria will be subject to periodic review and, where necessary, to change.

It is anticipated that the proposed wastewater discharge will have a negligible effect on the present water quality in Mamala Bay. Except for a slight deviation from the microbiological requirements when the effluent is not chlorinated no significant deviations from the water standards are anticipated. The median total and fecal coliform counts after initial dilution for field submerged conditions are estimated to be 1000 per ml and 250 per ml respectively. If the sewage field surfaced, it is estimated that coliform counts will be fifty percent smaller. A "zone of mixing" for coliform bacteria, beginning at the ocean bottom and extending upwards to the surface will have to be established. The initial and subsequent dilutions of the wastewater effluent and the high rate at which coliforms decay in Island waters will eliminate the necessity for a large zone of mixing and will be sufficient to protect the nearshore waters.

The present water quality along Sand Island and in Keehi Lagoon should improve considerably since the proposed system will replace an inadequate disposal system which consists of a raw sewage discharge into 40 feet of water 3,600 feet offshore. The development of a water-oriented recreational area on Sand Island, which would be impossible under existing conditions, would be possible.

3. Chlorination

a. Application of Chlorine

Chlorine can be used to disinfect the treated sewage effluent from this plant prior to its discharge into the ocean. With the application of a proper dosage, thorough mixing and adequate detention time, the treated effluent should easily meet the microbiological requirements of the water quality standards.

Another use of chlorine is for odor control. Chlorine is effective in the oxidation of hydrogen sulfide and in the control of the decomposition of organic materials, thus preventing further septicity of sewage. For this control of odor, chlorine will be injected into the force mains at their entrances into the sewage treatment plant.

Chlorine is also used in the sludge thickening process where it is used for odor control during the holding period. It can be applied to the incoming sludge, as necessary.

b. Design Criteria

Chlorine requirements for disinfection in this plant will range from 20 to 25 parts per million (ppm) depending on the strength and characteristics of the final effluent. A residual of 0.5 mg/l total chlorine is usually required after a contact period of 15 minutes.

Since the location of the plant is adjacent to a public park and an industrial area, nuisance odors from the plant must be eliminated or substantially reduced to acceptable levels. Five ppm of chlorine will be used as an odor control agent in the plant operations. Chlorine will be injected into the incoming force mains.

In the sludge thickening process, chlorine will be added to prevent the sludge from becoming septic during the holding period. The application of chlorine will be at a rate of 5 pounds per 100 pounds of dry solids.

c. Chlorine Handling and Storage

Chlorine is not manufactured in the Islands at present. It must be imported from the U. S. mainland by ship. Transportation of chlorine from the West Coast to Honolulu can be done by using tanks, barges or ton containers. Tank barges, with a capacity of 600 to 1,200 tons, are commonly used in the transportation of chlorine. Bulk chlorine unloading facilities, such as a pier pumping and piping systems, may be required in the vicinity of Sand Island to avoid any further land transportation within the City limits. Ton containers can be shipped from the West Coast either as special or regular freight because chlorine is a hazardous substance. Special care is required in their handling.

Should barges be used for transportation of chlorine from the West Coast to Honolulu, stationary storage of chlorine at the plant site will be required. The size of the storage tank should be based on a 30-day supply at a maximum consumption rate. Special design criteria for the tank should provide for maximum convenience and safety in the area.

Storage of the ton containers is much simpler. Containers can be stored indoors or outdoors. If stored outdoors, the storage area should be designed and constructed to protect all elements of the chlorination system from fire and be clean and free of any accumulated trash in order to avoid the possibility of fires. Ventilation systems should be provided for indoor storage areas.

d. Alternative Sources of Chlorine

From the standpoint of economic and safety considerations, importing chlorine from the mainland generates several problems. These problems are the construction of some port facilities, storage and safety. In analyzing the problems mentioned, local production of chlorine by a system similar to the Pepcon Electric Chlorine system (hypochlorite generation) was evaluated. Results indicated that from an economic standpoint, the local manufacture of chlorine is favorable only if continuous chlorination is required.

The selection of liquid chlorine over on-site hypochlorite generation was made on the basis of (1) intermittent use of chlorine for disinfection, (2) liquid chlorine is better suited for prechlorination, odor control and sludge handling, (3) high initial cost of the PEPCON installation, (4) PEPCON is relatively new (no large installation to date), (5) the need for a large holding tank for hypochlorite solution, and (6) savings are possible by using container size tanks.

4. Chlorination Facilities at the Plant

Chlorination equipment and the chlorine storage area are to be located on the first floor of the Effluent Pump Station building. Since the upper floor of the building is to be used for effluent pumping facilities, the chlorinator section will be isolated by a gas-tight partition and provided with separate doors leading to the outside. It will also prevent unauthorized people from entering the chlorine application area. The entire chlorination area will be well ventilated by natural means and by use of blowers.

The chlorinators will be of the automatic control solution feed, vacuum type, capable of manual operation. The rate of feed shall be automatically adjustable. A chlorine residual analyzer will also be utilized.

Chlorinator dosages will vary according to the sewage flow and strength, purpose and point of application of the chlorine solution. Each chlorinator shall be equipped with the necessary meters, orifices and other parts capable of delivering chlorine at the range adequate to produce a residual of 0.5 parts per million total chlorine after 15 minutes contact in the final effluent. Chlorine evaporators are required in this treatment plant to convert chlorine from a liquid form from ton-containers to a gaseous form. All equipment and materials shall conform to the Chlorine Institute standards.

Safety considerations require that areas used for the stationary storage of chlorine should be covered. Ton containers will be shielded in order to avoid direct exposure to sunlight which might cause hydrostatic rupture of the container due to high co-efficient of expansion of liquid chlorine. Containers are designed and tested to withstand a pressure of 500 pounds per square inch and are equipped with fusible plugs which melt at 158 degrees Fahrenheit (equivalent to a gas pressure of 303 pounds per square inch).

Massive storage of ton containers at the Sand Island Sewage Treatment Plant site is not recommended because the area is too close to the flight path of the Honolulu International Airport. Though there has never been an airplane crash on Sand Island, with over a million and a half flight take-offs occurring during the last 10 years, and the risk of a crash is minimal, the possibility still exists. The storage will therefore be limited. Maximum storage will be for 8 days of consumption (equivalent to 69 tons). The storage area in the effluent pumping station building will have equipment for detecting chlorine since there is a possibility of leakage from the containers. This area will also be located as far away as possible from the work areas of plant personnel.

Industrial type gas masks with chlorine type canisters, first aid equipment and warning signs shall be provided and posted.

5. Effluent Chlorination

Chlorination facilities provided at the plant will have the capacity for continuous chlorination of the primary effluent in the event a demonstrated need for disinfection arises. Presently, the City sees no need to chlorinate the effluent continuously because the design indicates a submerged effluent field and a rapid bacteria decay rate off Sand Island; but the City plans to chlorinate during adverse or emergency conditions. Submerged effluent fields at San Diego, Los Angeles and Orange County meet bacterial standards (California) without chlorination. As in Southern California, there are no known documented instances of disease transmission by bathing in Hawaiian waters attributable to waste discharge.

As indicated earlier, if the wastewater discharge is not chlorinated, the microbiological requirements will not be met in a limited area. In this regard, a zone of mixing is presently being processed by the State Department of Health for the Sand Island outfall sewer. The proposed zone of mixing shown in Figure 3, is 1,500 feet wide on each side of the pipe and extends 1,700 feet outward from both ends of the diffuser section (3,000 ft. by 6,750 ft.).

The distance of any boundary of the proposed zone of mixing will be greater than 6,000 feet from any land area. We strongly believe that this zone of mixing will not unreasonably interfere with any actual use of the water area.

To determine when effluent chlorination is necessary, the City intends to pursue an intensive ocean monitoring program in Mamala Bay prior to and after the completion of the treatment and disposal facilities. The monitoring program will be conducted by City personnel using facilities which include two well-equipped laboratories and an 18-foot outboard motor powered boat. City personnel assigned to the monitoring program include two engineers, three sanitary chemists, and two laboratory assistants. These personnel are well versed with the conduct of the monitoring program,

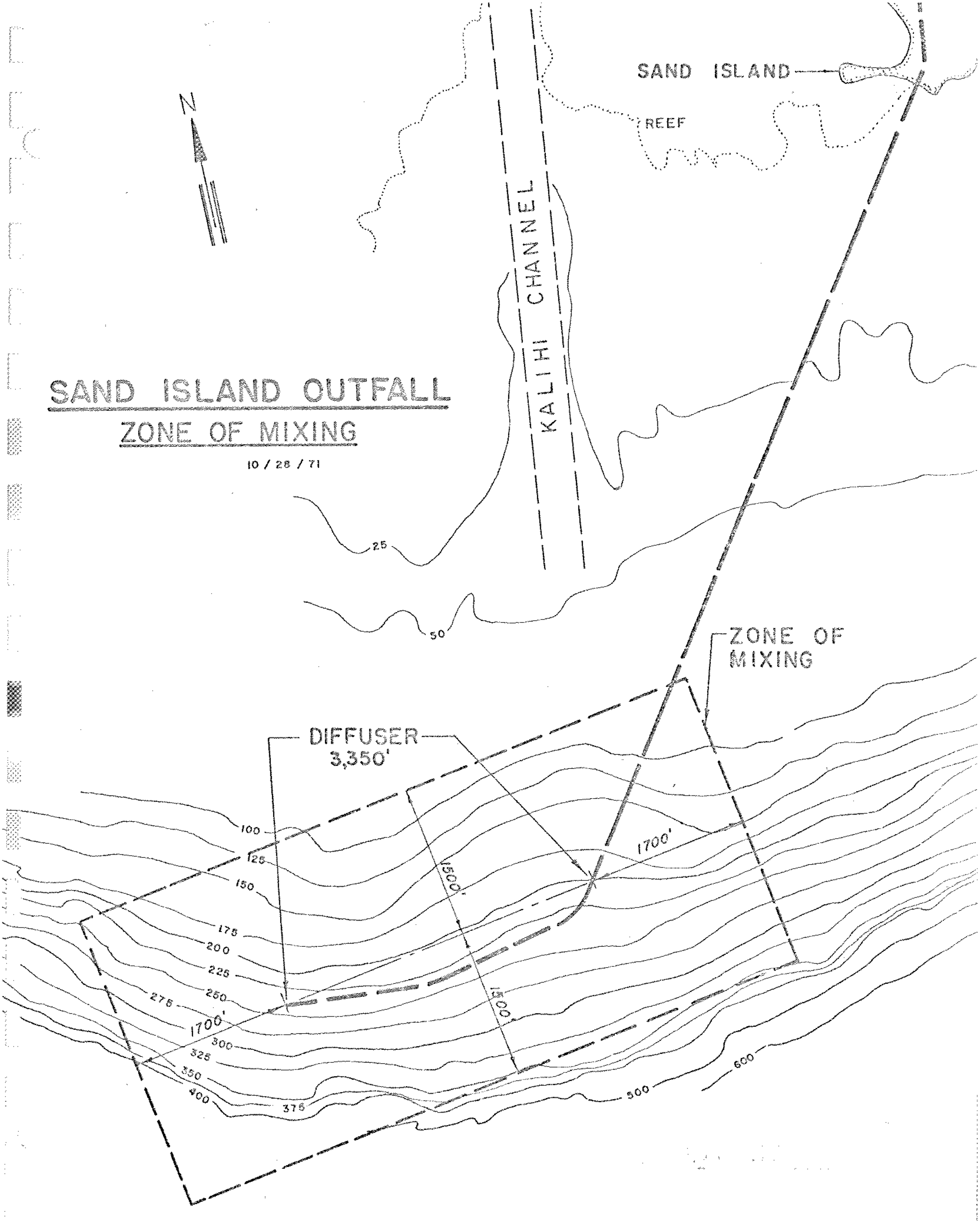

SAND ISLAND OUTFALL
ZONE OF MIXING
10 / 28 / 71
N
SAND ISLAND
REEF
KALIHI CHANNEL
ZONE OF MIXING
DIFFUSER 3,350'
1700'
1500'
1500'
1700'
25
50
100
125
150
175
200
225
250
275
300
325
350
375
400
500
600

Figure 13

having actively participated with the consortium of WQPO. The program will also be coordinated with the Water Resources Research Center of the University of Hawaii. Technical assistance, if necessary, will be obtained from the University of Hawaii.

The major factors which must be considered in chlorination are (1) hazards of transportation, (2) cost, and (3) need. Other related factors are minor hazards in the application of chlorine, the large amount of electric power required in the production of chlorine (contributing to thermal pollution), and the release of mercury vapor to the atmosphere during its production.

a. Hazards of Transportation

From the standpoint of safety, importing chlorine from the U. S. mainland is a problem. If continuous effluent chlorination is mandatory, approximately 3,300 one-ton containers must be shipped annually during the initial period up to 1990. If chlorine escapes from a container, it could result in a serious health hazard for people on board ships or barges and in the transshipment areas since the gas irritates the respiratory system and may cause death from suffocation. Hence, handling, at the factory, during transportation and at the plant site must be done with utmost care.

b. Cost

The price of liquid chlorine delivered at the site is estimated to be 10 cents per pound for low and intermittant use and 6.5 to 8 cents per pound for year round use. The estimated operating cost of the liquid chlorine system, including amortization as well as operation, maintenance, power and water costs (does not include the cost of liquid chlorine), is about $300 per day. At the average use of 18,500 pounds of chlorine per day for continuous disinfection, odor control and sludge handling during the initial period to 1990, the estimated daily cost of using the liquid chlorine system would be $1,780, using an average chlorine cost of 8 cents per pound and an operating cost of $300 per day. For continous disinfection, the annual cost would average $649,700.

If chlorination for disinfection was practiced only during extreme "Kona" weather or when the effluent field surfaces, the annual chlorination cost would amount to $380,500. The difference in annual cost would amount to $269,200. At the end of year 2020, the annual chlorination cost could reach $993,000 for continuous chlorination and greater savings would be realized.

c. Need

It is well established fact that the indicator coliform bacteria undergoes a drastic reduction in numbers in the ocean. The rate at which bacteria decay, sometimes called bacteria die-away rate, can be the result of a number of processes. Bacteria probably decay due to exposure to insolation, saline water, unfavorable changes in temperature, and bacteriophages and other predators. Other bacteria may be absorbed by the sediments or settle to the bottom with particulate material. The individual importance of each of these stresses on the decay of coliform bacteria in the marine environment is not fully understood. Many processes may effect the decay of coliform bacteria around an outfall, not all of which cause a rapid die-away of the bacteria. In the design of an ocean outfall system, engineers generally refer to coliform decay in terms of a T-90 time. This is the time it takes for 90 percent of the bacteria to decay once they reach the marine environment.

Three T-90 cruises (Reference 8) were conducted for the City to determine the rate at which coliform decay around the Sand Island Outfall during the summer and winter seasons. The period between the first of August and the end of September was chosen for the first two T-90 cruises since this is the time of the year when the local water temperature and salinity at the surface normally reach their annual maximum. In contrast, the month of February was chosen to represent the winter season, when the temperature and salinity generally reach their annual minimum.

The coliform decay rate was obtained by determining the number of total coliform bacteria present at each of the oceanic stations during the T-90 tests from the plates inoculated at each station at sea. These counts had to be corrected for dilution since the sewage leaving the outfall was mixed with seawater. The dilution factor was obtained using fluorometry techniques and Rhodamine B dye. Verification of the dilution factor was made during each cruise by analyzing surface salinity in the laboratory with a precision salinometer. Dilution factors obtained by the two methods compared favorable within plus or minus 6 percent.

The T-90 values for the summer varied between 9 to 18 minutes and for the winter it was 15 minutes. The average T-90 value was 13 minutes. The data off Sand Island indicate a rapid coliform decay rate when compared with the 3-hour T-90 value established off the southern California coast. It should be pointed out that a coliform bacteria decay rate of 99 percent in 10 minutes was determined in Kailua Bay during 1959 using radioactive carbon and allowing for dilution. Low T-90 values have been reported elsewhere. Values as low as 20 minutes have been reported in England, Israel and Brazil.

Analyzed statistically and determining T-90 values for all positive data at all stations, the 50 percent and 80 percent cumulative frequency distribution T-90 values were 20 and 45 minutes respectively. For design purposes, a conservative T-90 value of 1 hour is being used.

Investigation of ocean currents off Sand Island indicated that general circulation is controlled by tides. The tidal contribution to the total current structure varies about 70 percent for near surface currents (also influenced by the wind) to about 90 percent for deep currents.

The velocities of nearshore surface currents ranged from 0.3 to 0.8 knot and net transport was to the south with a velocity averaging 0.25 knots. Deep currents ranged from 0 to 0.7 knot and net transport was generally to the southwest with velocities not exceeding 0.15 knots. Deep onshore currents occurred 9.5 percent of the time with velocities (90 percent speed) less than 0.3 knots.

The probability of transport to shore within 4 hours is less than 2 percent of the time when the effluent field surfaces and even less when there is submergence. The coliform reduction factors (combined reduction for diffusion and bacterial die-off) for the outfall ranged from 0.099 to 0.000077 for 1 hour to 4 hour respectively. It is anticipated that the effluent will meet Class A standards for bacteria within 2 hours without chlorination.

In summary, it is clear, therefore, that the probability of significant coliform concentrations at the beaches due to the discharge of unchlorinated primary effluent at the new Sand Island outfall is nearly nil. Class A standards for coliforms are easily met at the water surface when the effluent field is submerged. During times when the field surfaces, the standards will be reached within 2 hours after the effluent is discharged from the diffuser ports. If the distance the effluent field travels during these 2 hours extends beyond the mixing zone, then intermittent effluent chlorination will be used to keep the frequency of coliform counts within the limits of the microbiological standards at any monitoring station outside the zone of mixing.

E. SOLID WASTES

1. General

Solid wastes resulting from wastewater treatment processes include settleable solids and floatable solids. The settleable solids include sludge, the major solid waste constituent, and grit. The floatable solids consist of screenings, scum, grease and "float", the material that floats to the water surface of process tanks either naturally or under the influence of induced forces such as gas bubbles.

The handling and disposal of these wastes is probably the most troublesome part of any wastewater management program. The advent of newer processes and more efficient treatment plant operations tend to produce solid wastes that are not only more difficult to handle but are also greater in volume.

2. Brief Description of Solid Wastes

a. Sludge

Sludge is the precipitate resulting from the treatment of wastewater and includes both organic and inorganic substances. It may be defined as a semi-liquid waste having a total solids concentration of at least 2500 ppm. It flows, can be pumped, and exhibits hindered settling characteristics in a sedimentation tank. This waste product is removed from the liquid flow in a clarifier or sedimentation tank and is handled and disposed of separately. The handling and disposal of this material is discussed further later in this section.

b. Grit

Grit can be described as small inorganic solids that are removed from the wastewater. Examples are sand, silt, gravel, ashes, bones and coffee grounds. These solids are removed from grit chambers and as clarifier or sedimentation tank underflow together with sludge. The grit is separated from the sludge in a degritter, dewatered in a classifier, and conveyed to a sludge incinerator for disposal together with the sludge or transported directly to a land fill site.

c. Screenings

Screenings are materials in the raw wastewater that are caught on screens placed at the head of a treatment plant having openings usually 1/2 inch to 2 inches. These screenings, consisting of materials such as rags and sticks, are conveyed to a sludge incinerator for disposal together with sludge or transported directly to a land fill site.

d. Scum and "Float"

Scum and "float" consist of all types of floatable material which rise in clarifiers and similar tanks. These are skimmed off the water surface of the tanks and are processed along with sludge, usually beginning at the dewatering stage.

3. Solids Loads (dry weights)

	1970	1990	2020
Domestic Sewage (1000 lb/day)	57	80	117
Cannery (seasonal) (1000 lb/day)	21	23	23

4. Sludge Handling and Disposal

There are two distinct phases involved in sludge handling: (1) processing of the sludge to convert it to a form suitable for disposal, and (2) the ultimate disposal of the sludge.

a. Applicable Unit Processes

Applicable unit processes include: (1) thickening, (2) conditioning, (3) dewatering, (4) digestion, and (5) combustion. These are discussed in the following paragraphs.

(1) Thickening:

The basic objective of thickening is to reduce the volume of liquid sludge to be handled in subsequent processes. Thickening is usually accomplished by gravity settling, biological and dissolved air flotation, centrifugation, and chemical conditioning.

(2) Conditioning:

Sludges from the different wastewater treatment processes vary in composition, physical characteristics, ease in handling, etc. The objective of sludge conditioning is to render the sludge more amenable to dewatering.

The addition of inorganic chemicals has long been the method of choice. Chemicals used include lime, alum, and iron salts. The recent trend has been to utilize polyelectrolytes (long-chain organic polymers) which have the advantage of accomplishing equal or better results at a fraction of the dosage of inorganic chemicals. Although the unit costs of polyelectrolytes are signifcantly higher, the total cost of sludge conditioning is usually lower because of the smaller dosages required.

A recent innovation has been the application of heat and pressure to the sludge which reduces the hydrophilic nature of the sludge. The generic name given to this process is heat treatment. Several proprietary processes are on the market, including the Porteus Process, Farrer Process, and the Zimpro wet oxidation process at low pressures.

The required pressures range from 150 to 300 psig, and temperature range from 290 to 370 degree centigrade. The treated sludge is completely sterilized but not completely stabilized with respect to organic decomposition.

Another recent process involves the application of high doses of chlorine, which not only sterilizes, but enhances dewatering properties, and can be carried to the point of complete stabilization. The operating experiences with this process are still very limited. It is patented under the proprietary name of Purifax Process.

(3) Digestion:

The most common method of processing sludge has been anaerobic digestion. It stabilizes raw sludge and makes it suitable for final disposal. The process results in the reduction of volume by the destruction of organic matter with production of usable gas. As the word anaerobic implies, the process occurs in the absence of oxygen through specifically adapted microorganisms. Because it is a biological process, it is subject to upsets especially from toxic materials (especially in raw primary sludge) which tend to be accumulative.

Aerobic digestion occurs in the presence of oxygen which is introduced into the reactor (tank) by means of compressed air or oxygen. It is particularly adaptable to waste activated sludges. Unlike anaerobic digestion, the process is relatively free of odors. The end product of aerobic digestion is a biologically stable humus-like material that contains more of the basic fertilizer values than anaerobically digested sludge.

(4) Dewatering:

The primary objective of any dewatering operation is to reduce the sludge moisture content to a degree which allows ultimate disposal by incineration, landfilling, heat drying, or other means. It differs from thickening in that the sludge is processed into nonfluid form.

The following dewatering processes have been used with varying degrees of success: (1) vacuum filtration, (2) pressure filtration, (3) gravity filtration, (4) centrifugation, (5) sand bed drying, and (6) screening.

(5) Combustion:

Sludge combustion is becoming increasingly popular as land areas for sand beds, lagoons, and landfills become more difficult to find. The process results in the reduction of volume by conversion of organic sludge to an inert ash. Complete sterilization is achieved in this process. By comparison, digestion reduces the volatile (organic) content of the sludge by 60 to 75 percent, whereas combustion results in virtually complete destruction of the organic solids.

The following unit processes are included under the heading of combustion: (1) multiple hearth incineration, (2) flash drying-incineration, (3) fluidized bed incineration, (4) spray evaporation, and (5) wet oxidation.

The disposal of ash on land is less objectionable than the disposal of unburned sludge on land because of complete sterilization, virtually complete destruction of the organic matter and the reduction in volume. With disposal into the ocean having a dismal future, it appears that incineration will become increasingly popular.

b. Ultimate Disposal of Solids

The ultimate disposal of the solids after sludge processing is analogous to the disposal of the liquid fraction of wastewaters after treatment. As with the liquid fraction, the only repositories are land or receiving waters.

Many coastal cities use the ocean to dispose of their solids. However, increasingly restrictive regulations by the Environmental Protection Agency have discouraged recent efforts to use this method of solids disposal.

The only other recourse is disposal on land or possibly into the underground strata. The type of land disposal method used depends on the method of processing. Liquid digested sludge has been successfully applied to land reclamation projects. Dried digested sludge has been used as soil conditioners, both commercially and non-commercially (given free to whomever was willing to haul it away). Heat treated waste activated sludge has some value as a fertilizer, but agencies that market such a product are limited. Milwaukee, Chicago, and Houston have successfully marketed heat treated activated sludge. For Milwaukee and Chicago, marketing successes were due in part to the high nitrogen content of the dried sludge.

Dewatered sludge has been successfully used as an additive when composting dry refuse and garbage. It enhances the composting operation because: (1) it provides seeding material for the required biological activity, (2) it helps to control the moisture content of the composting mixture, (3) it contributes nitrogen and other nutrients, and (4) it can be used to control the Carbon/Nitrogen ratio.

If consideration is being given to the composting of municipal refuse, it would be prudent to consider the addition of dewatered sludge. On the other hand, if composting is to be utilized primarily for sludge disposal, the real operational costs for processing the sludge approximate those for incineration. Operating costs can be reduced by selling the compost, but a market must exist for the material.

5. Sludge Handling and Disposal Alternatives

a. General

Sludge handling and disposal is the most difficult and demanding component of the wastewater management and disposal systems. It also entails a major portion of the capital cost and operation and maintenance cost of the total wastewater treatment facility. To provide a basis for the selection of the optimum system for the Sand Island plant, processing and disposal methods are considered and presented herein. The alternatives are compared on an economic basis and evaluated with consideration of environmental and other probable constraints. The alternatives include the following basic concepts:

Alternative 1 - Digestion and Marine Disposal

Alternative 2 - Digestion, Dewatering, and Landfill

Alternative 3 - Dewatering and Incineration

b. Alternative 1

Disposal of sludge into the marine environment is presently practiced by many U. S. coastal cities. The actual sludge handling process and disposal operations vary to some degree. Studies and results of various operations have shown that ocean disposal can be economically feasible.

For the purpose of this report, it is assumed that a feasible sludge handling and marine disposal system shall include anaerobic digestion of sludge and screening of the digested sludge prior to discharge into deep ocean through a separate sludge outfall line. A 10,000-lineal foot 8-inch steel outfall line is considered together with sludge pumping units. Screenings from the sludge and the floatables removed by the primary treatment units are to be incinerated.

c. Alternative 2

This alternative considers disposal of dewatered digested sludge by landfilling. It includes anaerobic digestion of waste sludge, mechanical dewatering by centrifuges, and hauling of dewatered sludge to a suitable landfill site. For the purposes of this report, hauling costs are based on 40 miles round trip. Reclamation of sludge as a soil conditioner has been suggested, but its immediate implementation is speculative in view of the indefinite future of marketing and reuse of the product. Should composting of refuse with sewage sludge or the marketing of processed sludge become viable in the future, this potential can well be worked into Alternative 2, with the final sludge processing substituted for landfill.

d. Alternative 3

This alternative considers the feasibility of sludge incineration. It includes sludge thickening, heat treatment, mechanical dewatering of raw sludge by centrifuges, incineration of sludge cake, and final disposal of ash to a landfill site 20 miles away. Disposal of ash into ocean waters by mixing with the treated effluent has been proposed but appears to be an unlikely alternate solution under recent Federal water quality policies.

e. Comparative Costs

The estimated cost of each alternative is shown in Table 6. The cost estimates of the various alternatives are based on the total solids load for the first stage design year, 1990, of 103,000 pounds per day of which approximately 72,100 pounds per day (70% removal) will be removed by the advanced primary process for handling and disposal. It is also anticipated that the total suspended solids contain 70% volatile matter, of which 50% would be reduced by digestion. Further, that centrifugation will provide a cake of 30% solids and that ash after incineration will amount to 30% of the total suspended solids.

Unit costs are also presented in Table 6. They were derived on the basis of the estimated 13,050 tons of dry solids per year (4,930 tons during the four month peak pineapple canning season and 8,120 tons during the remainder of the year) to be handled by the sludge handling facilities. The quantity of the end product from each alternative will vary with the process.

On an economic basis, the comparison indicates that marine disposal of digested sludge (Alternative 1) is the least expensive. Incineration of raw dewatered sludge (Alternative 3) is next. Hauling of dewatered sludge (Alternative 2) is the most expensive method.

TABLE 6

ESTIMATED SLUDGE HANDLING COSTS

	CAPITAL COST	AMORTIZED COST (per ton DS)	O&M COST (per ton DS)	TOTAL (per ton DS)
ALTERNATIVE 1 Digestion and Marine Disposal				
Digestion	$2,800,000	$ 14.50	$ 5.70	$ 20.20
*Incineration (Screenings Floatables)	3,000,000	16.20	5.20	21.40
Marine Disposal of Sludge	1,430,000	7.10	.70	7.80
	$7,230,000	$ 37.80	$ 11.60	$ 49.40
ALTERNATIVE 2 Digestion, Dewatering and Landfill				
Digestion	$2,800,000	$ 14.50	$ 5.70	$ 20.20
Dewatering	835,000	4.20	10.00	14.20
Heat Treatment (Floatables)	1,400,000	7.10	2.00	9.10
Hauling			12.00	12.00
Landfill			7.70	7.70
	$5,035,000	$ 25.80	$ 37.40	$ 63.20
ALTERNATIVE 3 Dewatering and Incineration				
Heat Treatment	$2,795,000	$ 14.50	$ 2.00	$ 16.50
Thickening	624,000	3.10	1.70	4.80
Dewatering	835,000	4.20	10.00	14.20
Incineration	3,320,000	16.80	2.30	19.10
Hauling Ash			1.20	1.20
Landfill			.70	.70
	$7,574,000	$ 38.60	$ 17.90	$ 56.50

1. Capital cost does not includes administrative, engineering and contingency cost.
2. Amortized cost based on 6½% for 30 years.

*Includes Heat Treatment and Dewatering

Other sludge handling alternatives that were considered include the possibility of dewatering undigested sludge and hauling the cake either to an existing refuse incinerator or a landfill site for final disposal. Dewatering raw sludge would eliminate the high cost of anaerobic digestion and would make these alternatives comparable to Alternatives 1 and 3. However, these alternatives cannot be considered at present because (1) existing refuse incinerators do not have the capacity to handle the anticipated sludge solids loads and (2) a suitable landfill site for disposal of dewatered raw sludge is presently unavailable.

6. Sludge Treatment Provided

Incineration (Alternative 3) was selected as the method of sludge disposal for the Sand Island system. It should be noted that marine disposal of sludge, although more economical, will not be permissible because of recent Federal water quality policies.

Dewatering and incineration of raw sludge would eliminate the need of large digesters, thus reducing difficult odor problems. It would also eliminate the chances for upsets in digesters due to solid loads that can vary considerably, especially during pineapple cannery season.

The incinerator and auxiliary equipment, including the mechanical dewatering units, will be housed with consideration for control of odors and noise nuisances. Emissions from the incinerator stack will be limited to comply with Federal and State air pollution standards. The incinerator stack should be kept low so as to be within the air traffic pattern limits and in harmony with the surroundings. Consideration also should be given to the storage of the sludge and the optimum capacity of the incinerators to provide flexibility in the incineration operation during suitable periods of the day.

The "float" and settled solids will be blended and passed to a thermal conditioning system. After the dewatering process, the solids may then be recycled to the soil or reduced in volume by incineration.

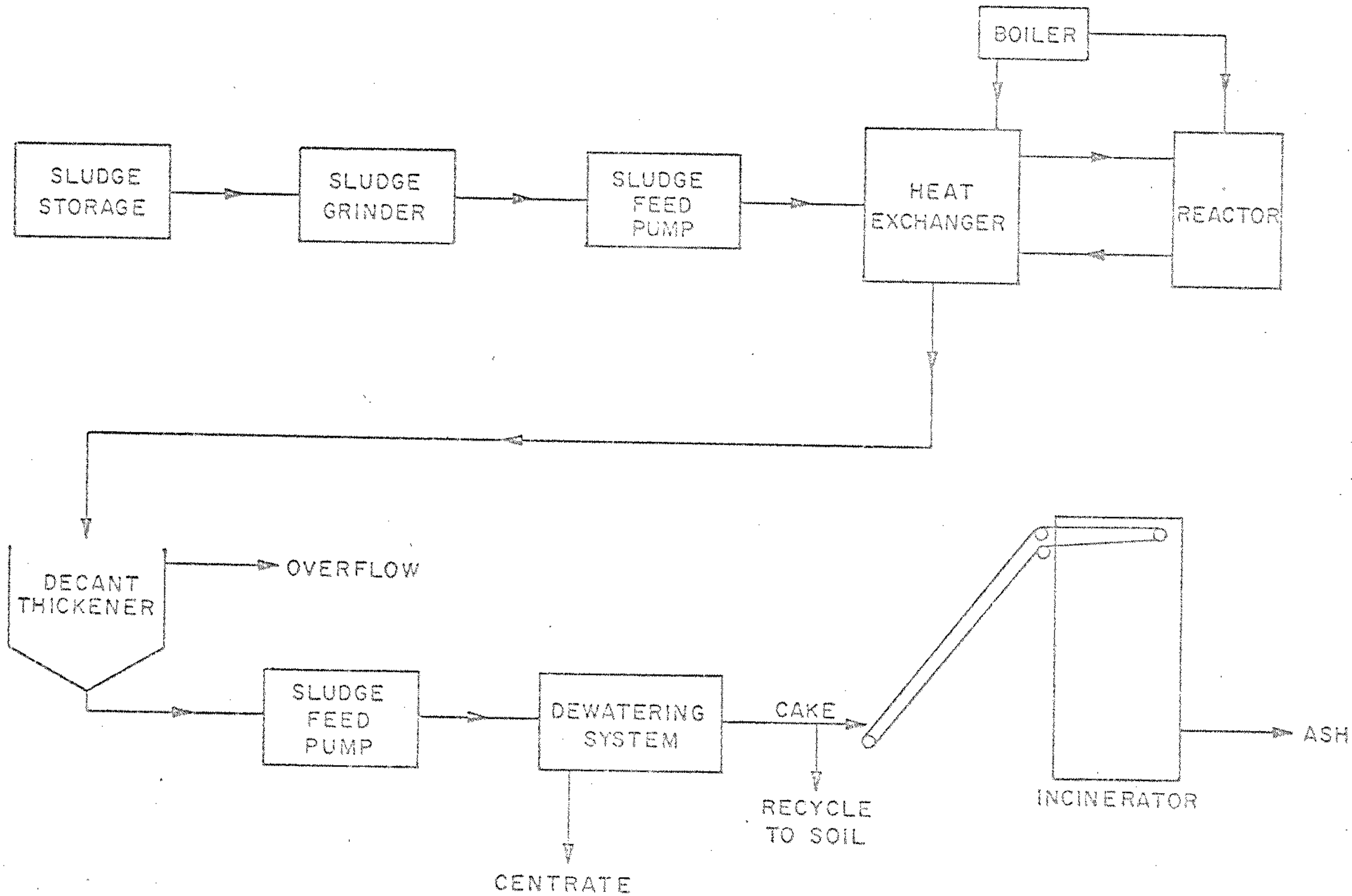
Heat treating of sewage sludge has been recognized as an effective aid in the sewage sludge dewatering process. Sewage sludge has a tendency to retain water. The breakdown of the gel-like structure in the sludge by heating consequently results in a more easily dewaterable material.

Chemical means have been frequently used to render sewage sludge more easily dewaterable. However, the fuel costs for the heat treatment method are much lower than the chemical method utilizing ferric chloride and lime. Cost of chemicals could amount to $174,00 a year. This cost does not include the additional cost of equipment, handling of the chemicals and storage. It is estimated that the total annual cost of the heat treatment-incineration system will be 10 to 15 percent less than the total annual cost of the vacuum filter-incineration system (using chemicals). The effect of sludge recovery as a soil conditioner has not been considered in the cost analysis.

Incineration of the sludge cake will be accomplished by multiple hearth sludge furnances. These units consist of a series of circular hearths, placed one above the other and enclosed in a refractory lined steel shell. The incinerator will be provided with a wet scrubber for cleansing the waste gases. Ash removal will be on a dry basis.

Positive odor control will be accomplished by covering all of the tanks and odor-emitting equipment in the solid waste system. A forced draft system will be used to collect the odor-laden air and pass it on through the incineration and scrubbing system to remove the odors. All objectional noise-producing equipment will be housed in properly designed structures to contain and dampen the noise.

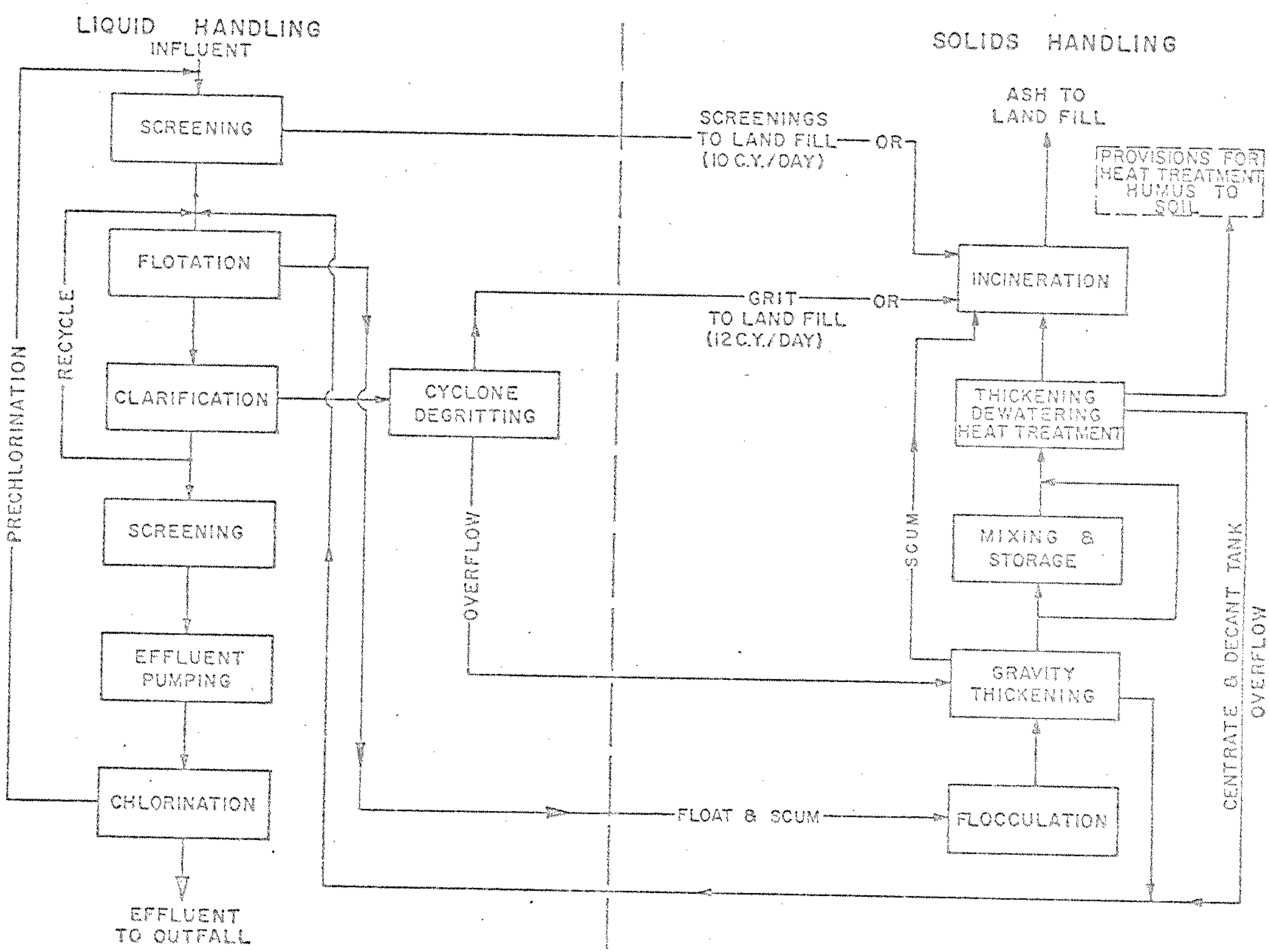
Process flow diagrams for sludge treatment are shown in Figures 14 and 15.



SCHEMATIC FLOW PROCESS
HEAT TREATMENT OF SLUDGE

Figure 14

Figure 14



TREATMENT PROCESS FLOW DIAGRAM

Figure 15

Figure 15

F. NOISE

After operation of the treatment plant begins, the only potential noise disturbance will be from the diesel engines of the effluent pump station. The diesel engines would be used only during peak wet weather flows which would occur during heavy rain storms. The estimated noise level at a distance of five feet from the engines will be about 85 dB (A-scale). At the property line of the treatment plant, which is about 200 feet from the effluent pump station, the noise levels can be expected to be 53 dB (A-scale) or equal to the background noise. It should be noted that during heavy rain storms, the use of the adjacent park will be negligible.

All machinery and noise producing equipment will be located within structures. The diesel engines for the effluent pumps will be located in the effluent pump station building. However, since the structure will not be completely enclosed, the diesel engines will be equipped with air intake filter-silencers and residential-type exhaust mufflers. Other noise producing equipment such as the air blowers and compressors will be equipped with air intake and/or exhaust silencers and mufflers. Noise problems resulting from the use of these equipment are not anticipated.

G. SEWER INFILTRATION

Early studies (References 20, 21 and 22) on sewerage in Honolulu showed high ground and storm water infiltration rates. The possibility of illegal connections is not precluded. Further studies of infiltration rates were conducted by the WQPO consultants to provide insight into the physical condition of existing sewers in Honolulu and to provide necessary data on the characteristics of sewage from Honolulu. It was determined that the total infiltration into Honolulu sewers leading to the Sand Island Outfall was 27 mgd. Compared to the annual total flow being discharged to the municipal outfall sewer at Sand Island, 27 mgd represents 49 percent of the average flow of 55 mgd.

Television inspection of sewers has been and is being conducted by the Division of Sewers maintenance personnel. Areas covered thus far are McCully, Liliha-Puunui, Punchbowl, Aina Haina, Kahala, Waikiki, Kapiolani and Ala Moana. Available TV logs show no major leaks; instead, numerous small leaks have been recorded. For example, the logs show that vitrified clay pipes in the McCully area have many leaking joints, sags, and cracks. They also show that some cast iron pipes are corroded and tuberculated.

TV logs of sewers in Liliha-Puunui district noted high incidences of cracked pipes and occasional root growths in lines. However, according to the maintenance personnel, infiltration in this area is small, estimated to be less than 5 gpm, except during heavy rains when infiltration is excessive. Defective sewers in this area have just recently been replaced.

Equipment used by the Sewer Maintenance Section include a TV camera, monitor, video tape recorder and other accessories and a van. Funds are appropriated each year for sealing service contracts and range between $15,000 to $30,000. Annual labor cost for the TV equipped maintenance crew is approximately $33,000.

Replacement of defective sewers in the City is being coordinated with street improvement district projects. A closed-circuit TV survey of all existing sewer lines is conducted within and outside the boundaries of the projects prior to their implementation. Lines which are leaking or otherwise defective are replaced. Latest projects falling into this category are South King Street Widening project and the Sheridan Tract and Punchbowl improvement district projects.

Leaks in some sewers have been sealed by firms under contract with the City. Sewers worked on include the Kuhio Trunk Sewer, Beach Walk Main Sewer, Kalia Trunk Sewer, Malani Main Sewer, and the Kuhio Relief Sewer, all located in the Waikiki area. Also worked on were sewers in the Honolulu International Airport area, the Enchanted Lakes Subdivision, and the Waianae Sewer Improvement District No. 100 area.

V. SECONDARY IMPACT STATEMENT

A. PUBLIC CONTROVERSY

As with all public improvement projects, considerable opposition was generated by small minority, but vocal, groups. However, the project appears to have an overwhelming acceptance from the general public. Information concerning the project was disseminated to the public by means of television, radio, newspaper coverages, and public and professional meetings. Many meetings were held with the Kalihi-Palama Community Council and other groups to resolve points of dissension.

After the preliminary design of the treatment plant and outfall sewer was completed, a public information meeting was held on January 19, 1972 at the Honolulu International Center. Approximately 150 people attended this meeting.

The public controversies or questions that have been raised concerning the project and the City's response are as follows:

1. COMMENT: Use Sand Island for recreational purposes as proposed by the Kalihi Community Association.

   RESPONSE: The planning and development of Sand Island must be well planned and closely coordinated so that the people of this State can receive maximum benefit. Despite the need for recreational facilities in West

Honolulu, we must not ignore other needs. The City is aware of the seriousness of the raw discharge problem off Sand Island and realize that immediate steps must be taken to eliminate the problem. To do so, we must have a site on which to build treatment facilities. Our studies indicate that a site on Sand Island is the most suitable location for the construction of the treatment facilities. We realize there are objections to locating such facilities there, especially in proximity to the proposed state park. While we appreciate this concern, we feel that this location will best serve the people and will not seriously affect the park plans. We sincerely believe a properly designed treatment plant is not necessarily incompatible with park uses. We feel that sewage treatment facilities can be built to offer both beautification and treatment. We would like to add that the decision to build treatment facilities on Sand Island was not a hasty one. Studies were made before the course of action was decided upon. Also, recognition must be given to the fact that Sand Island is adjacent to a harbor and an industrial area and activities related to such uses belong either on or near the island.

2. <u>COMMENT</u>: Construct the sewage treatment plant in a designated area on one of the reefs west or north-west of Sand Island. Although some additional cost would be

incurred in the relocation of the sewer outfall from Sand Island, the immediate and long range benefits that would be derived is ample justification for this expenditure.

RESPONSE: Having decided that the City's wastewater could best be disposed of off Sand Island, a number of sites were considered for the location of the treatment facility. Because of the substantial area requirements, it was obvious that available and suitable sites were indeed limited. Before making the final selection, three areas were closely studied.

The three locations given serious study were: (1) a site on Sand Island, (2) reclaimed land in and around the reefs off Sand Island, and (3) the Federal and State lands ewa (west) and mauka (north) of the Bascule bridge.

The reclaimed reef land location presents problems of excess costs, time, and the impracticability in building up a site that is located offshore. We also have serious reservations regarding the effect that such a buildup might have on the circulation and hence the flushing of Keehi Lagoon and Honolulu Harbor. An extensive study of Keehi Lagoon would have to be undertaken to determine these effects. Also, the State Department of Transportation will not allow anyone to construct structures in this area because of the proposed Reef Runway Project. The disadvantages of the location ewa and mauka of the Bascule bridge include the limitation of the area, the potential foundation problems, the question of availability of the Federal and State lands, its proximity to homes, and the additional costs required for the construction of extra facilities needed for conveying sewage to and from the site. Therefore, the site on Sand Island is, in our judgment, the best location for the treatment plant.

3. COMMENT: Sand Island and adjacent waters could be used better if the treatment facility site is located on reef. More people would benefit since we would not only have a much needed park site but we would also have a sewage treatment plant that would be downwind during trade or "Kona" (south) winds. The stench of sewage would normally be dissipated towards the open ocean by the prevailing trade wind. However, during south wind conditions, peculiar odors would be wafted towards the old airport area; whereas, if the plant were constructed on Sand Island, the smell would permeate the Kalihi and industrial areas. Until such time as the operation of the treatment plant produces less offensive odors we must temporarily live with this less than ideal situation.

RESPONSE: The problem of the control of odors from sewage treatment plants lies not in who is offended and when, but the actual reduction of odors at all times. Even though the prevailing winds are predominately from the northeast, they may change direction continually during any given day, creating this need for odor control. This control of odors will be given detailed consideration during the design of the treatment plant.

4. COMMENT: The reef sewage treatment plant would permit immediate conformance to Federal water pollution standards and the project site has acres of free State land for immediate construction and future expansion.

   RESPONSE: The location of a sewage treatment plant does not alone determine if its effluent discharge will or will not meet the Federal water pollution standards. We can say, however, that the proposed plant on Sand Island and the Outfall Sewer will be designed to meet the State and Federal water quality standards. There is sufficient land available on Sand Island for both a treatment plant and a park.

5. COMMENT: Why continue to use Kalihi, Honolulu's most densely populated and under-serviced neighborhood as a dumping ground for incinerators, the City's primary sewage treatment plant, all sorts of noxious industry and other insults and neglect.

   RESPONSE: The City's consortium, and subsequently the Board of Advisors, considered other alternatives, including locating the plant near Barbers Point. The reason Sand Island was chosen is that even aside from the fact that it is the central collecting point for the leeward and urban areas of Honolulu, the Barbers Point location and others do not offer any substantial advantage over Sand Island. In fact, the added construction and operational costs are very much higher. It is most unfair to accuse the City of using Kalihi as a "dumping" ground. The City feels that it is greatly unfair and smacks of the usual response of some citizens who say "Yes, solve your problems but not in my neighborhood." If there were a better location for the sewage treatment plant than Sand Island we would go there.

6. COMMENT: The placing of the City's single major sewage treatment plant directly under the flight corridor for the Honolulu International Airport could present us with a prolonged major crisis if a plane ever fell into it.

RESPONSE: The point that the proposed sewage treatment plant would be under the flight corridor for Honolulu International Airport was well brought out. It would be a major crisis if a plane fell into it. However, what would happen if a plane crashed into a park teeming with people? Wouldn't this be far more tragic? Further, if the danger anticipated from falling airplanes is reason enough for relocating the proposed plant, the proposed State park should also be relocated. Frankly, the City never considered this a serious matter perhaps because subconsciously we have never recalled that a serious accident of this nature had ever occurred. In a recent check with the State Airport Division Chief's office, they confirmed the fact that an airplane has never crashed on Sand Island with over a million and a half flight take-offs occurring during the last 10 years at Honolulu International Airport. We can rest assured that the risk is minimal.

7. COMMENT: Examination of the question of recycling of used water after purification is a requirement now, not at the end of the 50-year design period of the plant.

RESPONSE: The matter of recycling has been given much consideration during our studies. The major components, ground water flux and draft, have been examined. Based on the examinations, our findings have indicated that there might be a shortage of water in the distant future if nothing is done about it. The Board of Water Supply estimates that this might occur sometime before the turn of the century.

Since the sugar industry is the greatest single user of ground water in the Pearl Harbor region, mostly for irrigation, it was determined that wastewater reclamation for reuse in agricultural irrigation would be most beneficial. By reducing the draft and by maintaining the replenishment of the groundwater supply through agricultural return waters, available water resources could be conserved. Thus, reclamation and reuse of sewage effluent for agricultural irrigation have been incorporated into the leeward area wastewater management plans.

Reclamation of wastewater from the Honolulu area is not considered critically essential at present, nor practical because of the high chloride content of the wastewater. Further, the Board of Water Supply is not prepared at this time to accept treated sewage effluent nor does it indicate where it would wish to have the effluent discharged. It would be many years before these questions are resolved and the solution to the present raw sewage discharge off Sand Island is needed now. For these reasons, an ocean outfall would still be required.

8. COMMENT: The important concept of a decentralized sewage treatment system for Honolulu as opposed to the single plant concept was not seriously studied.

RESPONSE: The present study adequately covered the engineering phases of alternative wastewater treatment and disposal methods. A decentralized system of wastewater treatment facilities will be provided for the Island of Oahu; however, multiple small plants located near the watershed areas of the city will be uneconomical to operate and maintain. Moreover, there will be times when sewage effluent would be in excess, such as during rainy weather in which case a tail-water discharge would be required.

Decentralized plants would require substantial land. It would also delay the solution to the problem by months or years. The guidelines of the Federal Environmental Protection Agency stress the need for centralized regional or sub-regional treatment facilities such as the Sand Island facilities whenever possible. Water quality management plans which do not substantially meet Federal guidelines are denied Federal aid. The City also seriously doubts that the Federal government would look favorably on a grant application which involved several small sewage treatment plants instead of one large one centrally located.

9. Comment: Some of the sewer lines now in use are as much as 70 years old and leak badly, yet they will tie into a new plant.

RESPONSE: Insofar as the City's sewer lines are concerned, many are old and many are leaky; however, other cities' sewer systems have the same problems. All sewer systems have infiltration problems if the lines are located below the ground water table as ours are. Provisions for ground water infiltration are provided for in our design criteria. Presently we are doing something about our ancient lines. The City is systematically locating infiltrating leaks in the system. When major leaks are discovered, they are sealed, repaired or replaced as soon as possible. Also, a closed-circuit television inspection crew has been working for the past three years inspecting miles of sewers.

10. COMMENT: Sand Island is the lowest point in the City's sewage basin complex. To convert even a portion of it to a full-treatment recycling system later would be extremely expensive from the standpoint of reverse pumping to the watershed areas.

RESPONSE: Sand Island is a relatively low area within its drainage basin complex and the pumping of effluent, whether it be to irrigation systems or watersheds, will be necessary. However, even if the plant were not located on Sand Island, pumping would still be required because of the gravity principle nature of all sewer system.

11. Comment: Why is the City embarking on a crash program of building a primary treatment plant when the Mayor stated that he was opposed to this type of action.

RESPONSE: The Mayor meant what he said in indicating that the City would not rush into a crash program. The City's Board of Advisors and staff convinced him that certain data had to be available before the proper decisions could be made. Sufficient data to permit these decisions to be made with a fair degree of confidence were subsequently received. With the data, the consortium which was hired to develop a Water Quality Management Program for Oahu made preliminary recommendations, as we had asked them to do.

These preliminary recommendations were presented to the Board of Advisors for evaluation. After considerable discussion, the Board accepted the consortium's plan and tentatively recommended the construction of an advanced primary sewage treatment plant on Sand Island and an extended deep water outfall as the best way to handle that problem.

12. COMMENT: Why did the City proceed with the implementation of the Sand Island system before the 18-month sewage disposal study was completed?

RESPONSE: The 18-month study period mentioned is the time required for the study of the entire Island of Oahu, not just the Honolulu-Pearl Harbor area. When given the notice to proceed, our consultants were mandated to complete the Sand Island study first and by December 1970. The City's decision to construct a treatment plant on Sand Island was not a hasty one nor was it made to create "quickie make-work government jobs" for contractors. We followed a previously established schedule decided on by our consultants who indicated that 8 to 9 months would be enough time to gather sufficient information for decision making.

13. COMMENT: It would be criminal to locate a sewage treatment plant in or near the new Sand Island State Park. The site of the plant is not in conformance with legislative intent, that is, the site is within park area. Also, the presence of the plant will interfere with the possible 250-acre park yet to be decided by the legislature.

RESPONSE: The City and the State Department of Land and Natural Resources have been working together very closely since 1967 for an enlarged site for the Sand Island treatment plant. The original site, which is being returned to the State's jurisdiction, consists of some 12.2 acres conveyed to the City under Governor's Executive Order No. 1188 dated February 5, 1947 for sewage treatment plant use. This site was located makai of the new 50-acre plant site.

Numerous potential sites for the plant were considered and evaluated by the City and State. One of them was a 35-acre site along the shoreline. These considerations were discussed with the State before the concept of a major State park was proposed on Sand Island.

A shoreline site was considered only because of the possibility that the reef lands off Sand Island might be reclaimed, in which case the shoreline would be extended seaward and be available for park and other uses. The public would have been allowed access to the beach frontage side of the plant for recreational purposes. Reef reclamation would also permit the plant site to be expanded to 70 acres if secondary or advanced treatment facilities were necessary in the future. Twenty acres of the proposed 70-acre site was for the purpose of creating a park-like buffer around the perimeter of the treatment plant.

Because reclamation of the reef area did not appear to be feasible, the site was relocated inland, far enough to insure the development of a strip park along the beach. The present site will not deter the creation of a potential 250-acre park complex since additional acreage is available on the ewa and waikiki boundaries of the treatment plant site. Further, the plant area was reduced to 50 acres by reducing the buffer area around the site by incorporating covered treatment facilities and odor destroying devices into the plant design. The inland location of the plant site is outside of the 600-foot wide strip park extending from the fishery site to the Bascule bridge along the makai coastline of Sand Island. This park has been delineated by the State Board of Land and Natural Resources with the concurrent approval of Governor Burns.

14. COMMENT: Kona wind season, with its pronounced effect on currents, was not taken into account since the study began. Also the Consortium's statement that southerly winds are common during the summer months are incorrect since all local persons know that southerly winds occur not in the summer but in winter months.

Development Plan for the area. Existing zonings are R-6 residential and heavy and light industrial uses.

18. COMMENT: The City's engineers, all far over 30 are apparently wedded to cost-cutting politics, old concepts, old facilities and old patrons. Yet the decision made by the City and a few consultants will have to be lived with by the entire young generation who are now under voting age. These people have not been told of your decision, though an entire education system is available for such a relevant purpose. Thus, they have no choice regarding an obsolete, centralized primary sewage treatment plant (that merely filters out cats and dogs) at a time when science and the people are calling for full treatment, recycling, and environmental protection. The drawing boards need to cleared of old concepts.

RESPONSE: The men who are guiding the water quality study are eminent, professional men in their respective engineering and scientific disciplines.

The composition of the Board who is guiding the work was carefully selected to include expertise in the several disciplines which are involved in the program. Chairman John D. Parkhurst is the Chief Engineer and General Manager of the Los Angeles County Sanitation Districts and has been engaged for almost 30 years in the field of sanitary engineering with emphasis on wastewater disposal.

Vice Chairman Dr. Richard K. C. Lee served the Territory and State of Hawaii as Director of Public Health for over 20 years and later as Professor of Public Health and Dean of the School of Public Health at the University of Hawaii. Dr. Robert W. Hiatt, the biologist member of the Board is presently Scientific Attache' with the U.S. Embassy, Tokyo, and former Professor of Zoology and Entomology at the University of Hawaii and also served as Director of the Hawaii Marine Laboratory. Dr. John W. Shupe, Dean of the College of Engineering at the University of Hawaii, brings to the Board a broad background in the overall Civil Engineering field. Dr. Erman A. Pearson is Professor of Sanitary Engineering at the University of California and recognized world-wide as an expert in water quality control problems, particularly regarding waste disposal in the marine waters. The combined Water Pollution Control, Public Health, Biological and General Engineering expertise of this team provides excellent guidance to the work program.

These people through long years of experience are familiar with new concepts. The fact that our decision does not coincide with others is not proof that it is ill-advised.

19. COMMENT: The bacteria die-out rate is questionable. A news article in the Washington Post dated December 5, 1971,

stated as follows: "Orkdeal, N. Y. Bacteria associated with human wastes have been found on the floor of Atlantic Ocean 110 miles off shore and more than 80 miles from where New York City and other municipalities dumped raw sewage. Experts said that the findings indicate the ocean may have a more limited capacity for purifying human wastes than generally believed.. sea has a limited capacity in killing bacteria. Bacterias are not natural to ocean... they have to come from sewage source."

RESPONSE: Bacteria decay rates are facts. In-situ tests conducted off the existing Sand Island Sewer confirmed rapid dieof rates in Oahu oceanic waters. The newspaper article probably referred to the dumping of sludge off the East Coast. Coliform bacteria die-away rates are discussed elsewhere in this report.

20. COMMENT: The Federal EPA requirement is for 85 percent BOD removal, but the City is requesting a waiver on this. We would like a clarification of this before any waiver is granted by the Federal agencies involved. What is the effect of allowing so much undecomposed matter in the water (granting of waiver) on swimmers and on shoreline usage? There is an increasing number of young people reporting eye infection and skin infection in areas where sewage is going into the ocean, such as Lualualei and Sandy beach, where algae growth is detected.

RESPONSE: A request for a waiver of the requirement for removing not less than 85 percent of 5-day BOD was submitted to the EPA by the City on January 21, 1972. As of this date (March 1972) a reply has not been received. For disposal to the open ocean through an outfall, the BOD requirement may be waived if it can be shown that such discharges will not adversely affect the open ocean environment and adjacent shores. This waiver is particularly applicable to the recommended Sand Island System of advanced primary treatment with a long outfall into deep waters. The proposed system provides the optimum and most economical system for protecting the marine environment because (a) the concept of deep ocean disposal is basically sound and is independent of the level of treatment--vastly greater dilution being available both with respect to short (initial dilution and jet mixing) and long term effects, hence vastly reducing any possible hazards of impairment to ecology; and (b) given the recommended outfall location, the recommended treatment will provide the necessary protection of the marine environment from a technical and scientific point of view.

Secondary treatment combined with a long deep-water outfall system could provide better results, but the benefits to be derived would not justify the expenditure of the additional funds especially in view of the funds required to solve other urgent pollution problems.

The proposed discharge will have no significant deleterious effect on the beneficial uses of this area. These include shipping, boating, fishing, and aesthetics. Water contact sports generally do not occur in this area, but even if they did, no health hazard would be anticipated because effluent field submergence is provided by design.

Effluent discharged off Sandy Beach and Waianae are chlorinated. Both discharges meet water quality standards for microbiology. There are no waste discharges off Lualualei. Also algal growth is a natural phenomena.

21. COMMENT: A previous study indicated an outfall depth of 300 feet. It is now 225.

RESPONSE: The proposed outfall system will consist of a 9,000 foot long pipe section and a 3,350 foot long diffuser section, extending off Sand Island. It will lie westerly of the present outfall and terminate with the diffuser at depths varying from about 220 to 240 feet. The proposed outfall system will discharge effluent below the pycnocline, resulting in the effluent field being submerged most of the time. During some periods in the summer and winter, weak stratification may cause the field to rise to the surface. When the field does surface, however, the quality of the effluent and the subsequent higher dilutions produced during surfacing will cause the field to be undetectable at the surface to all but an experienced eye.

For weak or moderate stratification, the depth of submergence is essentially equivalent for the two systems; however, when the stratification is strong, the deeper outfall gives deeper submergence. Because of similiar behavior for weak stratification, the percentage of the time that the effluent field will surface will be closely the same for the two schemes. The additional depth of submergence by the deeper outfall when the stratification is strong is probably of marginal benefit and may even be a disadvantage because the flushing currents become progressively weaker with depth.

With regard to dilution, the dilutions achieved at the proposed outfall will exceed those at the deeper outfall for all conditions, ranging from 60 percent to 80 percent higher in winter, about 40 percent higher in fall, and from 35 percent to 100 percent higher in summer. The proposed design will achieve a 200:1 dilution at all times when the submergence is less than 80 feet; when the plume surfaces, the dilution will be on the order of 400:1.

Further disadvantages of the earlier scheme, with depths up to 345 feet, are: (1) risks and the expense of outfall construction at unprecedented depths; (2) the expense and difficulty of installing a "wye" structure; (3) bottom slopes up to 25 percent; and (4) the difficulty of obtaining flows from the deeper offshore ports at low and medium flows without creating excessive hydraulic heads.

22. COMMENT: The air could become contaminated via air bubles originating from water containing pathogenic bacteria (referring to the fine bubbles of the flotator-clarifier tank).

RESPONSE: The interior of the flotator-clarifier would be under a partial vacumm and these bubbles would not escape to the outside of the building. The air within the building will be treated with ozone before it is released to the atmosphere.

23. COMMENT: Section 102 of PL91-90 states that "All agencies of the Federal Government shall study, develop, and describe appropriate alternatives to the recommended course of action in any proposal which involved unresolved conflicts concerning alternative uses of available resources." There is a conflict in the plan and this provision should be invoked in order that adequate studies are done by the citizens.

RESPONSE: The City developed several alternatives and these were submitted to the Federal and State governments for review and approval. With respect to Sand Island, these alternatives are included in the Interim Metropolitan Water Quality Management Plan (Mamala Bay Area). This plan has been approved by both State and Federal governments. The City has and will comply with all Federal and State requirements.

24. COMMENT: Have long term degradation effects of the ocean been considered or studied?

RESPONSE: The WQPO consultants studied the ocean for approximately 18 months. A desirable study, at least from the standpoint of gathering background information and for monitoring the effects of a given discharge, will require about 5 years. However, we cannot study the problem for 5 years because we have a situation that requires immediate action. Special studies conducted by our consultants of the existing Sand Island raw sewage discharge clearly show that after about 20 years (actually 17 years) of operation, the effects of the discharge are limited to an area of about 300 acres, which is very small. Nearly normal conditions return within about 500 yards upwind or downwind from the outfall.

Treatment aimed at removal of settleable materials should provide for a substantial reduction in the bottom area affected by the proposed discharge. In addition, an extensive ocean monitoring program will be undertaken by the City to study the effects from the proposed treatment and disposal system. The plant can be modified later, if required.

25. COMMENT: The waters off Sand Island are now polluted and affecting swimmers.

RESPONSE: The proposed treatment and disposal systems will permit the development of a water orientated recreational program off Sand Island and Keehi Lagoon.

26. COMMENT: Virus in sludge might pose a health problem.

RESPONSE: Sludge treatment at high temperature and pressure will render the sludge sterile.

27. COMMENT: Was a nuclear plant considered, especially with the strong possibility of manufacturing drinking water from sea water in 20-30 years?

RESPONSE: The City has not received any evaluation of the nuclear-powered waste disposal plant from technical agencies nor State or Federal water quality control agencies and hence cannot make any comments regarding its use and effectiveness at this time.

The matter of recycling was given much attention during our water quality study. The City's Board of Advisors has recommended, as a result of the study, that wastewater recycling in certain areas of Oahu be considered as alternative disposal means.

28. COMMENT: Citizens have been carefully screened out of a meaningful role on the design of the Sand Island treatment plant. The City has denied citizens the opportunity to meet with the advisory board council.

RESPONSE: The City has not denied anyone the opportunity to meet with our Board of Advisors. We disagreed that it is absolutely necessary and proper for interested citizens to participate in our bi-monthly Advisory Board meetings. The mission of the Board was to provide guidance for the study and to recommend solutions to the numerous sewage disposal problems which confronted us. The Board met bi-monthly and three of the five members are scattered throughout the world. These men must travel great distances for the meetings and all of the available time must be spent on this task of guiding the study and recommending solutions. One can imagine the size and the resultant chaos if all interested persons were invited to participate in these meetings. We seriously doubt that anything constructive would be accomplished at any such large and lengthy meeting and for the sake of order, the City refrained from opening these meetings to the general public.

B. DEVELOPMENT

The General Plan (1964) for Sand Island designates industrial uses for the major portion of the island, a small site for fire station use and an area along the makai (seaward-Waikiki sides of the island for park use. The location of the proposed sewage treatment plant is within the industrial portion of the island; hence it is compatable with the General Plan designation. There is no adopted Detailed Land Use Map or Development Plan for the area.

Water and sewer facilities on the island are not adequate but the State intends to install the necessary water and sewer systems. Treatment of sewage generated on the island, including sewage from the Coast Guard docking facilities, will be accomplished at the proposed plant.

The park expansion areas shown on the General Plan at the makai (seaward) and Waikiki ends of the island are on existing reef areas which might be reclaimed. The City Planning Department considers a park at the entrance channel to Honolulu Harbor as an important factor in connection with the Historic, Cultural and Scenic District of the State Capitol and Civic Center complex. They also see a possibility for some multiple or dual use of a portion of the park area that adjoins the treatment plant facility.

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