ENVIRONMENTAL ASSESSMENT
for the
MICRODREDGING OF TUMON BAY
ADJACENT TO THE FUJITA HOTEL

Prepared for

T & NN INTERNATIONAL

GMP ASSOCIATES, INC
CONSULTING ENGINEERS

JULY 1990

EXECUTIVE SUMMARY

The purpose of this Environmental Assessment is to provide supplemental information to be submitted in conjunction with necessary application forms to various local and Federal permitting agencies for a proposed microdredging and construction of a sea wall abutting the Fujita Hotel on Tumon Bay.

The proposed plan calls for a 1,000-foot by 150-foot area, located directly in front of Fujita Hotel, to be dredged over a two-month work schedule. An average of 3 feet of sand and substrate material will be removed from the proposed dredging site to provide a finish depth of -4.5 feet below the MLLW mark. The landward boundary of the proposed dredging site will begin 50 feet from the MLLW mark to preserve the natural slope of the beach, as well as the delicate moat region that serves as an important fishery for the bay. Silt curtains will be used to contain the dredging operation and impede movement of sediment beyond the dredging area.

The volume of dredged material is estimated to be about 18,033 cubic yards. The dredged material will be settled in two 65-foot square settling basins to be located on the Fujita Hotel's property. The sediments from the basins will be sifted, washed and used for beach nourishment and restoration. The undesirable spoils will be sent to a landfill.

A computer model simulating the circulation in the Bay specifically developed for this project shows that the proposed dredging will have no significant effect on circulation pattern in the bay. The increase in water depth, due to the proposed dredging, will not change the residence time in the Bay significantly. It, however, provides for effective dissipation of secondary wave energy in the area and, thus, reducing beach erosion.

No historical or cultural sites are found within the boundaries of the proposed projects. In addition, the project will have no known adverse effects on the marine environment. In contrast, the proposed dredging will provide a better habitat for marine life, due to cooler and deeper environment.

TABLE OF CONTENTS

TABLE OF CONTENTS, Continued

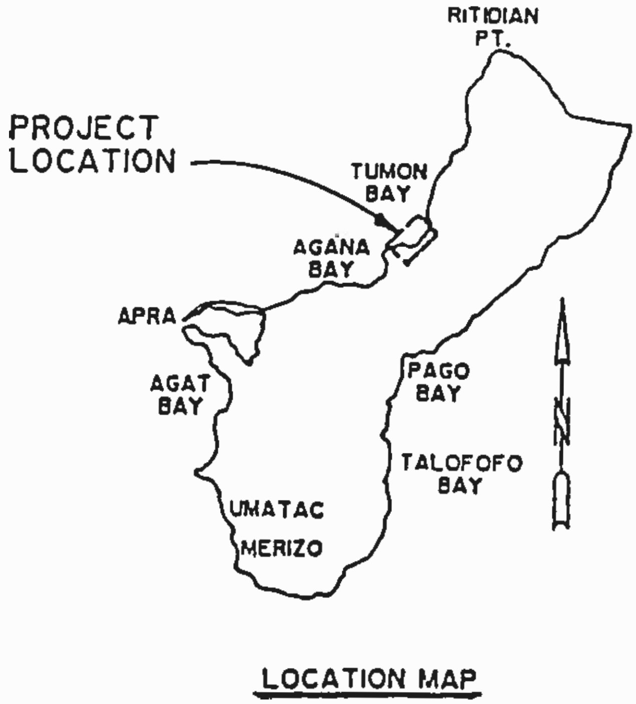
LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

A 1,000-foot-long, 3-foot-high sea wall will also be constructed at the edge of the vegetation line and on the hotel's property to further prevent erosion of the hotel property during storm conditions. The proposed project site, shown in Figure 1-1, delineates the dredging area, the seawall and the settling bains. Details of this operation are discussed in the proceeding sections of this document.

This Environmental Assessment addresses the existing conditions found at the project site. The bathymetry, current pattern, water quality and sediment analysis were performed specifically for this project. Several studies of the marine and terrestrial plants and animals have been previously conducted in Tumon Bay. These studies have been used as sources of additional information and historical overview of the environment.



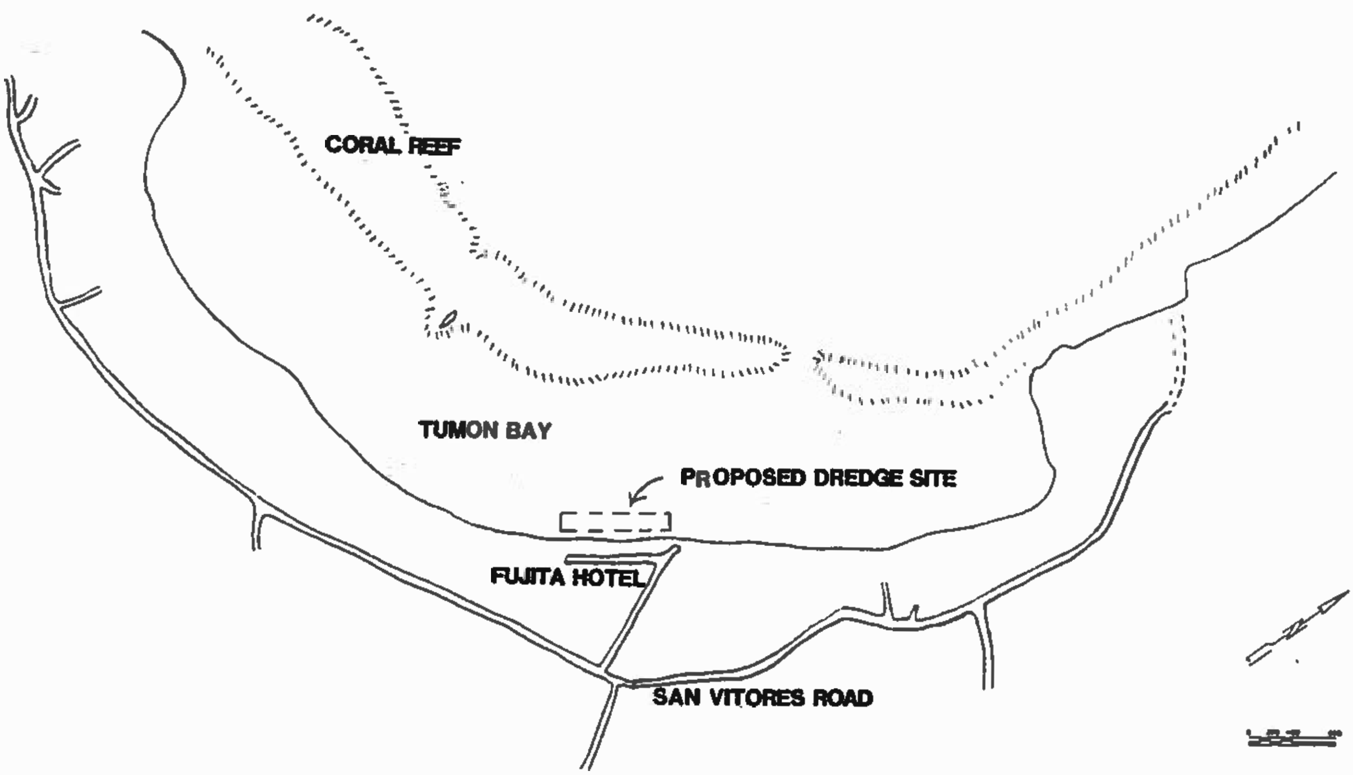


FIGURE 1-1 LOCATION OF PROPOSED DREDGING

EXISTING CONDITIONS

SECTION 1

INTRODUCTION

1.1 GENERAL DESCRIPTION

Tumon Bay is the major recreational and tourist area on Guam for both residents and tourists. By 1993, it is estimated that one million tourists will enjoy swimming, snorkeling and sailing in the bay. Tumon Bay has one of Guam's most desirable beaches, but, because of the layout, expanse and bathymetry of the bay, it is susceptible to erosion caused by long waves and/or storms impinging upon the shoreline. The stretch of Naton Beach abutting Fujita Hotel, which is the subject of this project, is particularly vulnerable to eroding wave actions.

Dredging is proposed as a means to reduce wave energy and, consequently, diminution of beach erosion during storms. The dredging will also result in a better swimming area. The proposed action would involve dredging of a 1,000-foot by 150-foot area in the bay, directly in front of Fujita Hotel. The dredged material will be settled in two basins specially designed for this purpose and located on the hotel property. Silt curtains will be used to contain the dredging operation and impede movement of sediment beyond the dredging area. The dredge material recovered from settling basins will be used to restore the beach, where erosion has occurred previously.

SECTION 2

EXISTING CONDITIONS

2.1 TERRESTRIAL ENVIRONMENT

Tumon Bay is a wide, crescent-shaped embayment on the northwestern coast of Guam. The bay is 2.5 miles wide at its north and is marked by Ypao point in the south and Dos Amantes Point on the north. Most of the shoreline of Tumon Bay is beach, with a few rocky outcroppings separating the major beach areas. The beach along which the Fujita Hotel is situated, central Naton Beach, is approximately 3,200 feet long (0.6 miles) and runs between Matapang Beach Park and the Reef Hotel. Most of the land above the mean higher high water (MHHW) line has been developed for homes and apartments. The area between the MHHW and mean lower low water line (MLLW) is reserved as the public beach.

2.1.1 Soil and Geology

Tumon Bay is formed by a gently sloping limestone plateau, backed by very steep cliffs. Between these limestone cliffs, the bedrock has slumped, forming the gently sloping floor of Tumon Village and the bay. This plateau extends into the ocean, providing a base for the reef. In the area of the Fujita Hotel, the overlying soil is shioya loamy sand, at least 10 feet thick. The shioya soil is very permeable, so any rainwater percolates into the ground, rather than running off in streams or ditches.

2.1.2 Meteorology and Climate

Guam's tropical climate is characterized by two seasons, rainy and dry. The rainy season extends from approximately July through November, with an average of 11 inches of rain falling per month. The dry season occurs from December to June, with an average of 4 inches of rain per month. The average annual rainfall is 85 inches, but may range anywhere from 55 to 120 inches.

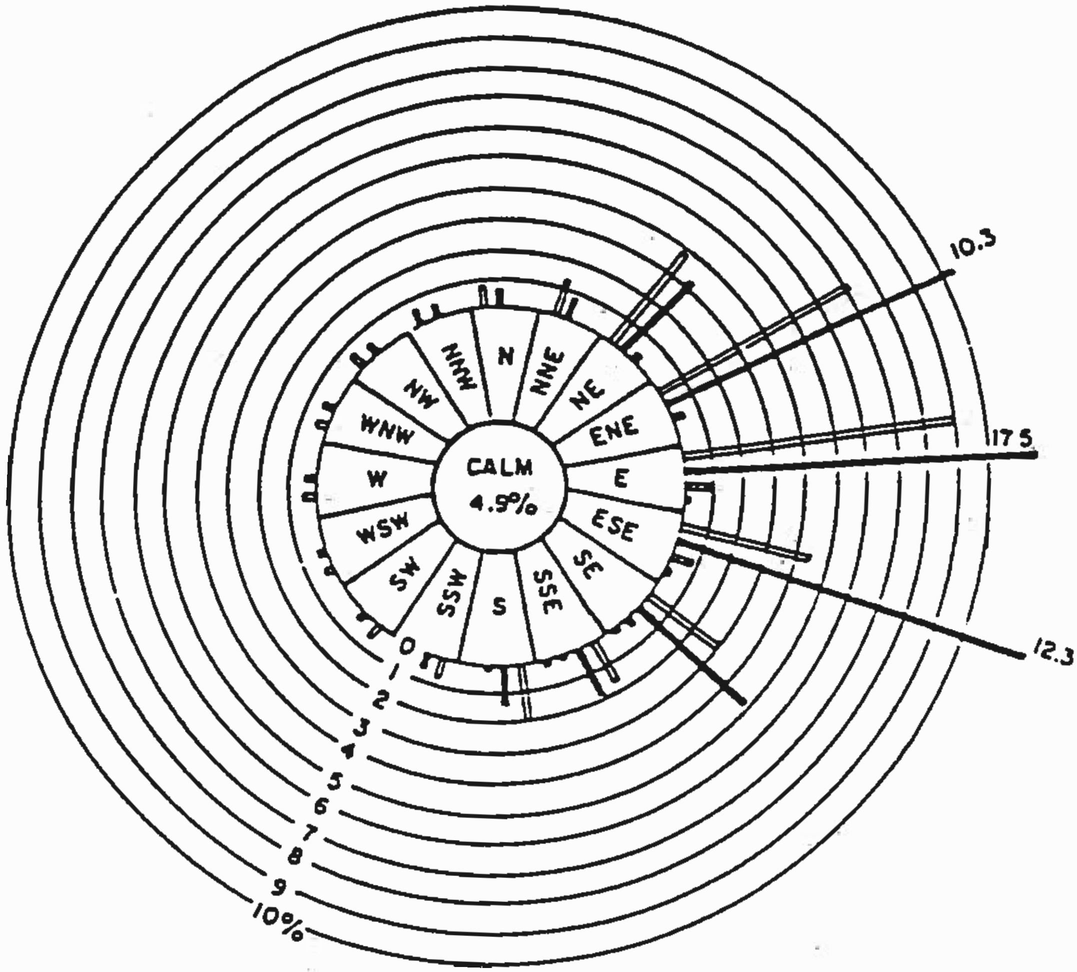
The predominant winds are trade winds from the east at 7 to 16 knots. These winds are nearly constant during the dry season. Calms are more frequent during the rainy season. A windrose showing the wind pattern is depicted in Figure 2-1. Typhoons and tropical storms can occur at any time during the year, but are most frequent during the rainy season. Typhoons bring intense rain, strong winds and large waves, typically.

Tumon Bay is sheltered from the prevailing trade winds by the island because of its location below the level of the northern plateau. Storms approaching from the west can impact Tumon Bay quite strongly.

2.1.3 Hydrology

Tumon Bay rests on a porous limestone foundation and because of this, no streams exist along the bay. Rainwater percolates down through the limestone to the saturation zone

SURFACE WIND DIAGRAM
AGANA FIELD FLEET WEATHER CENTRAL
GUAM, MARIANA ISLANDS



10% = TOTAL % OF THE YEAR

LEGEND

1-6 KNOTS

7-16 KNOTS

17-21 KNOTS

OVER 21 KNOTS

CONVERSION: 1 KNOT = 1.1516 MPH

PERIOD OF RECORD

1945-1967

SOURCE

NATIONAL WEATHER SERVICE
HONOLULU, HAWAII
DATA COMPILED BY U.S. AIR FORCE
ENVIRONMENTAL TECHNICAL
APPLICATION CENTER,
ASHEVILLE, N.C.

FIGURE 2–1 WIND ROSE

and then is transported laterally by gravity to the shoreline. Here, it emerges from cracks and fissures along the intertidal and subtidal zones. Emery (1962) calculated groundwater discharge to be 1.5 cfs along a 150-foot section of Gogna Beach.

2.1.4 Land Use

Tumon Bay is the center of the rapidly growing tourist industry on Guam. The majority of the hotels are located and planned in this area. As of the end of 1989, there were over 3,100 hotel rooms open in Tumon. Private homes and apartments are also located here. An additional 5,450 hotel rooms were under construction or planned for the near future, according to the Territorial Planning Commission in early-1990. Also, 1,342 condominim or apartment units were also in progress. These new additions will double the available tourist space within the next three years. As a result of all the construction, the Tumon Area is not exactly pristine. Tower cranes dominate the view, heavy trucks are frequently traveling San Vitores Road, and the general noise level is increased.

2.1.5 Storm Water Drainage

Besides the construction activities underway, the other infrastructure, which is of consequence to this project, is the storm water drainage. There are no natural streams or drainage features which empty into Tumon Bay. The soil and bedrock are extremely porous and storm water infiltrates, rather than running off over the surface. A study by Emery (1962) found the groundwater discharge to be 1.5 cfs along Gognga Beach, so this value can reasonably be applied in this situation.

Recent upgrading of San Vitores Road has included construction of storm water collection and infiltration structures. No drainage from the road or beyond will surface flow under most conditions. Infiltration beds are installed at the Fujita Wastewater Pumping Station and at Matapang Beach Park. There are no surface drains from the Fujita Hotel or adjacent facilities.

2.1.6 Historical and Archaeological Sites

Tumon Bay is known to have been an active settlement for the ancient Chamorros. An ancient Chamorro burial site can found along San Vitores Road near Central Naton Beach. In addition, the area was fortified by the Japanese prior to World War II. Some of these structures still exist along the coast-line. Japanese pill boxes can still be found on the upper reaches of North and South Naton Beach. An archaeological study of the entire Tumon Bay area, conducted by Graves & Moore in 1985, reported the presence of no significant cultural or historical artifacts onsite within the bay.

Paul H. Rosenthal, Inc., was commissioned in 1989, to perform a subsurface archaeological reconnaissance survey for the Fujita Hotel expansion. The beach and the lots adjacent to the beach were devoid of any archaeological artifacts or evidence of past human disturbance. The only areas of significance are well outside the one of influence from the proposed microdredging activity.

2.1.7 Terrestrial Flora and Fauna

The Tumon Bay area has been significantly altered by human activity over the years. Most of the vegetation has been purposefully planted, rather than occuring naturally. Any wildlife that is not dependent on humans (not domesticated or a pest) has been displaced long ago by human presence. No threatened or endangered species of plants or animals have been identified in the Tumon area in any surveys on record.

The Fujita Hotel property has been widely disturbed by its residents over the years. Most of the plants have been planted for decorative purposes. The vegetation in the beach front areas that may be impacted by the dredging project are common strand species or introduced species. Those plants that have been observed in the vicinity of the Fujita Hotel are listed in Table 2-1.

The only native resident bird that maybe found in the Tumon area is the Yellow Bittern. The other native birds are only found in remote forests, particularly in northern Guam, according to the Division of Aquatic and Wildlife Resources. Most shore birds that may be found in Tumon are migratory.

TABLE 2-1

TERRESTRIAL VEGETATION IN CENTRAL TUMON

BOTANICAL NAME	COMMON NAME
Adenanthera pavonina	
Artocarpus mariannensis	Breadfruit, Dokdok
Barringtonia asiatica	Fish-kill tree, Puting
Bidens pilosa	
Bougainvillaea spectablilisq	Bougainvillea
Casuarina equisetifolia	Ironwood, Gagu
Coccoloba uncifera	
Cocos nucifera	Coconut, Niyok
Delonix regia	Flame tree, Atbot del fuego
Hernandia nymphaeifolia	
Hibiscus tiliaceus	Sea hibiscus, Pagu
Leucaena leucocephala	Tangantangan
Melanolepis multiglanduloa var. glabrata	Alom
Messerchjmidia argentia	
Musa sp.	Banana
Passiflora suberosa	Wild passion flower
Phymatodes scolopendria	
Pisonia grandis	Umumu
Plumeria obtusa	Plumeria
Plumeria rubra	Plumeria
Rhoeo spathacea	
Saccharum spoptaneum	
Sanseviera trifasciata	
Scaevola taccada	
Thespesia populnea	Binalo tree

Source: Draft EIS Microdredging of Tumon Bay prepared by Barrett Consulting Group for Guam Visitor's Bureau, July 1988.

Table 2-2 lists the birds seen in Central Tumon and the animals of the area.

2.2 MARINE ENVIRONMENT

2.2.1 General Description

Tumon Bay is a wide, crescent-shaped bay on the northwestern coast of Guam. The bay is 2.7 miles wide at its mouth, and is marked by Ypao Point on the south and Dos Amantes Point on the north. Between these limestone cliffs, the bedrock has slumped, forming the gently sloping floor of Tumon Village and the bay. As a result, the bay is shallow to the outer edge of the reef.

Most of the shoreline of Tumon Bay is beach, with a few rocky outcroppings separating the major beach areas. The beach along which the Fujita Hotel is situated is Naton Beach. This beach is approximately 3,200 feet long (0.6 miles) and runs between Matapang Beach Park and the Reef Hotel. Most of the land above the mean higher high water (MHHW) line has been developed for homes and apartments. The area between the MHHW and mean lower low water line (MLLW) is reserved as the public beach.

The bay is divided into three areas for the purpose of this report, as shown in Figure 2-2. The nearshore/intertidal zone is located between the MLLW and MHHW lines on the shore. This zone is approximately 30 feet wide in the vicinity of the

TABLE 2-2

TERRESTRIAL FAUNA IN CENTRAL TUMON

REPTILES

Anolis Caroliniensis (Chamelon)
Emoia caeruleocuad (Blue-tailed Skink) *
Emoia sp. (Skink)
Gehyra sp. (Gecko)
Hemidactylus frenatus (Gecko)

BIRDS

Arenaria i. interpres (Ruddy Turnstone)
Dicrurus macrocercus harterti (Black Drongo)
Egretta s. sacra (Reef Heron)
Gygis alba candida (White Tern)
Heteroscelus brevipes (Grey-tailed Tattler)

Ixobrychus sinensis (Yellow Bittern) *
Numenius phaeopus variegatus (Whimbrel) *
Passer montanus saturatus (Eurasian Tree Sparrow)
Pluvialis dominica fulva (Golden Plover)
Streptopelia bitorquata dusumieri (P.T. Dove) *

MAMMALS

Canis familiaris (Feral Dog)
Felis catuks (Feral Cat)
Rattus exulans (Polynesian Rat) *
Rattus rattus (Roof Rat) *
Suncus murinus (MuskShrew) *

*Expected, but not observed at time of survey

Source: Draft EIS Microdredging of Tumon Bay, by Barrett Consulting Group for Guam Visitor's Bureau, July 1988.

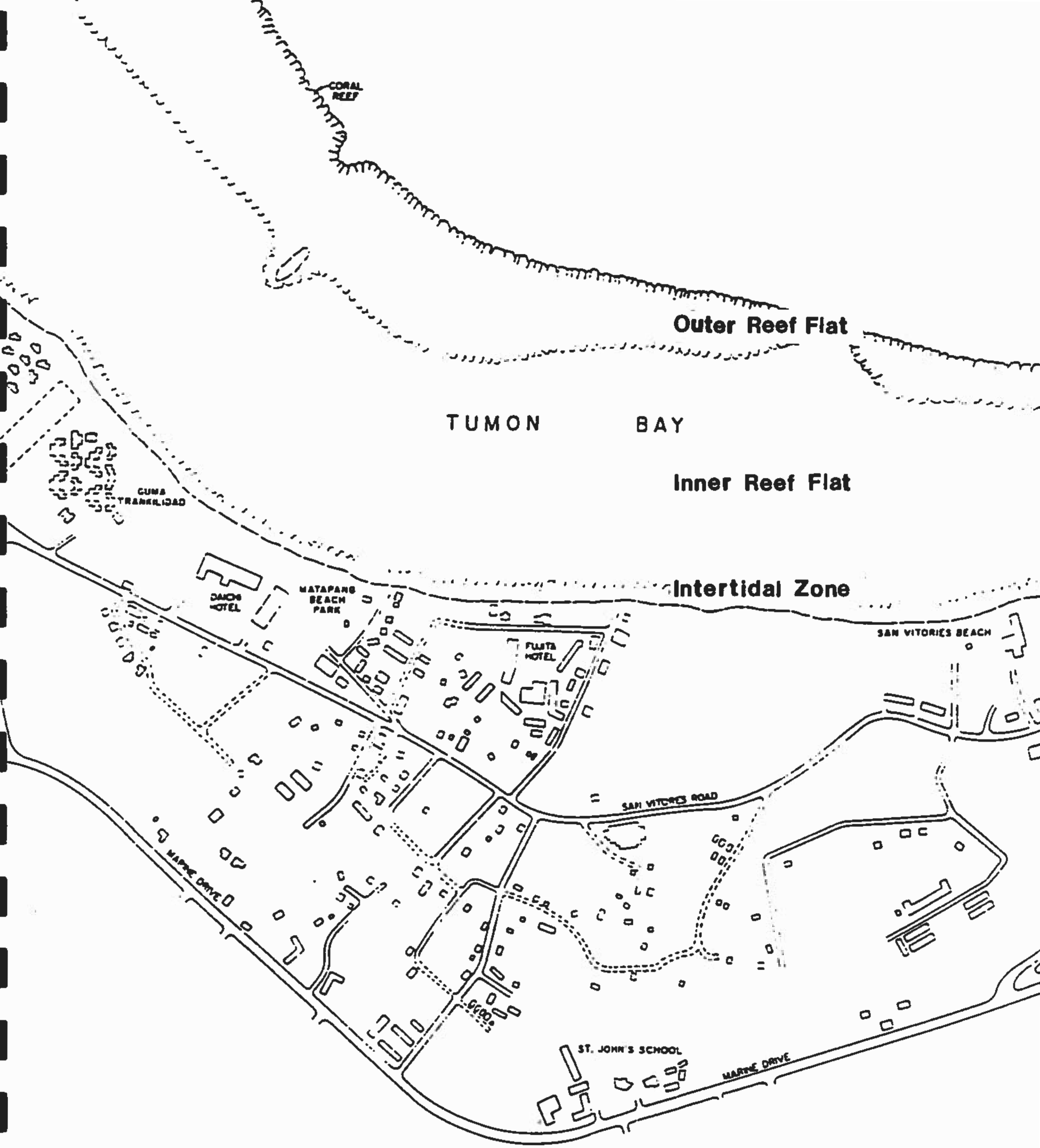


FIGURE 2-2 STUDY AREA

project site. The inner reef flat zone extends out from the MLLW line to the elevated outer reef. This zone is also referred to as the moat. Adjacent to the Fujita Hotel this zone is approximately 1,500 feet wide. The outer reef flat zone is the elavated portion of the reef that extends out to the open ocean. The outer reef flat is frequently exposed during low tide. This zone is 400 to 600 feet wide along Central Naton Beach. Beyond the outer reef flat, the reef drops off steeply.

These three zones exhibit differences in water movement, bottom surface and biological activity. The outer reef flat zone is the most productive and prolific area for plants and animals. This zone also absorbs most of the wave energy from incoming waves. The strength of the waves during storms can be seen by the boulders that have been thrown onto the outer reef flat. The inner reef flat remains submerged generally. Fish can be found here during low tides. The area has fewer corals than the outer reef flat, due to the water quality and predominantly sand bottom. The microdredging is proposed in this zone. The intertidal zone is the least diverse biologically, and the most prone to erosion by wave action.

2.2.2 Bathymetry

Tumon Bay is a very shallow embayment, with very small differential bottom elevation Because of the extreme shallowness of the bay, very little information on the bathymetry has been obtained. Estimations, based on observations throughout the bay, give a depth range of 1 to 3 feet below the MLLW. The beach slopes down to the inner reef flat at 6 to 10 percent grade on the average. The inner reef flat has been found to be relatively level with gradually changing grades. The relief in less than 1.6 feet between any two points in the bay. The water is deepest in the center of the inner reef flat. The outer reef flat is also level, in general, though its rocky surface has small depressions. The storm-deposited boulders provide the greatest variation in the bathymetry. The bathymetric data for a 150-foot by 1,000-foot portion of the bay proposed for dredging is presented in Figure 2-3. The average depth where dredging will take place is -1.5 feet. Finish depth after dredging will be approximately -4.5 feet from the MLLW. Transects taken parallel to shore line at 100, 150 and 200 feet off shore from the established baseline in the vicinity of proposed dredging site are shown in Figure 2-4. The average water depth is about 1.5 feet. Sediment depths were determined by using a jet probe. The average sediment depth is 0.8 feet.

2.2.3 Substrate Material

Naton Beach is composed of unconsolidated, medium-grained, calcareous sand formed from coral and shells with some coral gravel. Grain size analysis by Emery in 1962 found the

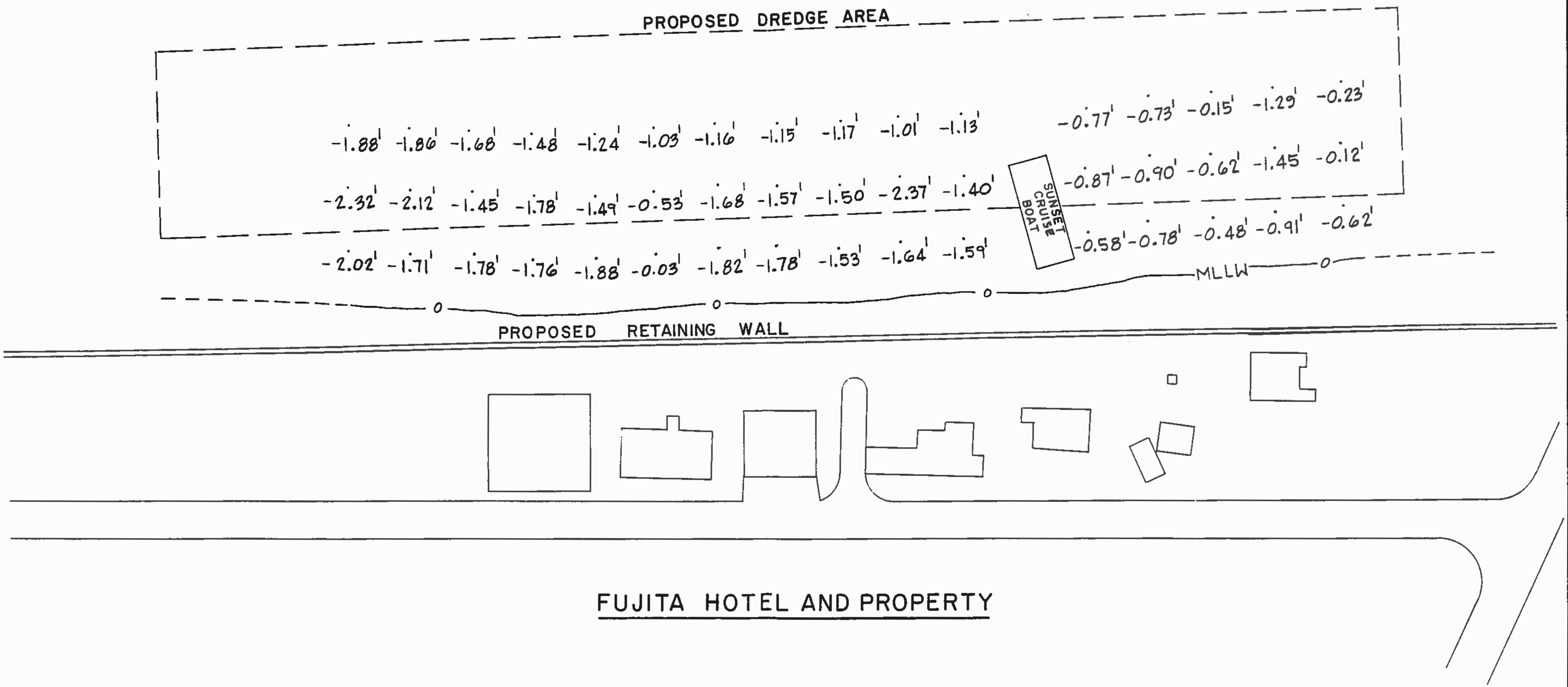


FIGURE 2-3: BATHYMETRY IN VICINITY OF PROPOSED DREDGE ZONE

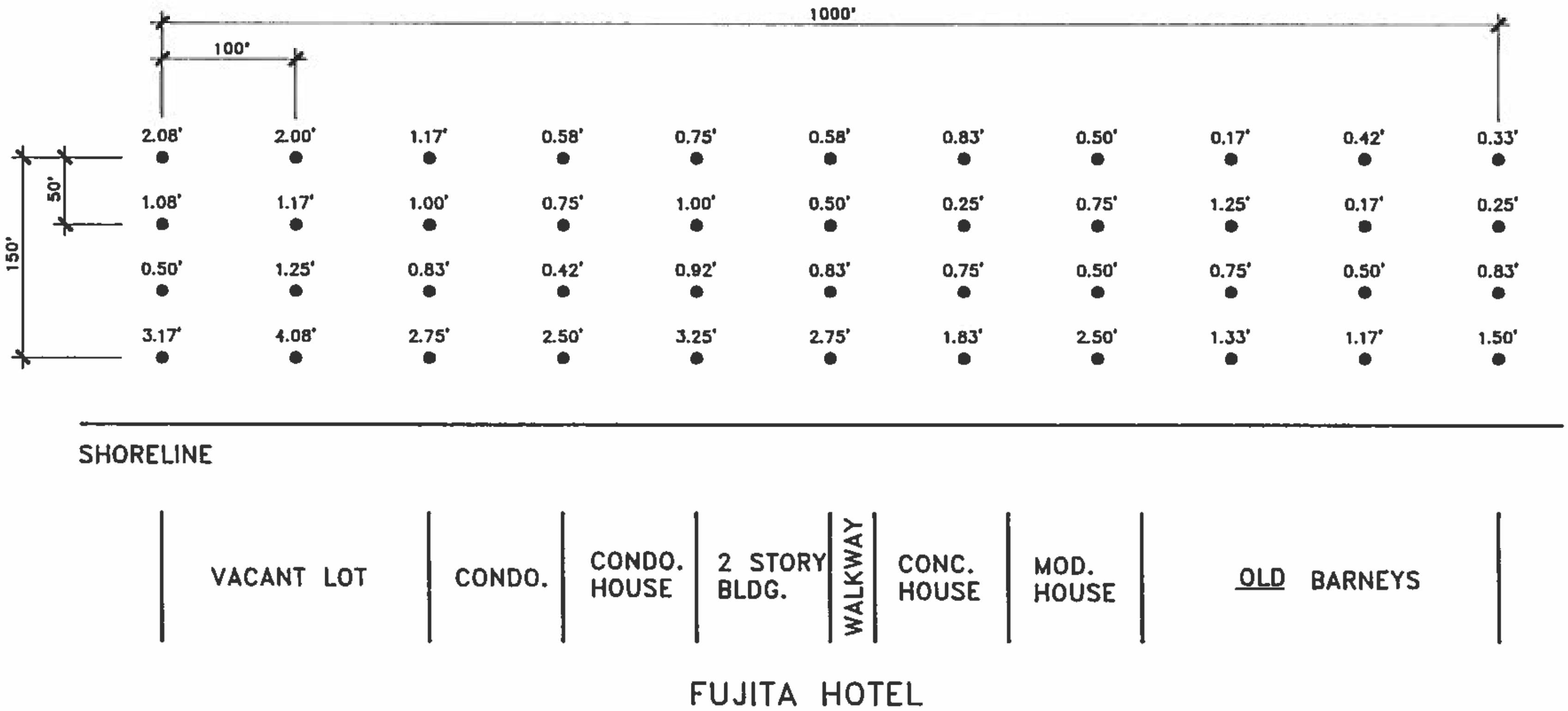


FIGURE 2-4 SEDIMENT DEPTHS WITHIN PROPOSED DREDGE ZONE

sand grains to range from 0.26 millimeter to 0.64 millimeter in diameter. No hard pavement is found on the shore.

The inner reef, commonly referred to as the moat, is about 1,500 feet wide along Central Naton Beach, and is relatively flat with a general relief less than 50 centimeter. Unconsolidated sand and algae sediments vary in thickness from greater than one meter near the beach, to less than 1 centimeter near the outer reef flat. Emery (1962) reported a grain size of .26 millimeter 90 meters from the low-tide level. The deepest water in this zone can be found 150 meters from the shoreline.

The outer reef flat is formed of rocky substrate, with sand collected in depressions. Corals are found in areas that are not exposed during low tide. Rubble and boulders can be found on the outer reef, where wave action has deposited them.

During field data collection, sediment samples from the proposed dredging sites were collected. Locations of the sampling sites are depicited in Figure 2-5. Results of sieve analysis indicate that sediment sizes range from 0.15 millimeter to 25.4 millimeters in diameter. The grain size distribution for four samples are presented in Figures 2-6 and 2-7.

2.2.4 Tides

Measurements of tides at the proposed site have not been conducted although data from the nearest tide gauge at Apra Harbor is considered to be applicable to this study. Tidal

SC3075AB

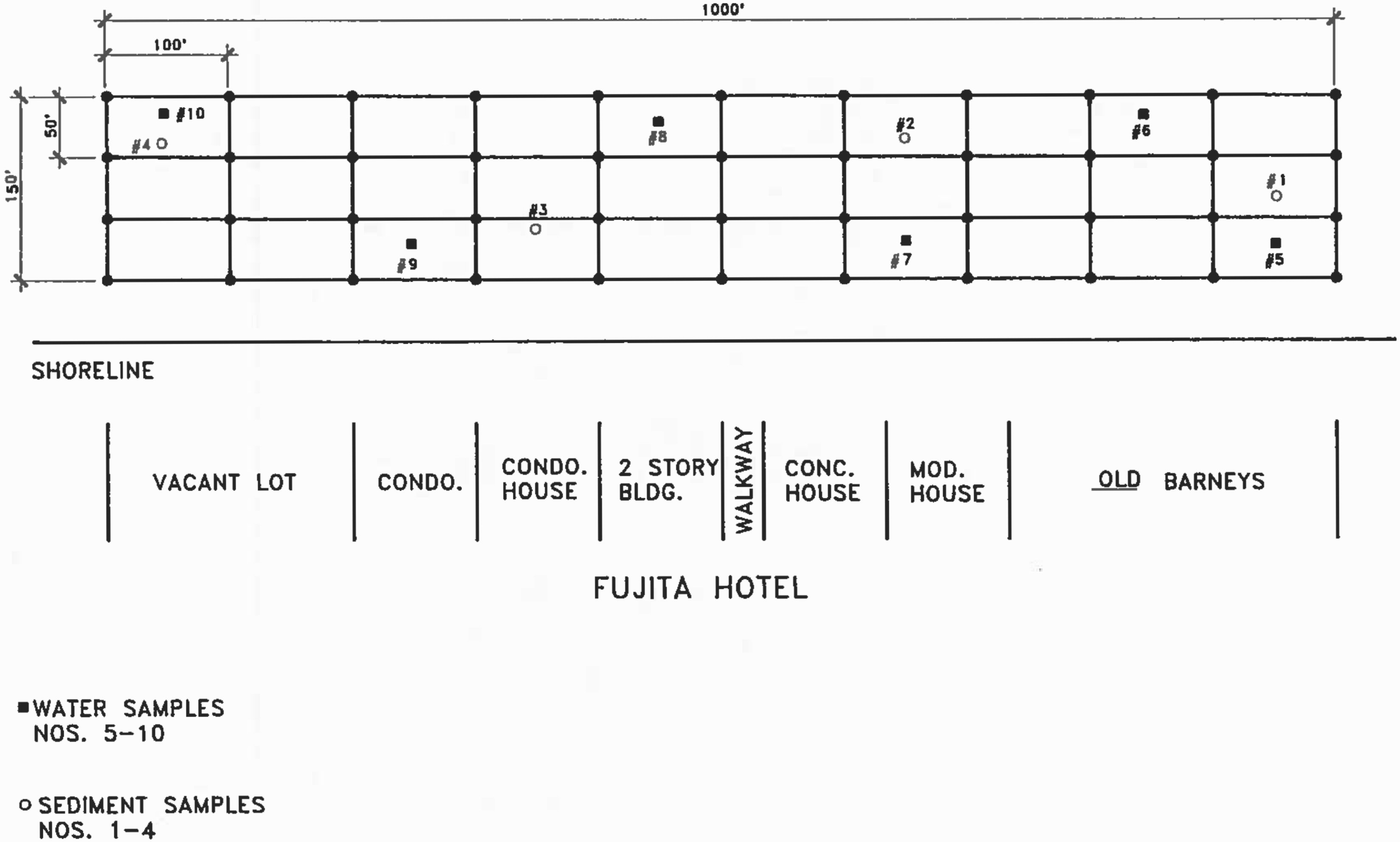


FIGURE 2-5 WATER AND SEDIMENT SAMPLING LOCATIONS

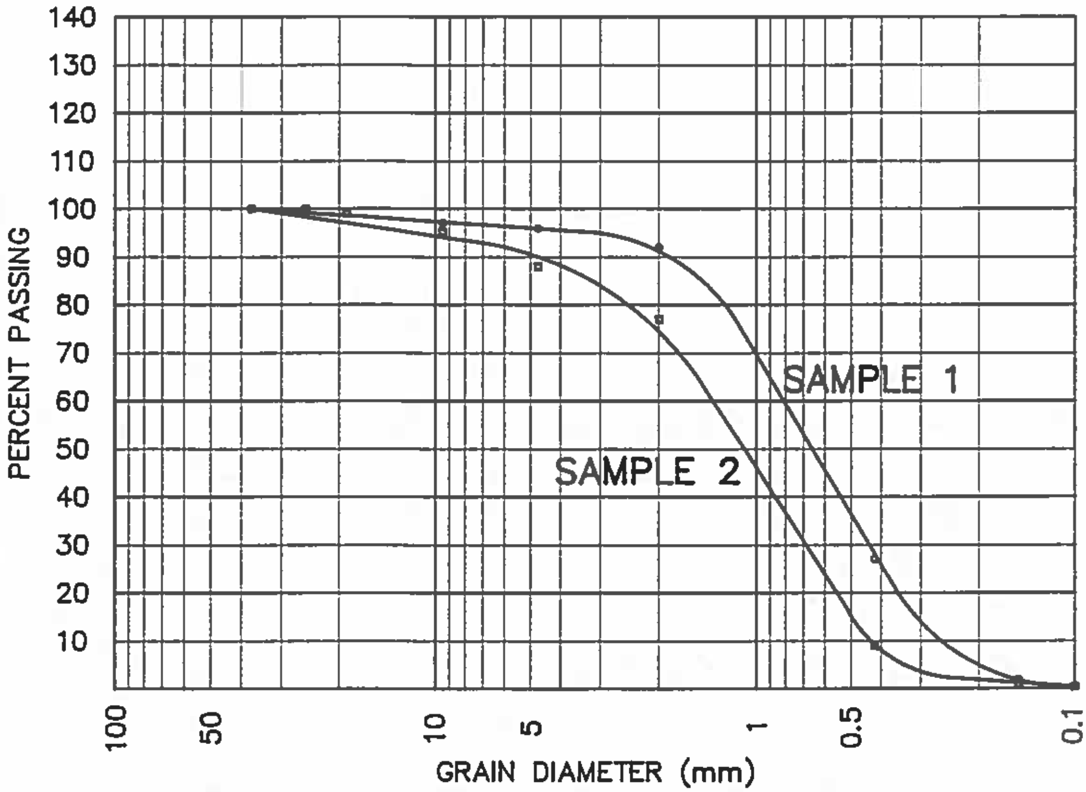


FIGURE 2–6: GRAIN SIZE DISTRIBUTION CURVE

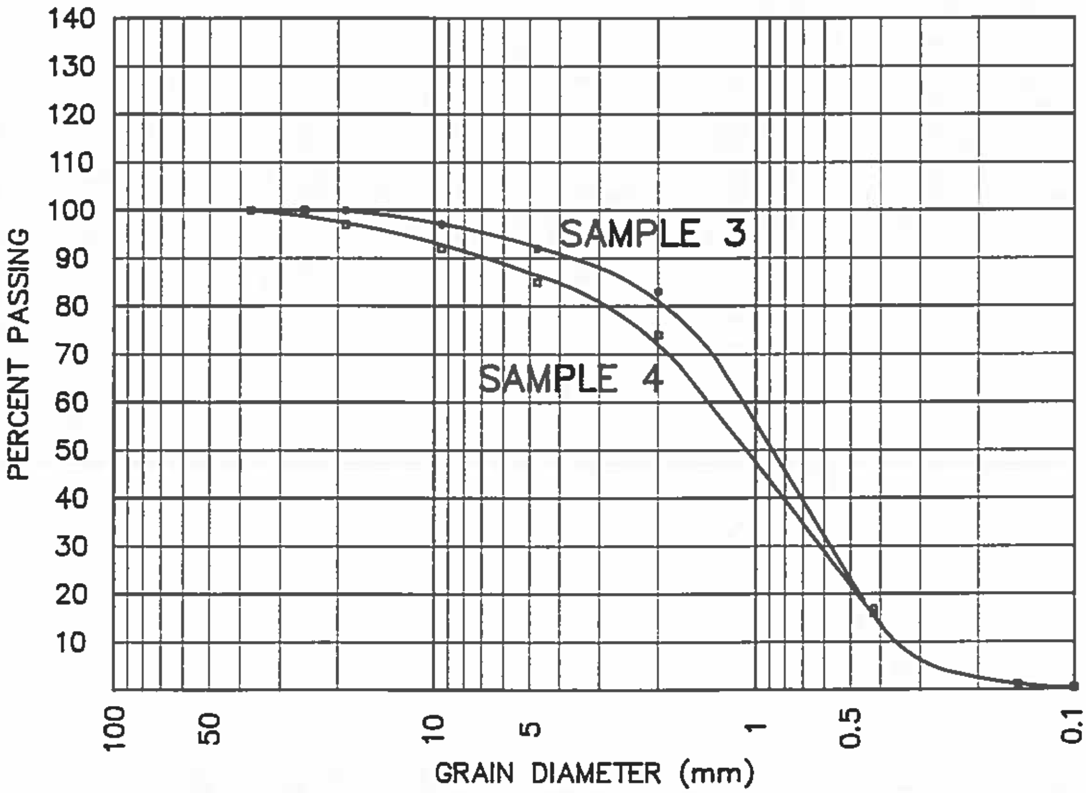


FIGURE 2–7: GRAIN SIZE DISTRIBUTION CURVE

SC3075AA

data collected at Apra Harbor for a 19-year period (1949-1967) is shown in Table 2-3. The mean tide level is 1.45 feet, as compared to the MLLW elevation. (Recorded tide extremes are -1.90 and 3.30 feet.)

TABLE 2-3

TIDAL OBSERVATIONS FOR GUAM

	Feet
Highest tide observed	3.30
Mean higher high water	2.40
Mean high water	2.30
Mean tide level	1.45
Mean sea level	1.40
Mean low water	0.60
Mean lower low water	0.00
Lowest tide observed	-1.90

Note: All elevations in this report are referenced to mean lower low water (MLLW) datum.

2.2.5 Waves

Tumon Bay is sheltered from tradewind-generated waves and is primarily affected by waves produced from local winds. These waves approach the bay from the southwest and exceed heights of 4 feet about 6 percent of the time. Long-period waves break on the outer reef, releasing most of their energy, and go on to reform as smaller, short-period secondary waves in the lagoon. Waves with heights of 0 to 6 inches are commonly observed along the beach during normal conditions. Under storm conditions, waves of 1 to 2 feet can reach the shore, while typhoons have produced inner wave-reef heights of several feet.

2.2.6 Current and Circulation

Most seawater exchange in Tumon Bay is caused by the tides, although wave- and wind-induced currents are also important in the exchange processes. Currents inside the lagoon are induced by great volumes of water, driven by long-period waves, moving over the outer reef. Current studies performed by Randall and Jones (1972-73) and the U.S. Navy (1974) showed that longshore currents along Naton Beach move from the south to the north. Water eventually flushes out of the Bay at San Vitores Channel, north of the Fujita Hotel beach. The general circulation pattern is shown in Figure 2-8.

Average current velocities for the bay have been found to be .2 ft./sec., while the residence time has been estimated to be 2.6 days, using an assumed value of 70 percent for the ebb and flood exchange ratios (Sea Engineering, 1987). Storm conditions have been found to increase current velocities to .7 ft./sec. Marsh, et al. (1981) calculated residence times of 3 to 6 days for the bay. A current study utilizing drogues was conducted to specifically determine currents in the proposed dredging side. The currents were found to be in the northwest direction, with magnitudes ranging from 0.04 to 0.21 fps over the tidal cycle.

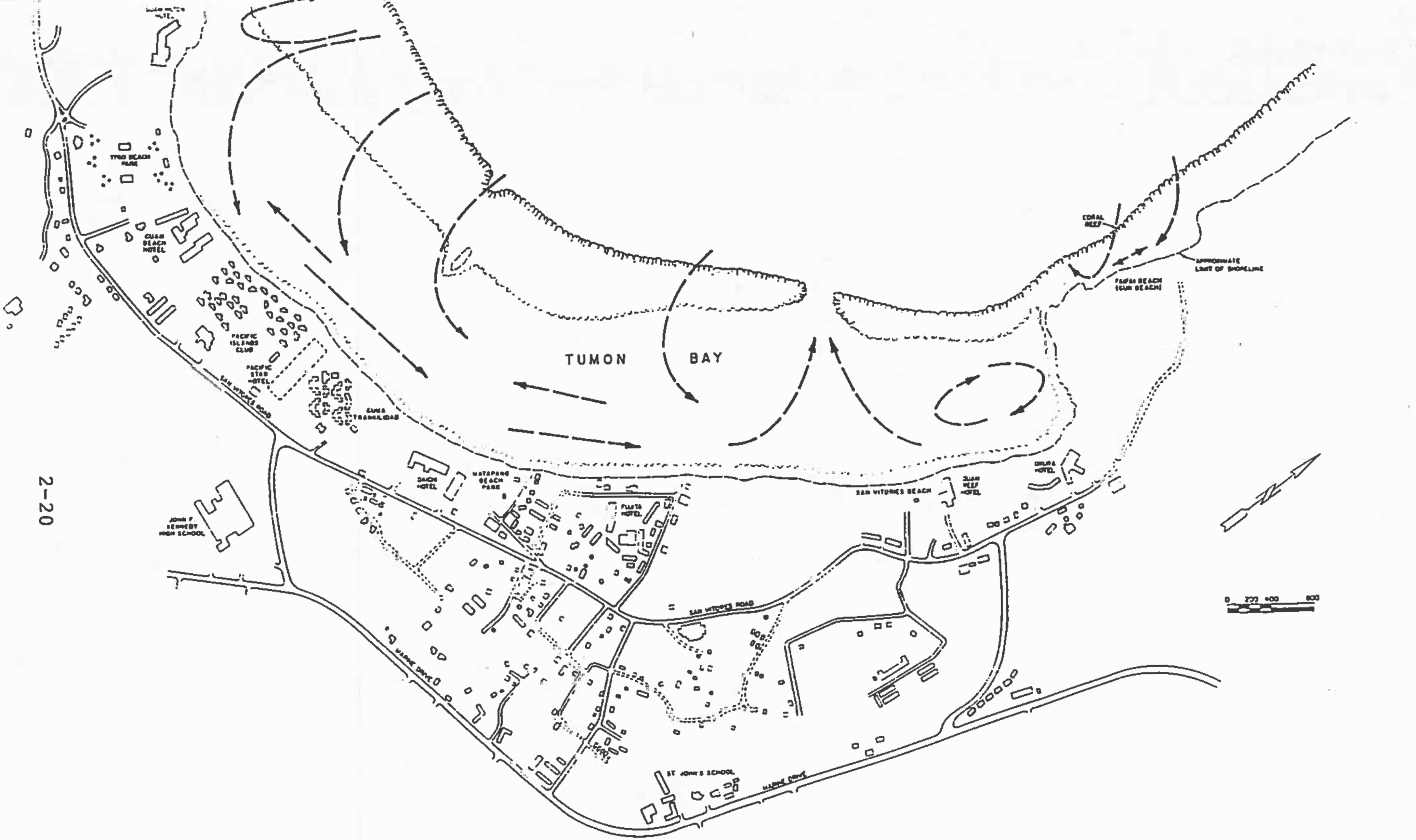


FIGURE 2-8 GENERALIZED WATER CIRCULATION PATTERN IN TUMON BAY

ADOPTED FROM MICRODREDGING OF TUMON BAY DEIS

2.2.7 Sediment Transport

The transport of sediment along beaches is driven by many factors, th emost prevalent being waves, currents, tides and sediment characteristics. In order for a beach to be considered stable, the amount of sediment in a reasonable amount of time. One concern for this study is the slowly eroding beach abutting Fujita Hotel.

Observations conducted by Sea Engineering (October 1987) strived to identify sediment sources and sinks in Tumon Bay. It was found that most sediment is produced by the grinding action of waves on the outer reef flat. Coral, shells, foraminifera, calcareous algae, and reef rock are ground into sand particles. Very little sediment enters the bay via storm drains, or from nearby eroding land. Sediment tends to be deposited along the beach, or in depressions along the outer reef, or among the three swimming holes previously dredged in the bay. Tumon Bay can be described as a closed littoral cell, meaning that, under normal conditions, there is no exchange of sediment sources, and sinks inside the lagoon with sediment sources and sinks outside the lagoon. Only under storm conditions will sediment move out San Vitores Channel to the ocean.

The currents found in the proposed dredging area are not sufficiently strong to lift sediment into suspension without the contribution of wave action. A sediment motion model was developed in the DEIS to theoretically estimate the conditions in Tumon Bay. A plot of initial motion according to particle size, wave height and water depth is shown in Figure 2-9. This plot show that wave height has a greater impact on initiating sediment movement, than does water depth. The plot also shows that, for the average water depth of 1.5 feet found in the proposed dredging area, very small waves are capable of setting the sediment in motion. For depths greater than 3 feet, the minimum wave height is 0.4 feet for sediment motion.

2.2.8 Water Quality

Most of the water quality studies on Tumon Bay have been conducted in the 1970's. Results from these studies, as well as that of a specific analysis conducted on samples taken at the proposed dredging site, are presented in this section.

Clayshulte and Zolan (1976) reported a mean salinity value of 32 ppt in Tumon Bay. Salinity levels between 31 and 32 were found 5 to 10 meters from the shoreline and increased to between 32 and 34 ppt 10 to 50 meters from the shoreline. Lower salinity levels along the shoreline were determined to be caused by freshwater seepage in this area.

Freshwater seepage is also thought to produce the high nutrient levels and low phosphorus levels found in the bay. James Marsh (1977) reported a mean nitrate concentration of

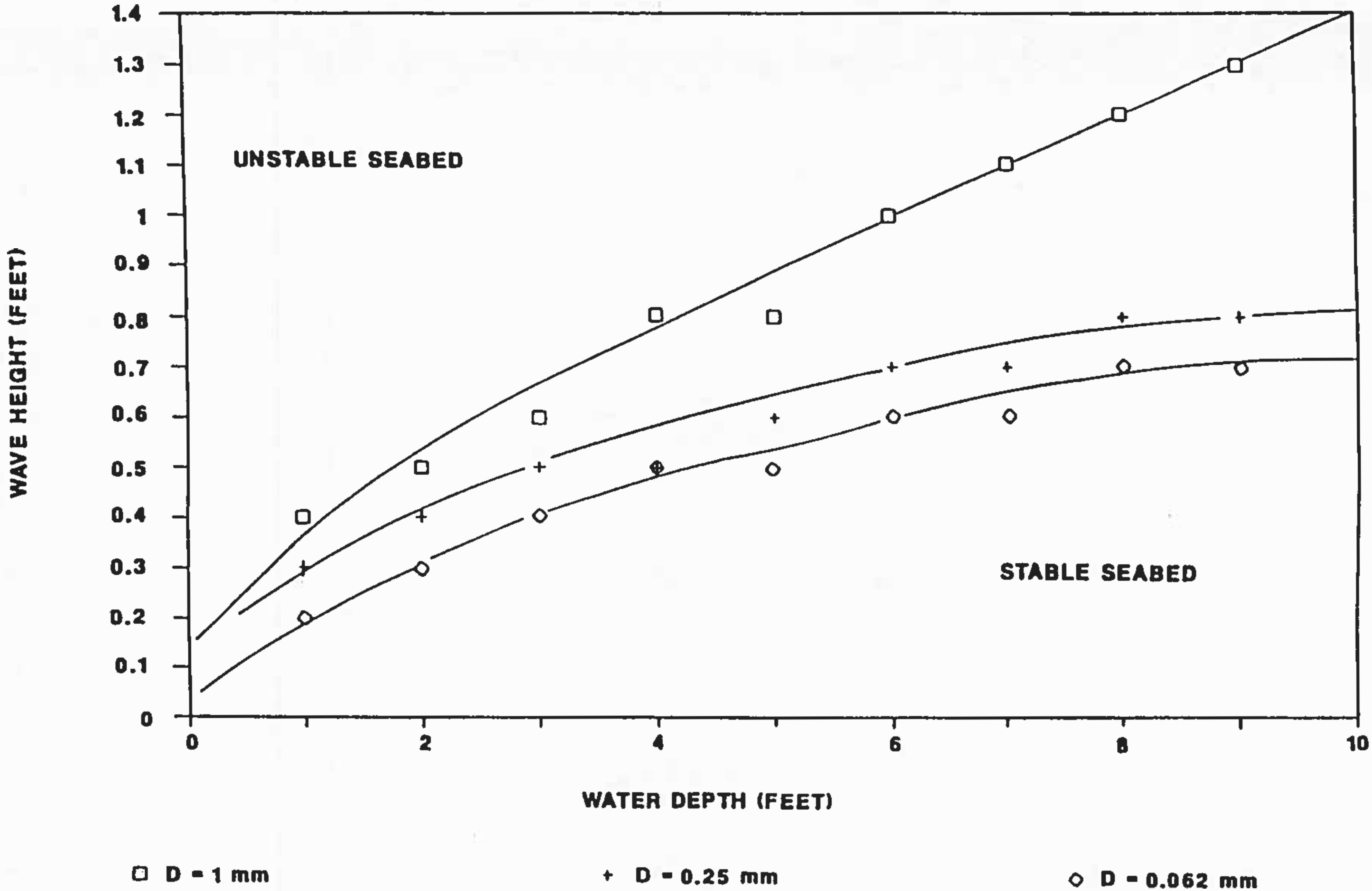


FIGURE 2–9 INITIAL SAND MOTION

ADOPTED FROM MICRODREDGING OF TUMON BAY DEIS

.008 mg/l and a reactive phosphorus concentration of approximately .02 mg/l for the bay.

Turbidity in Tumon Bay has only been measured in a few studies. Clayshulte and Zolan (1976) found turbidity levels of less than 1 NTU in the vicinity of Pacific Island Hotel. In order to describe the present status of water quality in the vicinity of the proposed dredging site, a series of water samples were collected and analyzed by GMP Associates in 1990. Results of this analysis are shown in Table 2.4.

2.2.9 Marine Flora and Fauna

Several studies of the marine life in Tumon Bay have been performed since 1970. The first few studied the crown-of-thorns starfish infestation in 1971 and its impact on the coral population. Subsequent reports have been prepared for specific purposes and for general study of the bay. Included in the specific reports was an environmental baseline study supporting the Hilton Hotel swimming area dredging proposal. The Department of Agriculture, Division of Aquatic and Wildlife Resources, conducts periodic surveys of fishing harvest and activity in the bay.

A comprehensive overview of the marine life in Tumon Bay is presented in the Draft EIS from 1988. Three of the transects used in this study are located directly in front of the Fujita Hotel, in the nearshore/intertidal zone, the inner reef flat and the outer reef flat, respectively. The results

TABLE 2-4

WATER QUALITY DATA

Sample No.	Conductivity (umhos cm x 10,000)	Nitrate (N03-N) (mg/l)	pH (standard units)	Phosphorus Ortho P-04-P (mg/l)	Salinity (0/00)	Turbidity (NTU)
5	4.97	0.090	9.10	0.001	35	0.54
6	4.92	0.078	8.26	0.001	35	0.33
7	4.89	0.095	8.17	0.001	35	0.39
8	4.87	0.133	8.18	0.002	35	0.33
9	4.93	0.084	8.23	0.002	35	0.60
10	4.83	0.157	8.04	0.003	34	0.50

of surveying these transects and three others in front of Dai-Ichi Hotel are presented in Tables 2-5 through 2-8. The three zones are very different biologically, as can be seen from the tables. The outer reef flat is the lushest of the three zones. This zone is exposed to the cooler, richer water of the open ocean, which provides a better environment for plants and corals, thus, attracting fish and other animals. The inner reef flat is home to more plants than corals. The warmer water in this area is less condusive to corals. The nearshore/intertidal zone where the microdredging will take place, is the least rich biologically.

The entries in the tables indicating that the species has been noted in literature, but not found during the most recent survey, do not necessarily indicate that the diversity of life in the bay has decreased. The surveying technique can affect the species observed. The time of day, location of transects, season of the year and tidal phase, all affect the outcome of the survey. Fish and macroinvertebrate behavior varies during the day, and plants have growth and dormant seasons, so these will be more or less visible, depending on the timing of the survey.

The nearshore/intertidal zone is the most important zone to study, because it will be directly impacted by the dredging activities. Tidal action is most noticed in this zone, as the water is always very shallow. This area is the least favorable to living organisms, because of the shallow water, which becomes very warm, and the sandy bottom. Corals

TABLE 2-5

MARINE PLANTS OF CENTRAL TUMON BAY

Division Species	Nearshore/ Intertidal Zone	Inner Reef Flat Zone	Outer Reef Flat Zone
CYANOPHYTA			
Microcoleus lyngbyaceus	X	X	
Schizotrix calciocola	X	X	
Schizothrix mexicana	C	O	O
CLOROPHYTA			
Avrainvillea lacerata		X	O
Boodlea composita	O	O	O
Bryopsis pennata		X	X
Caulerpa recemosa		X	
Caulerpa sertularioides		O	O
Chlorodesmis fastigiata		X	
Dictyosphaeria versluysii		X	
Entermorpha clathrata	C	O	O
Halimeda opuntia	C	C	C
Neomeris annulata		X	
Rhizoclonium samoense		X	
Valonia ventricosa		X	
PHAEOPHYTA			
Dictyota bartayresii	C	X	C
Feldmannia indica	O	O	
Gracilaria sp.		O	O
Lobophora variegata		X	
Padina tenuis	X	O	C
Sargassum cristaefolium		C	O
Sargassum polycyctum		X	X
Sphacelaria trubuloides		X	
Turbinaria ornata			X
RHODOPHYTA			
Acanthophora spicifera		X	
Amphiroa fragilissima		X	
Dasyphila plumarioides		X	
Galaxaura clavigera		X	
Galaxaura fasciculata		X	
Gelidiella acerosa		X	
Gelidiopsis intricata		X	
Gelidium pusillum		X	

TABLE 2-5, (Continued)

MARINE PLANTS OF CENTRAL TUMON BAY

Division Species	Nearshore/ Intertidal Zone	Inner Reef Flat Zone	Outer Reef Flat Zone
RHODOPHYTA, (Continued)			
Gracilaria arcuata		X	
Hypnea esperi		X	
Hypnea pannosa	O	X	
Jania capillacea		X	
Laurencia sp.		X	
Tolypiocladia glomerulata		X	
"crustose coraline"		X	
ANTHOPHYTA			
Halophila minor		X	
Total Genra for each Zone	9	32	13
Total Species for each Zone	10	39	14

Abbreviations:

A - Abundant
C - Common
O - Occasional
R - Rare
X - Noted in literature

TABLE 2-6

MACROINVERTEBRATES OF CENTRAL TUMON BAY

Taxa Species	Nearshore/ Intertidal Zone	Inner Reef Flat Zone	Outer Reef Flat Zone
GASTROPODA			
Trochus niloticus			X
ASTEROIDEA			
Culcita novaeguineae			X
Linckia laevigata			X
OPHIUROIDEA			
Ophiocoma sp. 1			X
ECHINOIDEA			
Echinometra mathaei		X	X
Echinothrix diadema		X	X
HOLOTHOROIDEA			
Stichopus choloronotus		X	X
Stichopus horrens		X	X
Actinopyga echinites		X	X
Bohadschia arqus		X	X
Holothuria atra	X	X	X
Holothuria hilla	X	X	X
Holothuria leucospilota	X	X	X
Synaptid sp.		X	X
Total Genra for each Zone	1	2	5
Total Species for each Zone	3	10	15

X - Noted in literature

PROJECT DETAILS

TABLE 2-7

CORALS OF CENTRAL TUMON

Taxa Species	Nearshore/ Intertidal Zone	Inner Reef Flat Zone	Outer Reef Flat Zone
CLASS-ANTHOZOA			
ORDER-SCLERACTINIA			
SUBORDER-ASTROCOENINA			
FAMILY - THAMNASTERIIDAE			
Stylocoeniella armada			X
FAMILY - THAMNASTERIIDAE			
Psammocora contiqua			X
Psammocora stellata			X
Psammocora sp.			
FAMILY - POCILLOPORIDAE			
Seriatopora hystrix			X
Pocillopora damicornis	R	O	C
Pocillopora danae		X	X
Pocillopora setchelli		X	X
FAMILY - ACROPORIDAE			
Acropora acuminata		X	X
Acropora aspera		R	O
Acropora humilis			X
Acropora hystrix			X
Acropora irregularis			X
Acropora azurea			X
Acropora nasuta			X
Acropora squarrosa			X
Acropora surculosa			X
Acropora valida			X
Astreopora myriophtalma			X
Montipora hoffmeisteri			X
Montipora lobulata			X
Montipora verrilli			X
Montipora sp.			X

TABLE 2-7 (Continued)

CORALS OF CENTRAL TUMON

Taxa Species	Nearshore/ Intertidal Zone	Inner Reef Flat Zone	Outer Reef Flat Zone
SUBORDER - FAVIINA			
FAMILY - FAVIIDA			
Favia favus		X	X
Favia pallida		X	X
Favia Stelligera		X	X
Favites viren			X
Goniastrea edwardsi		X	X
Goniastrea retiformis		X	x
Platygyra pini		X	
Leptoria phyryqia			X
Diploastrea heliopora		X	X
Leptastrea bottae			X
Leptastrea purpurea			X
Cyphastrea serailia			X
FAMILY - OCULINIDA			
Galaxea fascicularis			X
FAMILY - MUSSIDAE			
Lobophyllia hemprichii			X
Acanthastrea echinata			X
SUBORDER - FUNGIINA			
FAMILY - AGARICIIDAE			
Pavoda decussata		X	X
Pavona divaricata		X	X
Pavona varians			X
Pavona (Polyastra) obtusata			X
Pavona (Polyastra) venosa			X
pavona (polyastra) sp.			X
FAMILY - PORITIDAE			
Goniopora arbuscula			X
Goniopora tenuidens			X
Porites annae			X

TABLE 2-7 (Continued)

CORALS OF CENTRAL TUMON

Taxa Species	Nearshore/ Intertidal Zone	Inner Reef Flat Zone	Outer Reef Flat Zone
FAMILY - PORITIDAE (Continued)			
Porites australiensis			X
Porites cyclindrica		O	O
Porites ichen			X
Porites lobata			X
Porites lutea		C	C
Porites murrayensis			X
Porites superfusa			X
Porites (Massive sp. 1)		X	X
Porites (Synaraea) convexa		X	X
Porites (Syunaraea) iwayamaenisis		X	X
Porites (Synarae) vaughani		X	X
Stlaraea pucntata			X
SUBORDER - CARYOPHYLLIINA			
FAMILY - CARYOPHYLLIIDAE			
Polycyachus verrilli			X
ORDER - COENOTHECALIA			
FAMILY - HELIOPHORIDAE			
Heliopora coerulea			X
CLASS - HYDROZOA			
ORDER - MILLERPORINA			
FAMILY - MILLEPORIDAE			
Millepora tuberosa			X
Millepora platyphylla			X
ORDER - STYLASTERIDAE			

TABLE 2-7 (Continued)

CORALS OF CENTRAL TUMON

Taxa Species	Nearshore/ Intertidal Zone	Inner Reef Flat Zone	Outer Reef Flat Zone
FAMILY - STYLASTERIDAE			
Distochopora gracillis			X
Total Genra for each Zone	1	12	23
Total Species for each Zone	1	19	64

Abbreviations:

C - Common
O - Occasional
R - Rare
X - Note in Literature

TABLE 2-8

FISHES OF CENTRAL TUMON BAY

Family Species	Nearshore/ Intertidal Zone	Inner Reef Flat Zone	Outer Reef Flat Zone
ACANTHURIDAE (Surgeonfishes)			
A. triostegus		X	
Ctenochaetus striatus			X
ATHERINIDAE (Silversides)			
Unidentified silversides			C
APOGONIDAE (Cardinalfishes)			
Apogon novemfasciatus	X	X	O
Cheilodipterus quinqulineatus	X		A
BALISTIDAE (Triggerfishes)			
Rhinecanthus aculeatus	X	X	
BLENNIDAE (Blennies)			
Plagiotremus tapeinosomo		X	
Unidentified Blennies	X	X	X
CHAETODONTIDAE (Butterflyfishes)			
Chaetodon auriga			R
C. lunula			R
FISTURAIIDAE (Coronetfishes)			
Fistularia commersonii	R		
GOBIIDAE (Gobies)			
Amblygobius	R	O	
Unidentified gobies	O	C	O
Ctenogobiops sp.	C	C	O

TABLE 2-8 (Continued)

FISHES OF CENTRAL TUMON BAY

Family Species	Nearshore/ Intertidal Zone	Inner Reef Flat Zone	Outer Reef Flat Zone
HOLOCENTRIDAE (Squirrelfishes)			
Flammeo sp.	X	X	X
LABRIDAE (Wrasses)			
Halichoeres margaritaceous		X	X
H. trimaculatus	X	X	C
Stethojulis bandanesis		X	X
T. quinquevittatum			X
MUGILIDAE (Mullet)			
Unidentified mullet	A		
MULLIDAE (Goatfishes)			
Mulloidichthys flavolineatus		X	
Parupeneus barberinus	X	X	
P. trifasciatus		X	
NEMIPTERIDAE (monocle Breams)			
Scolopsis cancellatus		X	O
POMACENTRIDAE (Damselfishes)			
Chrysiptera glaucus		X	
C. leucopomus		X	X
Daseyllus aruanus		X	C
Pletroglyphidodon dickii		X	
P. leucozonus	X	X	
P. lacrymatus		X	
Pomacentrus pavo			R
Stegastes albifasciatus	X	X	X
S. fasciolatus			X
S. nigricans		X	R

TABLE 2-8 (Continued)

FISHES OF CENTRAL TUMON BAY

Family Species	Nearshore/ Intertidal Zone	Inner Reef Flat Zone	Outer Reef Flat Zone
SCARIDAE (Parrotfishes)			
Scarid juveniles		X	X
IGANIDAE (Rabbit fishes)			
Siganus argenteus	X	X	X
S. spinus	X	X	X
YNGNATHIDAE (Pipefishes)			
Corythoichthys sp.			X
Unidentified syngnathids		X	
ETRAODONTIDAE (Smooth Puffers)			
Canthigaster solandri	R	R	
C. valentini		X	
ANCLIDAE (Moorish Idols)			
Zanclus cornutus			R
Number of Families per Zone	12	14	14
Number of Species per Zone	17	29	27

Abbreviations:
A - Abundant
C - Common
O - Occassional
R - Rare
X - Noted in literature

need a hard surface to attach themselves and are very sensitive to slight changes in water temperature. Without the coral, many fish and macroinvertebrates have no shelter and will not remain in the area. Therefore, the lack of corals, fish and macroinvertebrates is due to the natural conditions, not human interference. The only macroinvertebrates ever found here are sea cucumbers. The most noticeable plant in this zone is the algae, Enteromorpha clathrata, which is considered a nuisance by hotel owners, because it makes the beach less attractive to tourists. Ironically, this algae is the favorite food of the juvenile rabbitfish, manahac.

Fishing has been popular in Tumon, though the fishermen are apparently being forced out by the increasing tourist population. Tumon Bay is an important nursery area for juvenile fish, because the protected, shallow waters keep larger predator fish outside the reef. The moat feature, a deeper area in the inner reef flat, is an important fish habitat. The recent decision to set Tumon Bay off as a marine preserve will continue the trend that has reduced fishing and allowed the fish population to increase.

No threatened, endangered or rare organisms have been found to inhabit Tumon Bay, nor are any expected. The marine environment of the bay is not naturally favorable for the sea turtles or giant clams, which are usually found in the open ocean.

SECTION 3

PROJECT DETAILS

3.1 MICRODREDGING

The proposed plan calls for a 1,000-foot by 150-foot area, located directly in front of Fujita Hotel, to be dredged over a two-month work schedule. The landward boundary of the dredging site will begin 50 feet from the MLLW mark to preserve the natural slope of the beach and to preserve the delicate moat region that serves as an important fishery for the bay. Dredging would entail of removal of 3 feet of sand and substrate material to an average finish depth of -4.5 feet below the MLLW.

The bathymetry and sediment depth for the proposed dredging area have been surveyed. Based on these measurements, the estimated amount of sediment to be dredged is 18,033 cubic yards. The additional volume contributed by dredging is less than two percent of volume of the bay. Consequently, there will be no appreciable increase in the bay's residence time.

Shallowness of the bay may prevent use of hydraulic dredging equipment, since certain amount of submergence or water pressure is required for this type of operation. An alternative method is mechanical methods, which are suitable for shallow water dredging, as well as for penetration in hard substrate. The dredged material will then be suspended and pumped to the settling basins specially designed for dewatering of the spoils. Care will be taken to prevent undercutting of the beach in order to maintain the natural beach slope of 6 to 10 percent. The proposed dredging site will be divided into five separate zones, each covering a 200 by 150-foot area. Turbidity will be controlled by placement of a silt curtain around each zone as it is dredged. Once a zone has been dredged, the curtain will remain in place until turbidity drops to acceptable levels. A schematic of the dredging and desilting operation is shown in Figure 3-1. Similar dredging projects in Tumon Bay that have utilized silt curtains to impede sediment movement have curtailed any increase in ambient turbidity levels in surrounding water.

The settling basins will be located near the center of the dredge area, on Fujita Hotel property. The two basins each will be 65 feet square at the base and 5 feet deep. They will be excavated 2.5 feet below the existing ground level and berms built up with the excavated material. The maximum water surface level will be 4 feet to prevent overtopping of the berms. The berms will be covered with plastic sheeting to prevent seepage and erosion. The floor of the basins will be left uncovered, so that the ocean water can percolate through the ground. In addition, perforated pipe with a geotextile casing ("sock") will be laid on the floor of the basins as a drain line. The sock will prevent sediment from entering the pipe, but still allow water to pass through. There is very little fine material based on the sample analysis, so the risk of clogging the geotextile is very slight. By placing the

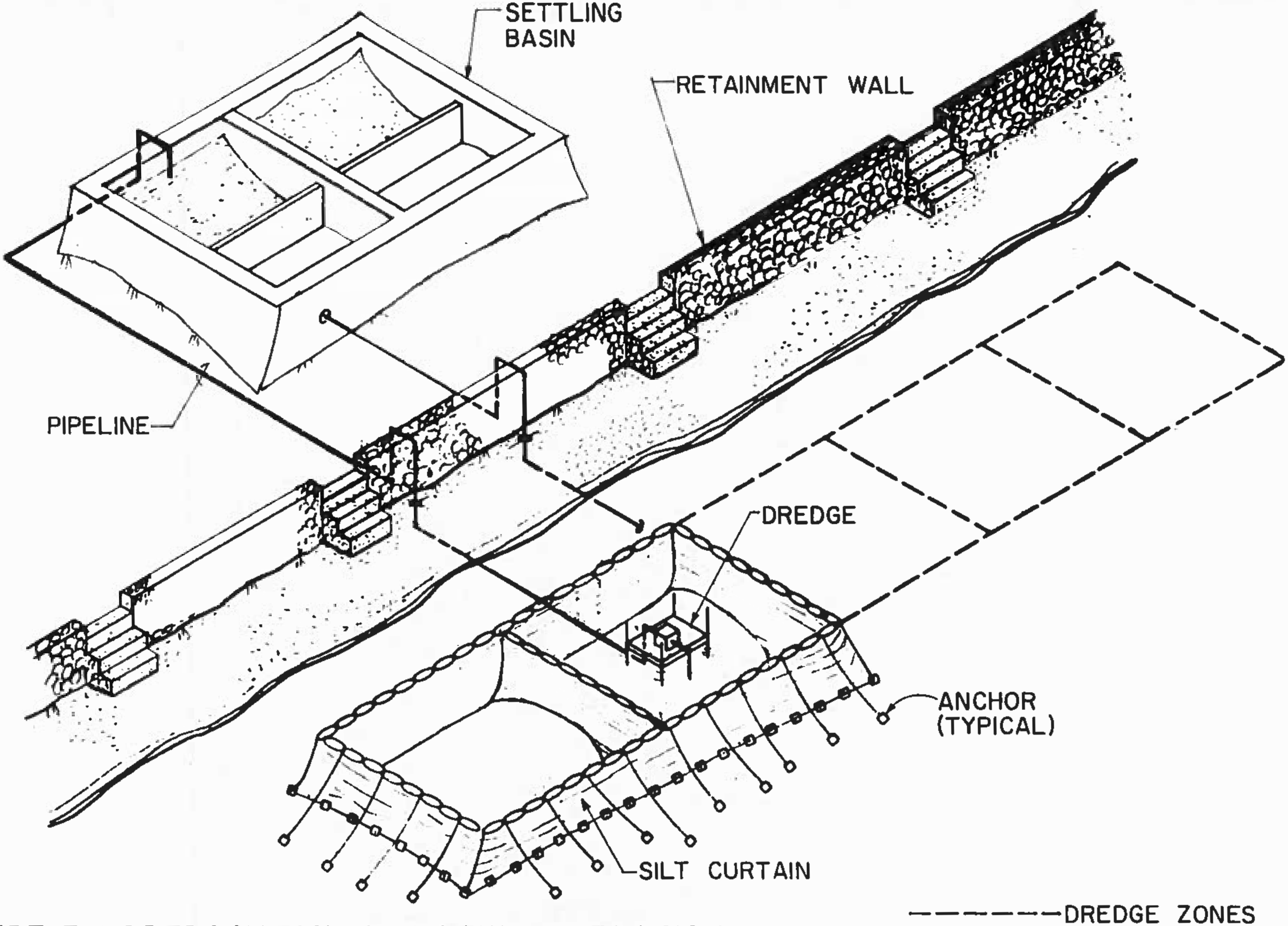


FIGURE 3-1: DREDGING AND DESILTING OPERATION

drain line on the floor of the basin, the basin will act like a sandfilter, rather than a standard settling tank, and the risk of short-circuiting is eliminated. A discharge pipe at a higher level would allow the possible discharge of water containing fine particles that had not been able to settle out sufficiently.

Alternating use of the two basins is planned. The first basin will be filled to its maximum water level by the dredge. When full, the discharge pipe will be switched to the second basin. The first basin will drain as the second one fills. Draining of the excess water is expected to take longer than filling the other basin, so short interruptions to the dredging is anticipated. The dredging is expected to yield approximately 20 percent sand from the total volume dredged. With the rapid drainage capacity of uniform sands, the excess water will drain quickly, leaving a large volume available for the next dredging period. In this manner, the settling basins can be used for an entire day. An estimated 18,200 cubic feet of sand can be collected in 6.5 hours of dredging time.

After allowing the sand to drain overnight, the collected sediments should be manageable. The settled material will be removed from the basins carefully to avoid damaging the drain pipes. Coarse sieving to remove the gravel and larger size spoils shall be performed at this stage. Larger granular material can be ground up to be ultimately used for beach restoration. Upon washing the sand and fine material for elimination of possible bio-containments, they will be ready for beach nourishment. Unusable spoils shall be disposed at an approved up-land site. Since there will be construction activity at the Fujita Hotel during the proposed dredging operation, it is likely that an on site use for sand and spoils can be found.

Impacts of dredging on circulation in the Bay is predicted with the aid of a computer model described in the next section.

3.1.1 Circulation Model

As discussed previously, circulation pattern in Tumon Bay is mainly forced by long-period waves and tides. Even though the wind-induced currents are also important in the process, currents within the embayment are induced by the volume of water, driven by long-period waves, moving over the outer reef

A computer model was developed to simulate circulation pattern in Tumon Bay and, therefore, determine the impact of dredging on the current structure. The shallow water finite-difference model describes long-period waves forcing the ocean boundary of the bay. The model is based on time-stepping long wave, frictionless, shallow water equations. The partly linearized shallow water equations are solved by finite difference method and Richardson scheme.

The variables computed are water level, W, from the undisturbed surface and the components of velocity (U,V) in a two-dimensional grid system. The velocity grids are interlaced in space with the water level grid, so that on each grid line in the Y-direction, a V grid point lies between two W grid points, and on each grid line in the X-direction, a U grid point lies between two W grid points. Because of this, all space differences of the variables are central differences. Likewise, in time derivatives, the velocities and water levels are calculated at alternate half-time steps. In the linear part of the equations, which actually dominates the process in our case, the time differences are all central differences. For this reason, the calculations are stable if the time-step selected is small enough to satisfy the well-known stability criterion for hyperbolic equations. Presumably, the calculations should also be accurate approximations to the continuous case, since differences in time and space are central differences.

An orthogonal grid system was chosen, which represented the bay geometry as realistically as possible. The bay was divided into a square grid system consisting of 17x47 squares with sides of 200 feet. The time step used in the model that satisfied the convergence criteria was 2.5 seconds. In the case of coastlines, there was no volume transport through these boundaries, and they were represented by corresponding velocity components equal to zero. The open ocean boundary of the model was provided with a time-dependent velocity, as determined from the existing data.

Once calibration of the model was completed, it was used to simulate circulation in the bay before and after the proposed dredging. Circulation pattern in Tumon Bay 8 minutes after flood tide, as simulated by the model is shown in Figure 3-2. The pattern is in general agreement with measurements and observations reported in other studies. Any minute discrepancies are attributed to linearization of governing equations, elimination of friction terms and lack of detailed bathymetric data for the entire bay.

Results of a similar simulation after implementation of the proposed dredging scheme is presented in Figure 3-3. Comparison of the last two figures show that dredging the bay at the extent proposed has no significant impact on alteration of the circulation pattern in the bay.

As a result of dredging, current velocities in the dredged area will decrease by almost 40 percent. This reduction, in turn, may be adequate to further reduce beach erosion.

It must be pointed out that the dredged area will act as a new sink for the area of the bay in its immediate vicinity and will eventually fill back.

The proposed dredging, in addition to its effect on reduction of current velocities and, therefore, dimunition of beach erosion, will provide an attractive swimming area. The proposed site will have a depth of 4.5 feet during low tide and 6.5 to 7 feet during high tide.

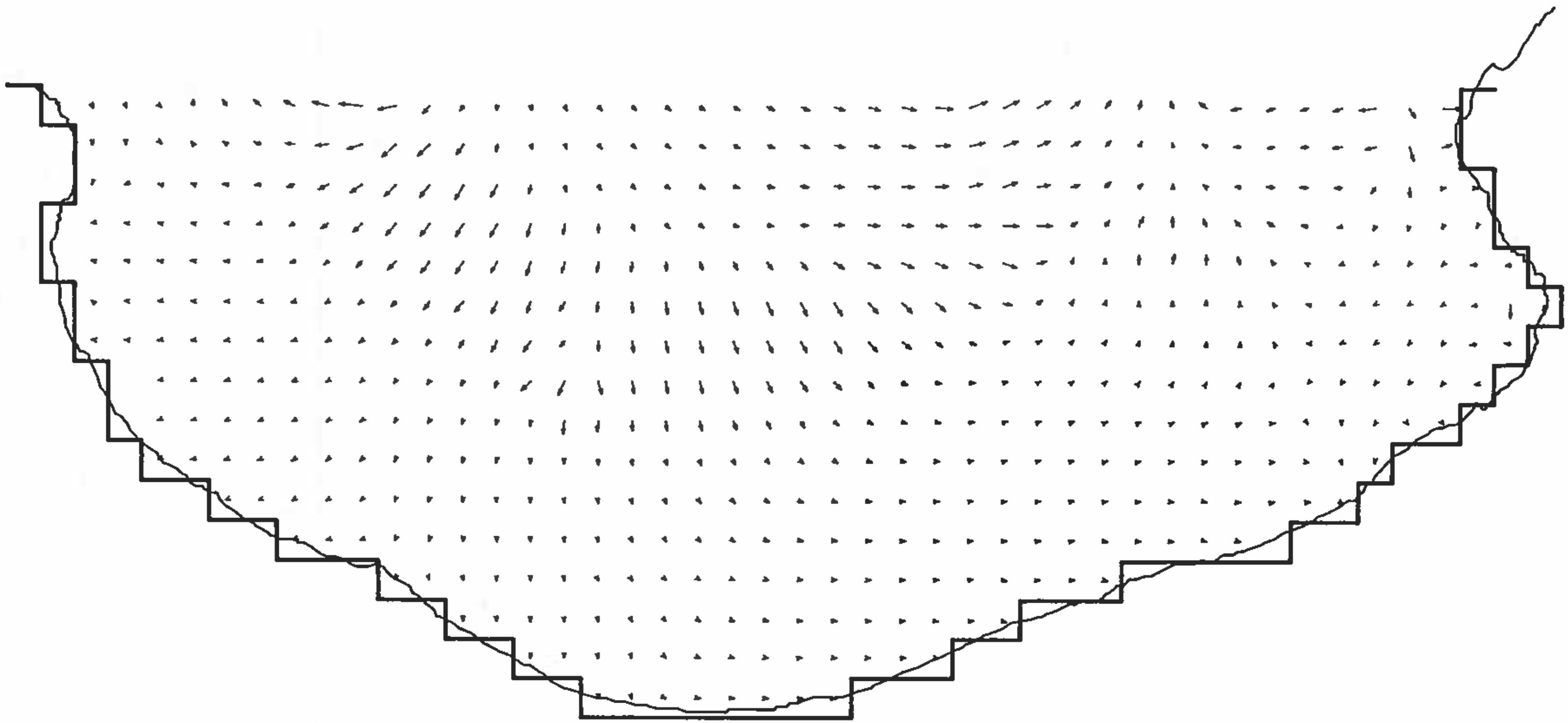
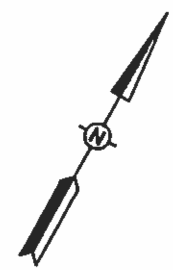
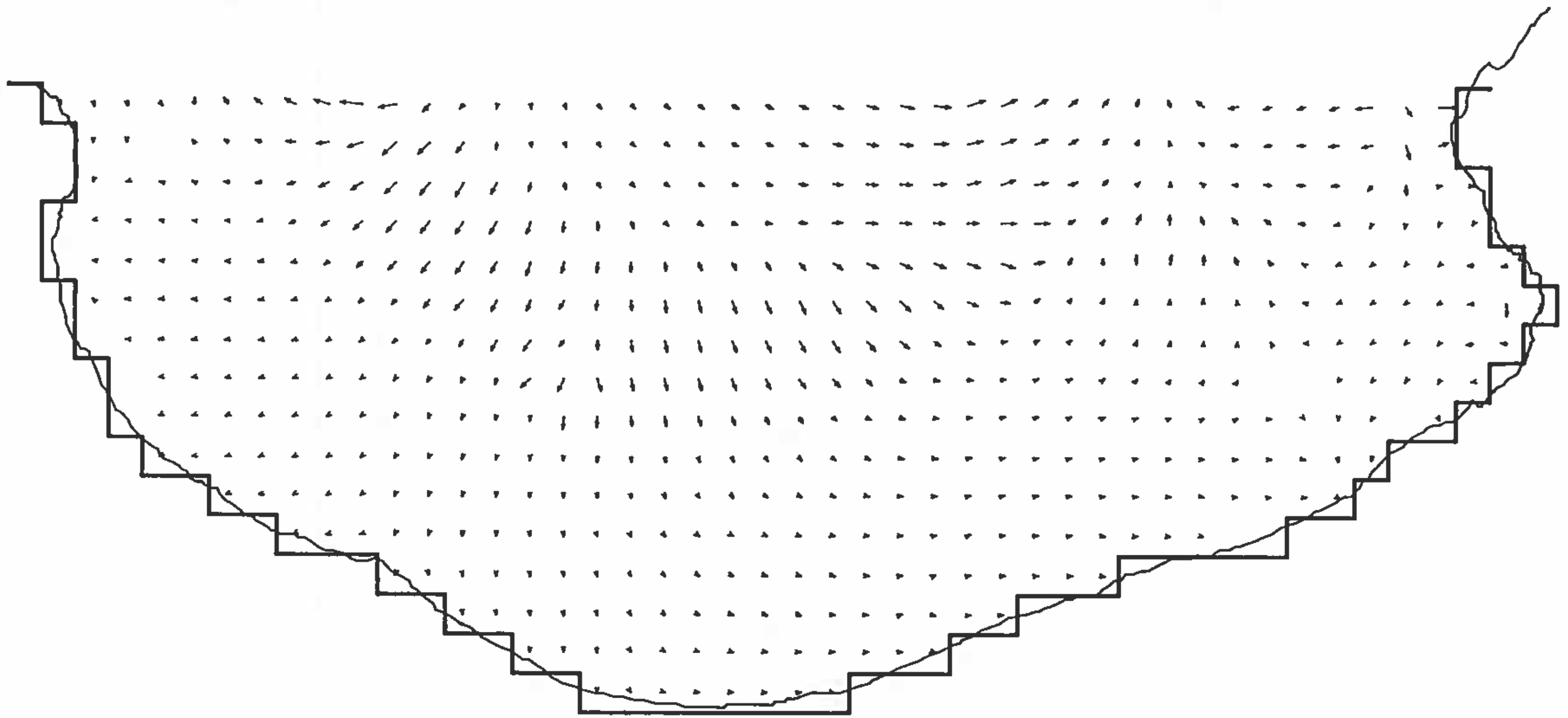


FIGURE 3-2: CIRCULATION IN TUMON BAY, 8 MIN. AFTER FLOOD – BEFORE DREDGING





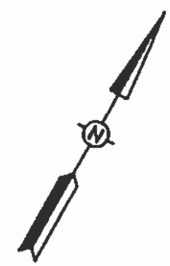


FIGURE 3–3: CIRCULATION IN TUMON BAY, 8 MIN. AFTER FLOOD – AFTER DREDGING

Fish, marine plants, microinvertebrates and coral are expected to reestablish themselves sometime after the dredging is completed. The dredged area will attract fish because of the increased depth and relatively cooler water. Furthermore, as a result of dredging an excavation of hard pavement, the area may prove to be and improved habitat for coral growth. The recolonization process could be further enhanced by artificial introduction of marine flora and fauna in the area.

3.2 SEAWALL

A 3-foot high, natural-looking retaining wall is proposed to be constructed along the Fujita Hotel property line. The wall will be running 1,000 feet long parallel to the vegetation line and approximately 15 feet landward of the MHHW. At every 200 feet along the wall, steps will be incorporated into the wall design to provide beach access from Fujita's lower lawns. The purpose of the seawall is to prevent further erosion of Fujita Hotel's property caused by breaking storm waves. The plan and cross section of the proposed seawall are shown in Figure 3-4. After completion of seawall construction, the land side of the wall shall be back filled to existing property's grade and planted with compatible vegetation.

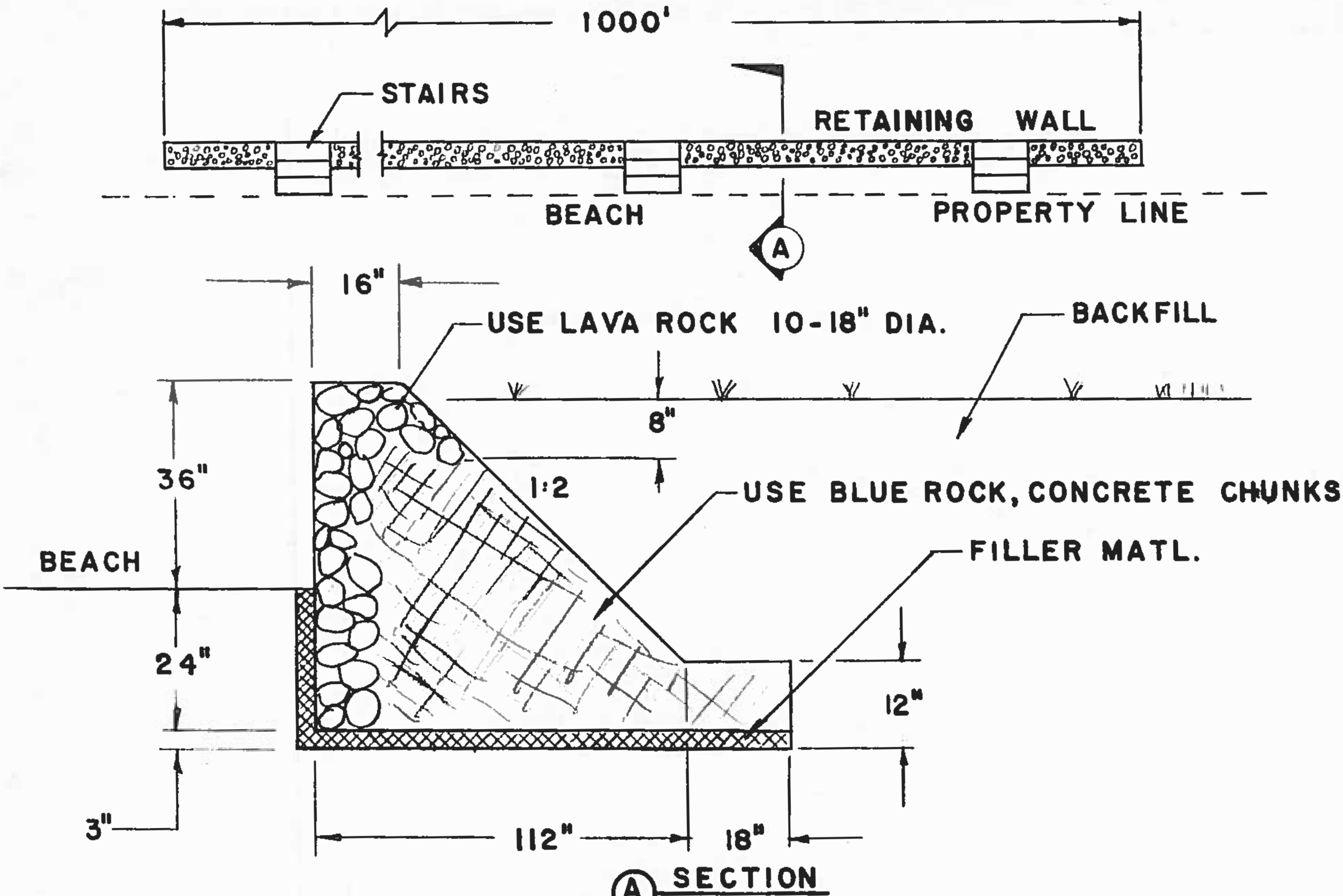


FIGURE 3-4: SEAWALL, PLAN & CROSS-SECTION

EVALUATION OF ALTERNATIVES

SECTION 4

EVALUATION OF ALTERNATIVES

The impacts of the proposed dredging and its alternatives are discussed in this section.

4.1 POSITIVE IMPACTS

The proposed dredging project will have several positive impacts for the area.

1. Reduced Wave Energy: The deeper area resulting from microdredging will reduce the energy of the waves approaching the shore. This will decrease the eroding action of the waves on the beach.
2. Beach Stability: The dredging will result in less erosion of the beach sand. In addition, the placement of dredged sand on the beach to replace that which was previously eroded. The resulting beach will be more stable in the future.
3. Improved Habitat: The dredged area will be significantly deeper than the surrounding water, because the original reef flat is very shallow. The deeper water will attract fish, because of the depth, especially during low tides and the cooler water. By excavating the hard pavement,

the dredged area may be a better habitat for coral growth.

4. Improved Human Enjoyment: A frequent complaint from visitors to Tumon Bay is that they were unable to have sufficient "water experiences". Tumon Bay is shallow during high tides and virtually dry during low tides. Swimming, snorkeling and windsurfing are severely restricted by the low water levels. The dredged area will be deep enough to allow swimming, even during low tides. Tourists and residents will enjoy Naton Beach more after the microdredging project is completed.

4.2 ALTERNATIVE ACTIONS

4.2.1 No Action

The alternative of no action would result in the continuation of beach erosion along Central Naton Beach. In addition, this area would remain so shallow, that swimming and other recreational activities would remain severely limited, further perpetuating tourist disappointments concerning the condition of the bay.

Immediate action may be postponed until a proposed dredging of the entire bay takes place, although it is not known whether this will ever be implemented.

4.2.2 Alternative Site Selection

This is not a viable alternative, since no alternative site could prevent beach erosion along Central Naton Beach, nor increase the depth of this area.

4.2.3 Dredging Plan Modification

Plan modifications are possible. Dredging zones could be reduced, sediment ponds could be relocated and work could be done during the nighttime. Scheduling for implementation of the project is also flexible.

MITIGATION AND ENVIRONMENTAL PROTECTION MEASURES

SECTION 5

MITIGATION AND ENVIRONMENTAL PROTECTION MEASURES

It has been shown in the preceding section that the proposed microdredging activity will take place in an area of low sensitivity. The immediate area contains very little marine life, which would be destroyed or harmed by the dredging. Nevertheless, any marine dredging has the inherent risk of suspending enough silt to impact water quality and corals. Other impacts arise from the intrusion of the dredging equipment into fish and human territories. The following mitigating measures have been included in the project to prevent or reduce negative impacts:

1. Divide dredging area into five zones for better manageability. These zones will be enclosed by a silt curtain to impede movement of sand outside of the dredging area. Silt curtains will remain in place until the turbidity has returned to ambient levels. Silt curtains have been successfully used in previous dredging projects in Tumon Bay with very good results.
2. Settling Basins: The dredged sediment will be pumped up to the Fujita Hotel property to one of two 65-foot by 65-foot basins. The basins will be formed by excavating and constructing berms with the excavated material. The berms will be covered with plastic sheeting to prevent erosion.

The floor of the basins will be unlined to allow percolation of the seawater. The sediment will be allowed to settle completely before the clear water is allowed to drain back to the bay. No silt will be in the discharge water. The basins' location up on the shore has been planned so that, in the improbable event that the berm fails, the sediment will be caught on the land surface before it can enter the bay.

3. Removal of Coral: No live coral colonies are expected to be found in the proposed dredging area. The area has been extensively surveyed and is continuously used by beach visitors. It is unlikely that any living coral is located in this shallow, warm water that is so frequently disturbed. If any live coral is found, it could be carefully removed and transplanted to another location.

4. Establish a "no-dredging" zone extending 50 feet from the MLLW to preserve the delicate moat region and the natural beach slope.

5. Implement an intensive water quality and substrate monitoring program to commence before, and continue during, the proposed dredging. Halt or change dredging procedures should environmental quality exceed set standards.

6. Timing of Dredging: Schedule project so that it does no interfere with the seasonal runs of juvenile rabbit, fish and goat fish. The proposed schedule for dredging between December and March will avoid interference with any of the seasonal fish runs in Tumon Bay, according to the Fish and Wildlife Service predictions.

7. Require Contractor to provide a comprehensive Environmental Protection Plan prior to initiating the project.

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Clayshulte, R.N. and W.J. Zolan. 1976. A study of Continental Hotel beach storm drain water quality and the surrounding marine environment. Unpub. study.

2. Emery, K.O. 1963. Marine geology of Guam. U.S. Geol. Surv. Prof. Pap. 403-B: 1B-76B.

3. Graves, M.W. and D.R. Moore, 1985. Tumon Bay area overview: cultural and historical resources. Micronesia Area Research center and Department of Anthropology, Univ. of Guam

4. Guam Aquatic and Wildlife Resources Div. 1986. Annual Report. Guam Dept. of Agriculture. 143 p.

5. Marsh, J.A., Jr. 1977. Terrestrial inputs of nitrogen and phosphorus on fringing reefs of Guam.. Proc. Third Internat. Symp. Coral Reefs 1:331-336.

6. Marsh, J.A., Jr., R.M. Ross and W.J. Zolan. 1981 Water circulation on two Guam reef flats. Proc of the 4th Int. Coral Reef Symposium, Manila.

7. Randall, R.H., et. al. 1978. Guam's reefs and beaches, Part II Transect studies. Univ. of Guam Mar. Lab. Tech. Rept. No. 48.

8. Randall, R.H. and L.G. Eldredge. 1976. Atlas of reefs and beaches of Guam. Bureau of Planning Gov. of Guam.

9. Randall, R.H. and J. Holloman. 1974. Coastal survey of Guam. Univ. of Guam Mar. Lab. Tech. Rept. No. 14. 404 p.

10. Reinman, F.M. 1968. Guam prehistory: A preliminary field report. pp. 41-50. In I. Yawata and Y.H. Sinoto. Prehistoric culture in oceana, a symposium. Bernice B. Bishop Museum Press.

11. Rowe, F.W.E. and J.E. Doty. 1977. The shallow water Holothurians of Guam. Micronesica Vol. 13, No. 2. pp 217-250.

12. Sea Engineering, Inc. 1987. Coastal engineering assessment for Tumon Bay micro dredging project. Prep. for Barrett Consulting Group, Hawaii.

13. Sea Engineering Services, Inc. and R.M. Towill Corp. 1980. Guam comprehensive study shoreline inventory. Prep. for U.S. Army Engineer Dist. Honolulu.

14. U.S. Navy Oceanographic Office. 1974. Nearshore currents and coral reef ecology of the west corast of Guam, Mariana Islands. Special publication No. 259.

15. Zolan, W.J., R.M. Clayshulte, S.J. Winter, J.A. Marsh and R.H.F. Young. 1978. Urban runnoff quality in northern Guam. Water Resources Research Center Tech. Rept. No. 5.

APPENDIX

- ESTIMATED TOTAL VOLUME OF BAY = 946,667 cyd
- ESTIMATED TOTAL VOLUME OF UNCONSOLIDATED SAND TO BE DREDGED = 4100 cyd
- ESTIMATED TO TOTAL VOLUME OF CORAL SUBSTRATE TO BE DREDGED = 13,933 cyd
- TOTAL VOLUME OF MATERIAL TO BE DREDGED = 18,033 cyd

SETTLING POND DESIGN

SETTLING VELOCITY OF SAND (.15 mm)

$d = .15\,\text{mm} = 8.86(10^{-4})\,\text{ft}$

$\rho_{H_2O} = 63.99\ \text{lb/cft}$ @ $84°\text{F}$

$\rho_s = 110\ \text{lb/cft}$ (assumed)

$\eta = 5.475(10^{-4})\ \text{lb/ft-sec}$ @ $84°\text{F}$

$$V_s = \frac{g}{18}\left(\frac{\rho_s - \rho_{H_2O}}{\eta}\right) d^2$$

$$V_s = \frac{32.2}{18}\left(\frac{110-63.99}{5.475(10^{-4})}\right)(8.86\times10^{-4})^2$$

$$V_s = 0.12 \ \text{ft/sec}$$

TIME TO SETTLE 4 ~~ft~~ = 33.3 sec

FLOW FROM DREDGE = 4000 gpm = 8.9 cfs

80% H_2O, 20% sand/substrate

ASSUME OUTFLOW THROUGH DRAIN PIPES ON BASE OF POND. POND WILL FUNCTION MORE LIKE A RAPID SAND FILTER THAN A SETTLING BASIN. FLOW WILL BE INTERMITTANT, NOT CONTINUOUS.

ASSUME 12" DIAMETER OUTFLOW PIPE
SLOPE = 1' in 100' = 0.01 %
MAX Q = 3.7 cfs FOR FULL FLOW

NET FLOW = DREDGE FLOW − OUTFLOW
= 8.9 cfs − 3.7 cfs
= 5.2 cfs INFLOW

FOR ONE HOUR DREDGE OPERATION –

TOTAL VOLUME IN = 5.2 cfs x 3600 $\frac{sec}{hr}$ = 18,720 cft

TOTAL VOLUME H_2O = .8(18,720) = 15,000 cft

TOTAL VOLUME SAND/SUBSTRATE DREDGED

= 3700 cft

DIMENSIONS OF POND:

SELECT 65' x 65' x 5' POND:

AREA OF POND = 4680 ft^2

VOLUME OF POND = 18,720 cft + 1' FREE-BOARD

CONSTRUCTION: EXCAVATE POND AREA AND FORM EARTH BERMS AROUND EDGE TO CONTAIN WATER LINE BERM (EXCLUDING FLOOR) WITH PLASTIC SHEETING TO PREVENT EROSION

POND EXCAVATION:

EXCAVATE: 65' x 65' x 2.5'

A_1 = 65' x 65' = 4225 ft^2

$$A_2 = (65 + (2.5 \times 2))^2 = 5625 \text{ ft}^2$$

$$D = 2.5 \text{ ft}$$

VOLUME TO BE EXCAVATED =

$$\tfrac{1}{2}(A_1 + A_2) \times D = \underline{12{,}312 \text{ ft}^3}$$

BERM CONSTRUCTION:

TOP WIDTH = 2', SIDE SLOPE = 2:1

HEIGHT = 2.5'

$$A = \tfrac{1}{2}(2' + 12') \times 2.5' = 17.5 \text{ ft}^2$$

$$L = 7' \times 75' = 525 \text{ ft}$$

$$\text{VOL} = 17.5 \text{ ft}^2 \times 525 \text{ ft} = \underline{9188 \text{ ft}^3}$$

FILLED

STOCKPILE/WASTE = $12{,}312 - 9188 = \underline{3124 \text{ ft}^3}$

WIDTH OF PONDS AND BERMS

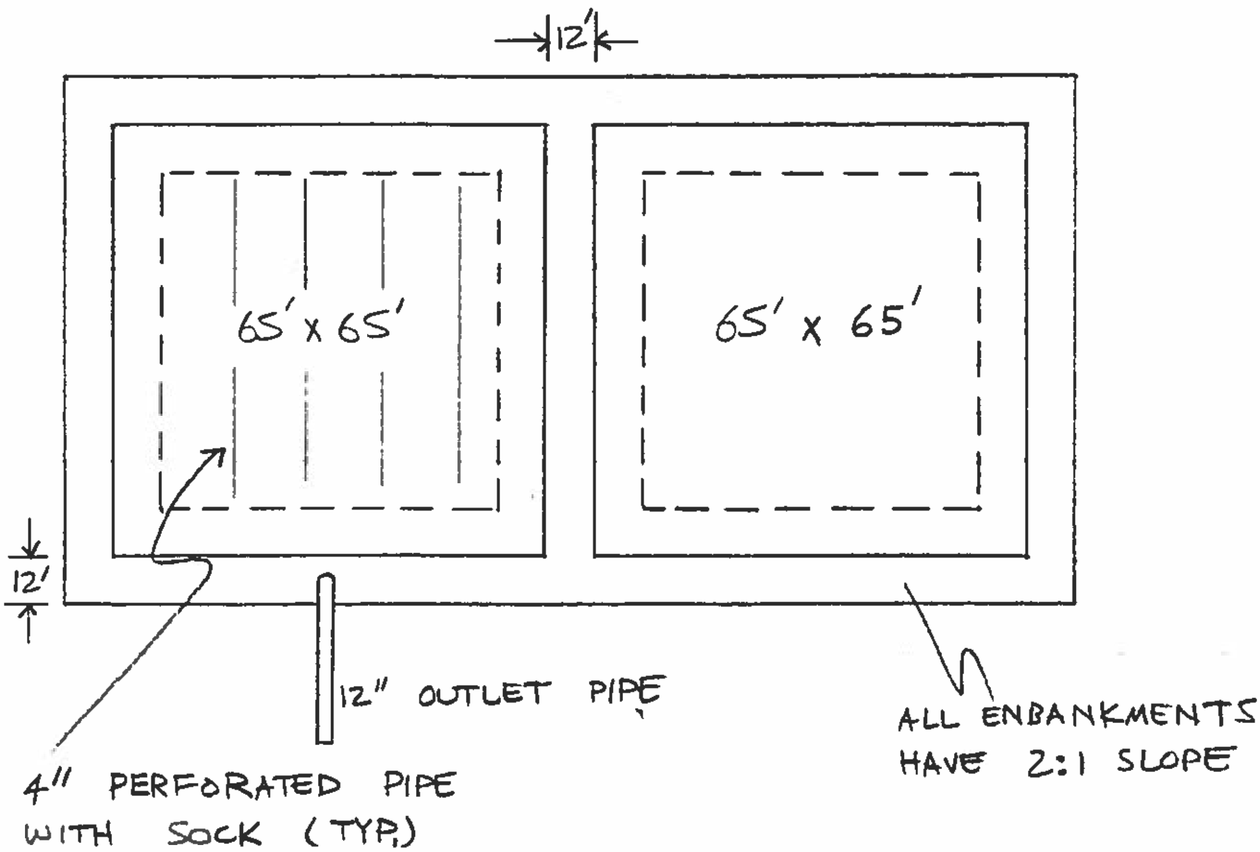
$$= 75' + 75' + 3(12) = \underline{186 \text{ ft}}$$

GMP ASSOCIATES, INC.
CONSULTING ENGINEERS

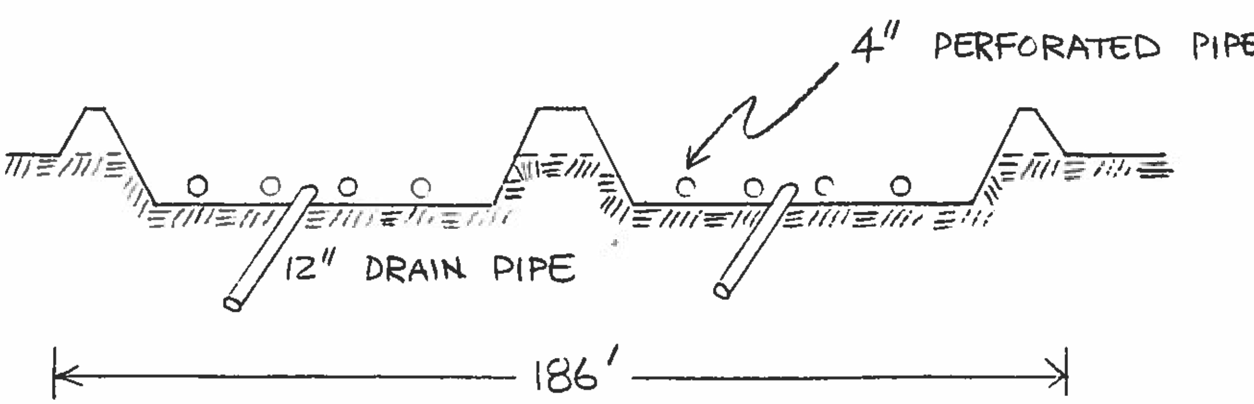
BY KAM DATE 6/7/90 SUBJECT TUMON MICRODREDGING SHEET NO. 5 OF

CHKD. BY DATE JOB NO. 3075/00

SEDIMENT POND DESIGN



PLAN VIEW



SECTION

GMP ASSOCIATES, INC.
CONSULTING ENGINEERS

BY KAM DATE 7/3/90 SUBJECT TUMON MICRODREDGING SHEET NO. 6 OF
CHKD. BY DATE JOB NO. 3075/00
WATER QUALITY ANALYSIS

DISSOLVED OXYGEN CALCULATION:

CONDUCTIVITY = 48,300 μmhos/cm to 49,700 $\frac{\mu mhos}{cm}$

AVERAGE CONDUCTIVITY = 49,000 μmhos/cm

IONIC STRENGTH, $\mu = 1.6 \times 10^{-5} \times$ SPECIFIC CONDUCTIVITY

$$\mu = 1.6\,(10^{-5}) \times 49{,}000 \ \frac{\mu mhos}{cm}$$

$$\mu = 0.78$$

USING HENRY'S LAW: $K_H = 1.29\,(10^{-3})$

$K_S = 0.132$ SALTING OUT COEF.

@ 25°C $P_{O_2} = 0.203$ (PARTIAL PRESSURE OF O_2)

$$\log \gamma = \mu K_s = 0.78\,(0.13) = 0.103$$

$$\gamma = 1.267$$

$$K_H = \gamma\,[O_2] / P_{O_2}$$

$$[O_2(aq)] / P_{O_2} = \frac{\gamma\,[O_2]}{P_{O_2}}$$

GMP ASSOCIATES, INC.
CONSULTING ENGINEERS

BY KAM DATE 7/3/90 SUBJECT TUMON MICRODREDGING SHEET NO. 7 OF
CHKD. BY DATE JOB NO. 3075/00
WATER QUALITY ANALYSIS

$$[O_2(aq)] = (1.29)(10^{-3})(0.203)/1.267 = 2.07(10^{-4})\,m$$

$$[O_2(aq)] = 2.07(10^{-4})\,m \times 32\,\frac{g}{mole} = 6.614\,\frac{mg}{l}$$

RANGE = 6.58 to 6.63 mg/l

USE D.O. = 6.6 $\frac{mg}{l}$