CHAPTER 2

PRESENT SITUATION OF BETIO AND OTHER PORTS

2. PRESENT SITUATION OF BETIO AND OTHER PORTS

2.1 General

The Island of Tarawa belongs to the Gilbert Islands and is situated at approximately 2,000 km north of Fiji and 300 km east of Nauru. It is a typical atoll with the land area of 31 km^2 formed by a narrow strip of reef surrounding a central lagoon of varying depth. The capital is in Tarawa, which is focus of economic activity. Population in 1990 is given as about 30,000, accounting for about 40 per cent of the total and producing the congested situation. The island of Betio, which is at the south-west corner of the atoll, provides the major port named Betio Port and trading facilities and has developed into the country's main economic centre. The island of Bairiki, which houses the country's government and administrative centres, was linked to Betio by the construction of a causeway in 1986/87.

The island of Christmas belongs to the Line Islands and is situated two degrees above the equator, 2,000 km south of Hawaii and 3,200 km east of Tarawa, the centre of the Kiribati Government. These distance typify its physical isolation from world trade and economic activity. The island is the largest coral atoll in the country, and the land area is 388.39 km^2, accounting for about the half of the total. Population in 1990 is given as 2,537, predominantly settling from the Gilbert Islands. Large area is open, with low or scattered scrub. About one third of the land is planted with coconut palm, these being introduced and cultivated for an export crop of copra.

2.2 Natural Conditions

2.2.1 Betio Port

(1) Topography

Betio is located at the south-west corner of the Tarawa Atoll and Betio Port is located in the north of Betio Island facing the lagoon side. The Port is formed like a U-shape by two breakwaters, the east and the west breakwaters, which are made of sand and coral gravel covered by armoured concrete bag slope. The two breakwaters surround main port facilities such as an access channel, a boat basin, a steel sheet pile wharf, some sheds and so on.

The study team executed topographic and sounding surveys and the results are shown in Figure 2-2-1.

(2) Meteorology

Meteorological data, from the years 1981 to 1992, such as temperature, relative humidity, rainfall and wind were obtained from the weather station in Tarawa (latitude: 1° 21' N, longitude: 172° 55.5' E). The meteorological elements such as temperatures, relative humidity and rainfall are shown in Table 2-2-1.

Meteorological conditions in Tarawa are characterized as following paragraphs.

1) Temperature

Temperatures vary between 25 ° and 32 ° C. The mean annual temperature is 28.4 ° C, and the maximum and minimum monthly mean temperature are 29.1 ° and 27.0 ° C, respectively, indicating that temperatures vary little throughout the year.

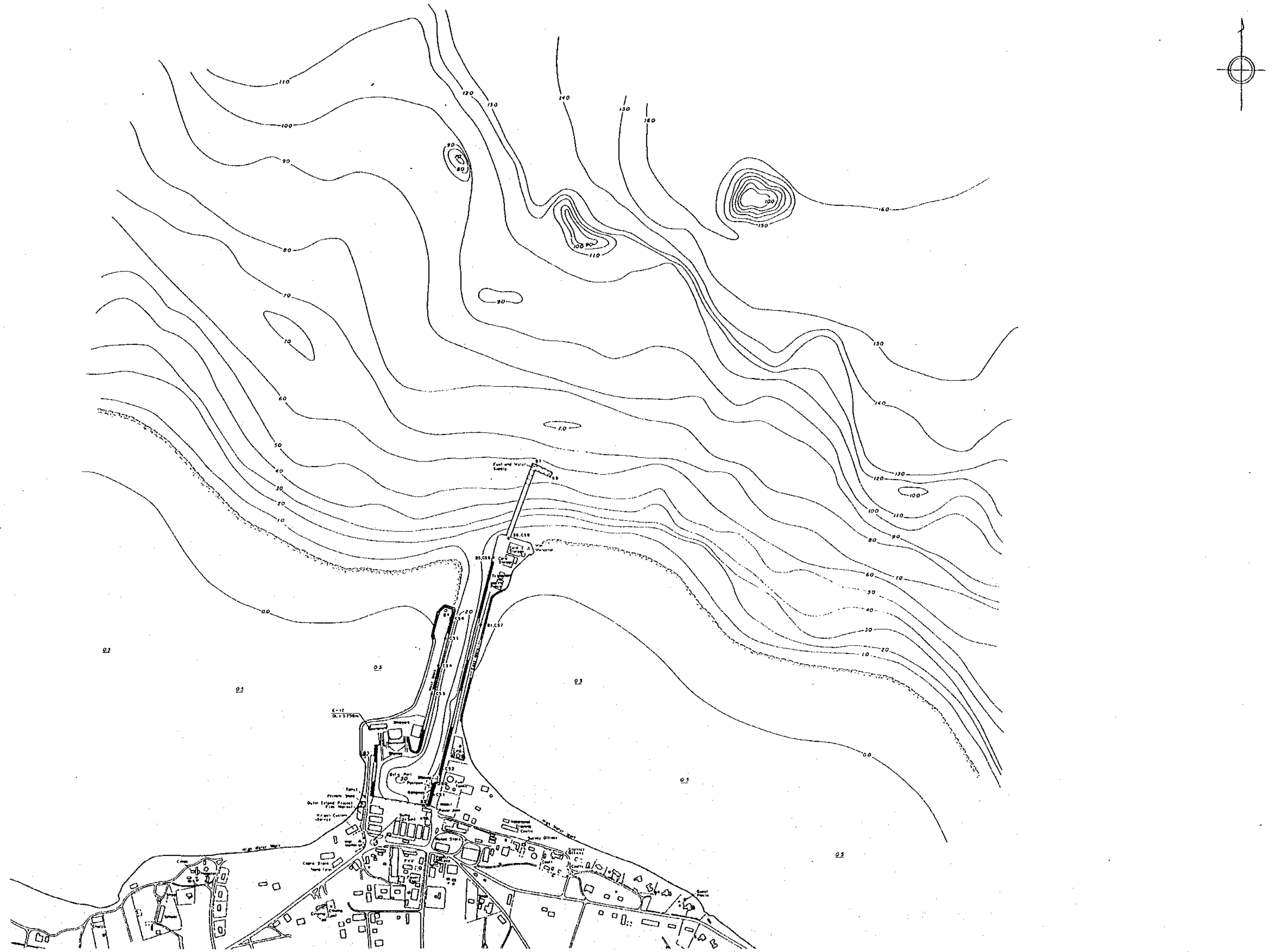
2) Relative Humidity

The mean annual relative humidity is 80.9 % and the difference between the wet season, November to April, and the dry season, May to October, is small.

3) Rainfall

The mean annual rainfall is 2,221.3 mm and the monthly variation is small, ranging from 121.5 mm (in October) to 259.2 mm (in December).

As shown in Figure 2-2-2, the variation in rainfall by year is much greater than the variation within a year: i.e. the drought with monthly rainfall of less than 50 mm occurred from July in 1988 to March in 1989. Further, droughts in most islands occur from time to time.



Note: Figures indicate depths in meter below the datum line.
Figures with underline indicate heights above the datum line.
The datum line is located 40 cm above the chart datum line.

Figure 2-2-1 Topographic Map of Betio Port

Table 2-2-1 Meteological Elements, 1981-1992

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Tx	28.9	28.7	28.9	29.0	28.7	28.8	28.6	28.8	29.0	29.0	29.1	29.0	28.9
Tn	27.9	27.5	27.8	27.8	27.8	27.6	27.5	27.0	27.9	27.9	28.0	27.2	27.7
Tm	28.4	28.3	28.4	28.3	28.3	28.3	28.1	28.3	28.4	28.5	28.6	28.3	28.4
UU	81.9	81.7	84.1	83.9	82.6	82.4	80.1	78.6	77.4	77.5	78.6	82.0	80.9
RR	237.8	188.8	166.5	218.8	199.1	169.0	185.5	165.8	140.6	121.5	168.7	259.2	*2,221.3

Source: Tarawa Weather Station

Note: Tx: Maximum temperature (^{0}C)

Tn: Minimum temperature (^{0}C)

TM: Mean temperature (^{0}C)

UU: Relative humidity (%) (Duration: 1978 to 1981)

RR: Rainfall (mm)

*: Annual total

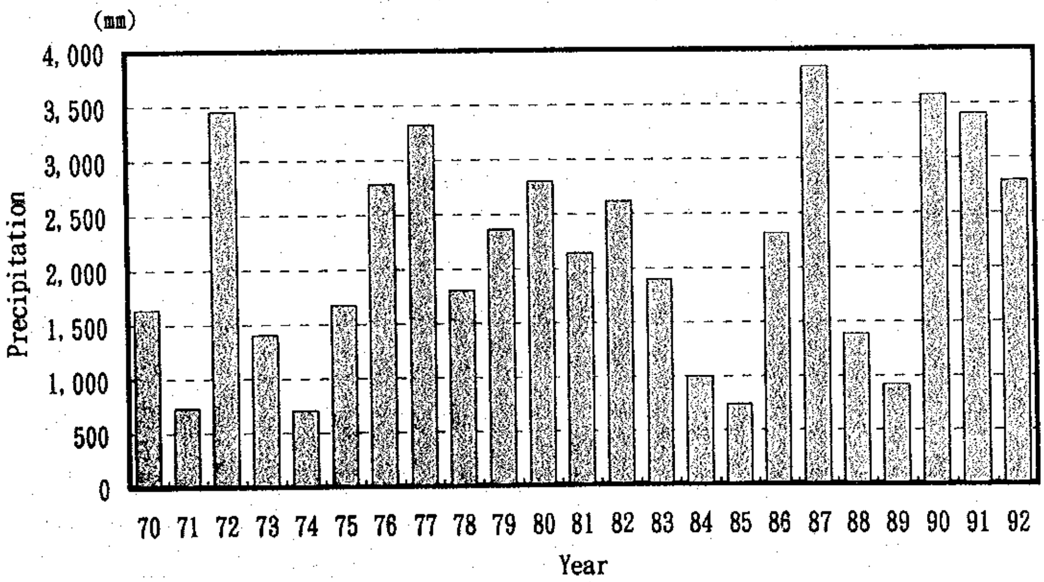


Figure 2-2-2 Annual Rainfall in Tarawa, 1970-1992

4) Winds

The winds data from 1991 to 1993 which were recorded at the weather station (observation height: 10 meters above G.L.) in Tarawa are compiled as shown in Table 2-2-2 and Figure 2-2-3.

These Table and Figure show the following wind characteristics.

- There is a predominant easterly wind having a frequency of occurrence of 53 %.

- Frequency of occurrence of wind velocity less than 7.5 m/sec is 93.6 %, which means calm most days.

New Zealand Meteorological Services reports on wind conditions in western Kiribati in "The Climate and Weather of WESTERN KIRIBATI" as follows:

- Mean wind speeds average 2.5 m/sec from June to August (July being the least windy month for most of the islands), and 3.1 - 4.5 m/sec from December to February.

- During May and June mean wind speeds rarely exceed 6.7 m/sec. Strong winds, 9.8 - 12.0 m/sec are not common and only occur two or three days each year. Wind of near gale force or greater strength (at least 12.5 m/sec) occur on average only one day per year.

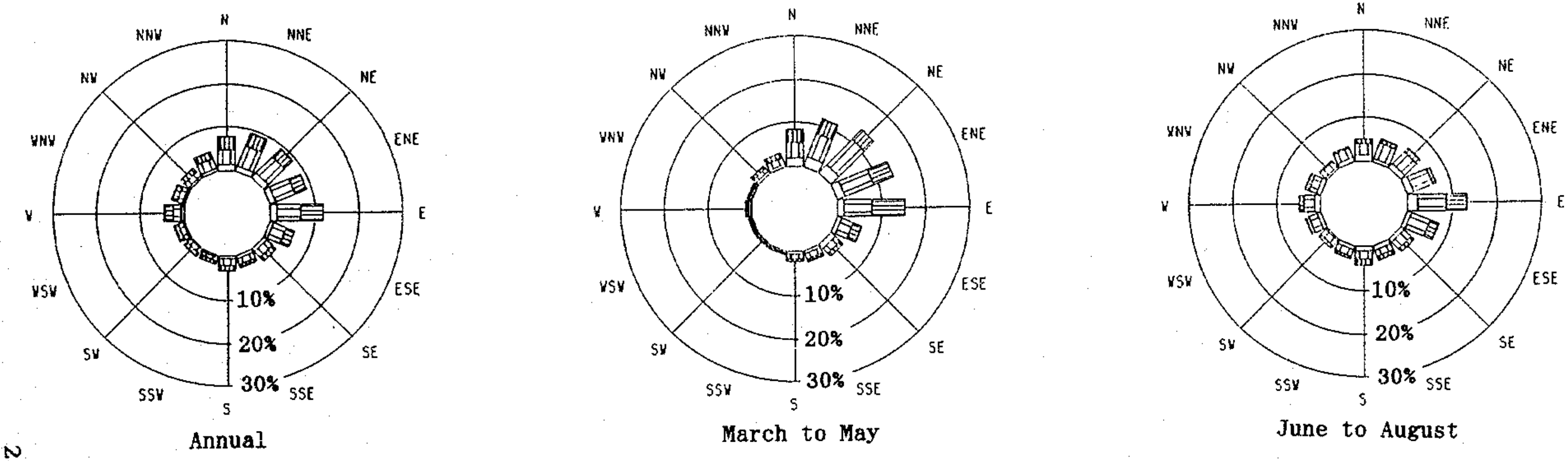
- The maximum gust recorded by the anemometer at the Tarawa Weather Station was 23 m/sec from 280° on November 18th 1982.

Table 2-2-2 Annual Frequencies of Occurrence of Winds
by Direction and Intensity, 1991-1993

YEAR 2500 MONTH 0 KESOK 2058

WIND DIRECTION / WIND SPEED(M/S)	U.K.	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
CALM	515 7.7	0 0.0	1 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	516 7.7
0.0 - 2.5	330 4.9	104 1.5	88 1.3	102 1.5	95 1.4	106 1.6	53 0.8	60 0.9	57 0.8	45 0.7	32 0.5	20 0.3	26 0.4	48 0.7	38 0.6	33 0.5	57 0.8	1294 19.3
2.5 - 5.0	0 0.0	230 3.4	336 5.0	356 5.3	325 4.8	363 5.4	210 3.1	121 1.8	91 1.4	97 1.4	59 0.9	72 1.1	80 1.2	121 1.8	91 1.4	92 1.4	160 2.4	2804 41.8
5.0 - 7.5	1 0.0	167 2.5	177 2.6	147 2.2	165 2.5	299 4.5	115 1.7	67 1.0	40 0.6	66 1.0	34 0.5	39 0.6	44 0.7	88 1.3	57 0.8	64 1.0	97 1.4	1667 24.8
7.5 - 10.0	0 0.0	34 0.5	26 0.4	24 0.4	18 0.3	46 0.7	21 0.3	14 0.2	6 0.1	21 0.3	14 0.2	23 0.3	21 0.3	39 0.6	18 0.3	20 0.3	12 0.2	357 5.3
10.0 - 15.0	0 0.0	1 0.0	3 0.0	2 0.0	1 0.0	2 0.0	3 0.0	1 0.0	4 0.1	2 0.0	4 0.1	5 0.1	10 0.1	15 0.2	9 0.1	2 0.0	2 0.0	66 1.0
15.0 - 20.0	0 0.0	0 0.0	0 0.0	0 0.0	1 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	1 0.0	0 0.0	0 0.0	0 0.0	2 0.0
20.0 - 25.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
25.0 - 30.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
30.0 -	0 0.0	0 0.0	4 0.1	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	4 0.1
TOTAL	846 12.6	536 8.0	635 9.5	631 9.4	605 9.0	816 12.2	402 6.0	263 3.9	198 3.0	231 3.4	143 2.1	159 2.4	181 2.7	312 4.6	213 3.2	211 3.1	328 4.9	6710 100.0

Source: Tarawa Weather Station



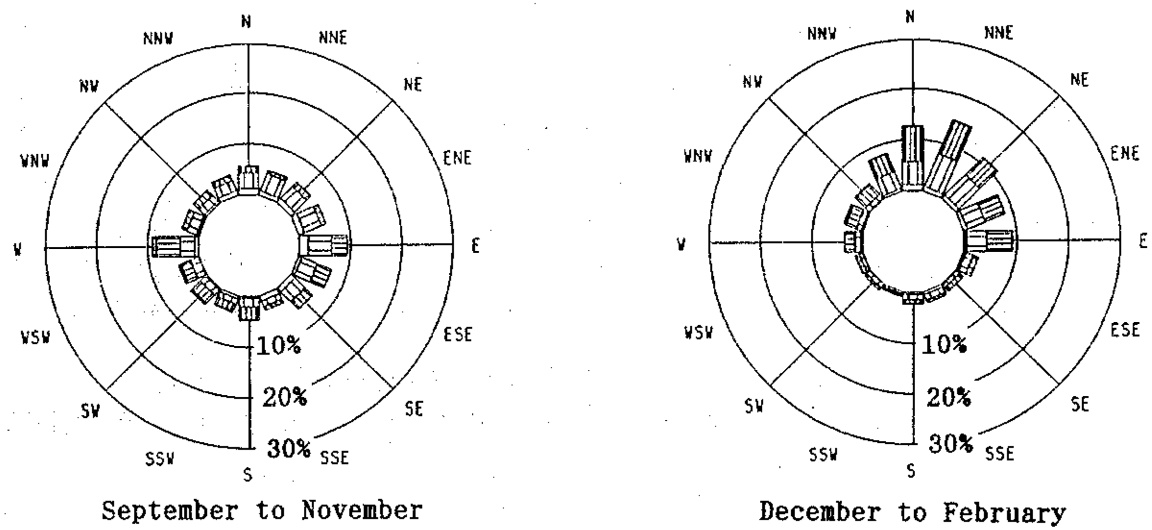


Figure 2-2-3 Wind Rose

(3) Sea Conditions

1) Tide

The Study Team conducted tidal survey using a water pressure type tide gauge at the top of the east breakwater in Betio Port for 31 days. Measuring was made with a position of zero "0" of the tide gauge being set at the level of Datum Line(D.L.) ±0.0 m in Betio Port. The results of survey and analysis have been incorporated into a tide curve shown in Figure 2-2-4, while results of the tide harmonic analysis are presented in Table 2-2-3.

The tide curve in the Figure shows a typical pattern of semi-diurnal tide.

From the results of the harmonic analysis, the tide amplitude (Z_0) consisting of the sum of the four main tide components, M_2, S_2, K_1, and O_1, is calculated to be 1.036 m. And the tide type index "T" which is expressed in $(K_1+O_1)/(M_2+S_2)$ as a ratio of semi-diurnal tide components against diurnal tide components is 0.161, which highlights the typical characteristics of semi-diurnal tide. Classification of tide type index is as follows:

1.50 <= T ——————> Diurnal Tide
0.25 <= T < 1.50 ——————> Mixed Tide
T < 0.25 ——————> Semi-diurnal Tide

Table 2-2-4 shows the comparison of the tide harmonic constants of the four main components between this study and the Admiralty Tide Table of the British Navy. A high level of agreement is evident.

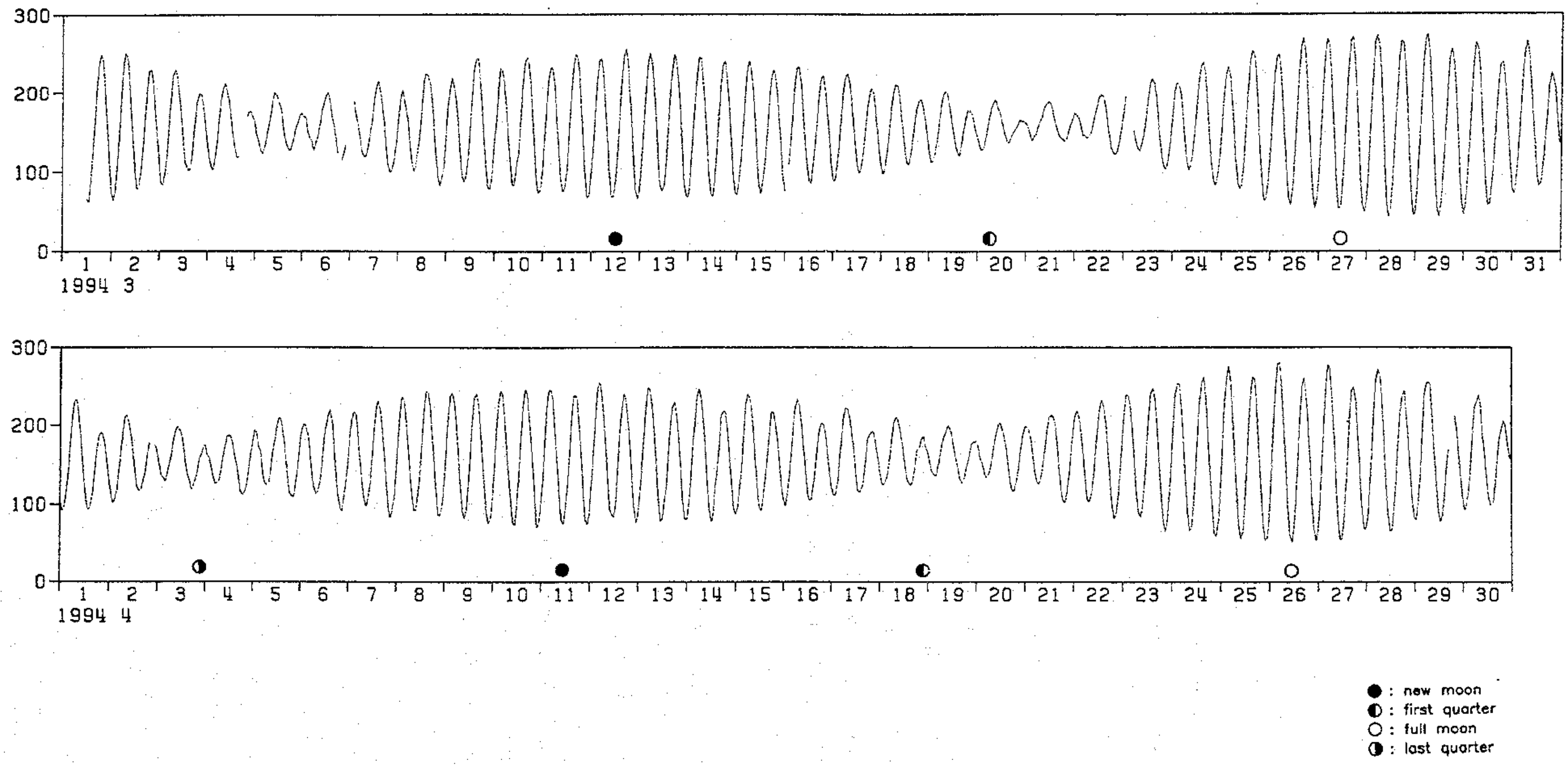


Figure 2–2–4 Tide Curve

Table 2-2-3 Results of Tide Harmonic Analysis

Position: Betio Port
Latitude: 1^{0} 21'42" N
Longitude: 172^{0} 55'48" E
Time Zone: 180 ^{0}E
Observation Start: 30th March 1994 (for 31 Days)

Tide Component	Amplitude (m)	Lag Angle (degree)
K_1	0.091	243.4
O_1	0.053	212.3
P_1	0.030	243.4
Q_1	0.010	206.5
M_2	0.596	125.5
S_2	0.296	142.2
K_2	0.081	142.2
N_2	0.136	124.5
L_2	0.041	129.5
NU_2	0.026	124.5
MU_2	0.035	113.8
M_4	0.002	298.6
MS_4	0.002	310.4
A_0	1.604	

Table 2-2-4 Comparison of Tide Harmonic Constants

		M_2	S_2	K_1	O_1	L.A.T	Z_0
This Study	H (m) K (^{0})	0.596 125.5	0.296 142.2	0.091 243.4	0.053 212.3	-0.090	1.036
Admiralty Tide Table	H (m) K (^{0})	0.591 124.4	0.307 137.3	0.092 240.3	0.060 214.0	-0.100	1.050

Note: H: Amplitude, K: Lag Angle, $Z_0 = M_2+S_2+K_1+O_1$

It is authorized by the Admiralty Tide Table that the lowest possible tide level or the level closest to the lowest tide shall be adopted to the Chart Datum Line, which is obtained by using Z_0 and a sea level departure from normal tide such as the astronomical tide, tropic tide and annual/seasonal variation of mean sea level. The sea level departure from normal tide vary according to the region, but it is stated by Admiralty Tide Table that one foot should be adopted in this tropical region .

The mean sea level by Admiralty Tide Table is reported to be 95 cm, while the mean sea level obtained in this study using a short term data is 87 cm based on the D.L. mentioned above. Since the both levels have a small difference and the former mean sea level, which is authorized with a long term data, is more reliable, it will be adopted. As a result, the Neap Lowest Low Water Level (NLLWL) becomes – 0.09 meter below D.L. as shown in Figure 2-2-5. Reducing the said one foot from the level of NLLWL, the Chart Datum Line becomes approximately – 0.40 meter below the D.L.

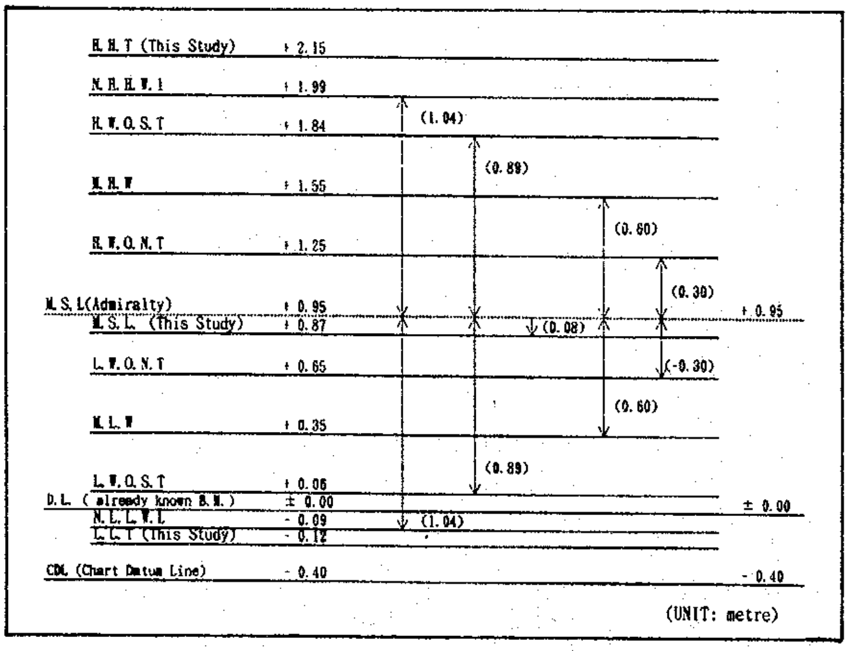


Figure 2-2-5 Tide Level Chart

Consequently, for the reasons mentioned below, the tide level chart of Betio Port can be drawn as shown in Figure 2-2-5 by using the amplitude of the four main components obtained in this study.

- The actual tide levels shown in Figure 2-2-4 Tide Curve are almost in accord with the predicted tide levels of Admiralty Tide Table.

- The four main components of the Admiralty Tide Table from which the tide prediction is made show a good agreement with those of this study.

- Therefore, it is proper to determine that the level 40 cm below the zero "0" of D.L. is the Chart Datum Line (C.D.L.).

2) Tidal Current

The Study Team executed current survey at 3 points using current meters. The direction and speed of tidal current varies in the vertical direction according to the water depth. The current meters were installed at the relatively shallow points to provide the tidal information for the layout plan of the port and the analysis of the littoral drift. The installation points are shown in Figure 2-2-6.

Measuring of tidal current was executed with 24 hours recording three times at spring and one time at neap tide.

The direction of tidal current is ESE at flood tide and is E at ebb tide. The highest speed is 30 cm and the mean highest speed is 18 cm/sec.

3) Waves

Since the Betio Port is located at the south-west end of Tarawa atoll facing the lagoon side, waves reaching the port have characteristics of primary surface wind waves and are occasionally accompanied by ocean waves invading from the opening of the atoll.

Since wave data around the Betio Port are not available, the Study Team hindcasted waves reaching the port based on the records of surface winds and the significant ocean wave dimensions (Ho) hindcast in the past study on the causeway project. The wave hindcast discussed here is divided into two types according to purpose of use as follows:

- Estimation of a rate of workable days of the port operation (a wave computation on ordinary surface wind conditions was performed).

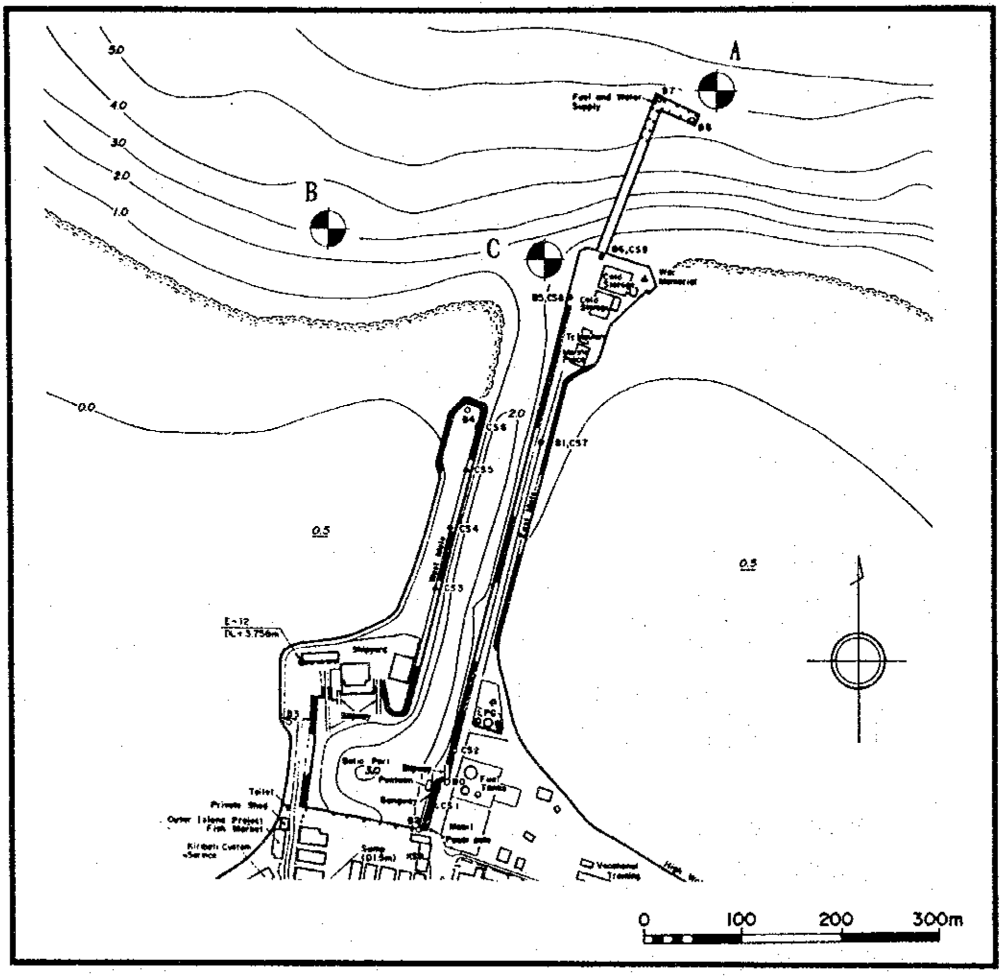


Figure 2-2-6 Installation Points of Current Meters

- Design of revetments of the port (a wave computation on extraordinary wind conditions was performed).

1) Wind waves in the lagoon generated by winds

Sverdrup-Munk-Bretschneider's method (S.M.B method, method for wave calculation from wind velocity, fetch and duration of wind blowing) was applied. Wind records in preceding subsection were used. The results of computation are shown in Tables 2-2-5 and 2-2-6. The frequency of occurrence of waves of 0.5 metre and above in height is found to be 9.9 %. And the maximum height of wave is not more than 1.25 metres.

Table 2-2-5 Frequency of Occurrence of Waves by Height and Direction

W.DIRECTION W.HEIGHT (M)	CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	TOTAL
CALM	3160 47.1	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	3160 47.1
0.00 - 0.24	0 0.0	265 3.9	282 4.2	264 3.9	284 4.2	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	217 3.2	235 3.5	1547 23.1
0.25 - 0.49	0 0.0	236 3.5	251 3.7	253 3.8	333 5.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	102 1.5	160 2.4	1335 19.9
0.50 - 0.74	0 0.0	107 1.6	87 1.3	77 1.1	171 2.5	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	8 0.1	95 1.4	545 8.1
0.75 - 0.99	0 0.0	19 0.3	10 0.1	9 0.1	26 0.4	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	1 0.0	36 0.5	101 1.5
1.00 - 1.24	0 0.0	3 0.0	1 0.0	1 0.0	1 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	10 0.1	16 0.2
1.25 - 1.49	0 0.0	0 0.0	0 0.0	0 0.0	1 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	1 0.0
1.50 - 1.74	0 0.0	0 0.0	0 0.0	1 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	1 0.0
1.75 - 1.99	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
2.00 - 2.24	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
2.25 - 2.49	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
2.50 - 2.74	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
2.75 - 3.00	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
3.00 -	0 0.0	4 0.1	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	4 0.1
TOTAL	3160 47.1	634 9.4	631 9.4	605 9.0	816 12.2	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	328 4.9	536 8.0	6710 100.0

Table 2-2-6 Frequency of Occurrence of Waves by Height and Period

W.PERIOD (S) W.HEIGHT (M)	CALM	0- 1	1- 2	2- 3	3- 4	4- 5	5- 6	6- 7	7- 8	8- 9	9-10	10-11	11-12	12-13	13-14	14-	TOTAL
CALM	3160 47.1	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	3160 47.1
0.00 - 0.24	0 0.0	139 2.1	1408 21.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	1547 23.1
0.25 - 0.49	0 0.0	0 0.0	102 1.5	1233 18.4	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	1335 19.9
0.50 - 0.74	0 0.0	0 0.0	0 0.0	450 6.7	95 1.4	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	545 8.1
0.75 - 0.99	0 0.0	0 0.0	0 0.0	1 0.0	100 1.5	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	101 1.5
1.00 - 1.24	0 0.0	0 0.0	0 0.0	0 0.0	16 0.2	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	16 0.2
1.25 - 1.49	0 0.0	0 0.0	0 0.0	0 0.0	1 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	1 0.0
1.50 - 1.74	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	1 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	1 0.0
1.75 - 1.99	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
2.00 - 2.24	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
2.25 - 2.49	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
2.50 - 2.74	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
2.75 - 3.00	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
3.00 -	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	3 0.0	1 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	4 0.1
TOTAL	3160 47.1	139 2.1	1510 22.5	1684 25.1	212 3.2	1 0.0	0 0.0	3 0.0	1 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	6710 100.0

2) Ocean waves outside of the lagoon

Ocean waves generated by cyclones or air depression passing over or near the port are transmitted around the atoll and waves in the vicinity of the Port are transmitted after deformation by wave refraction and diffraction.

According to the past study on causeway project in 1985, the significant ocean wave dimensions during extraordinary wind conditions are as follows:

Ho: 6.1 metres
To: 9.3 seconds

Latest records on cyclones in the Pacific Ocean shows that twin cyclones occurred in the south hemisphere in 1993 and they generated waves with return period of 60 years, the maximum waves in the vicinity of Tuvalu. In the northern hemisphere, typhoons does not generate big waves transmitting southward to Tarawa around latitude 10° north because of mutually canceling wind speed in typhoons and their moving speed. For hindcasting ocean waves generated by cyclones, the above twin cyclones are applied on the track along latitude 10° south, which is expected to generate highest waves for Tarawa. The calculation results are shown in Figure 2-2-7.

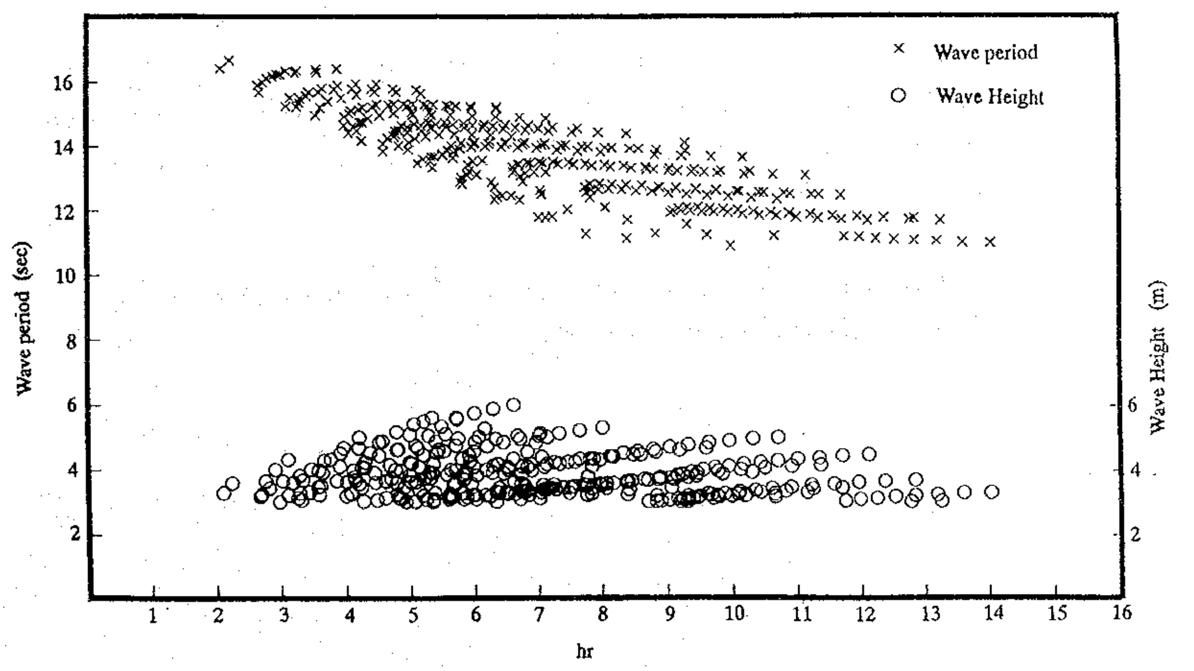


Figure 2-2-7 Dimensions of Hindcast Ocean Waves

Characteristics of waves at the mouth of Tarawa Atoll are summarized below:–

Wave height: 6.0 m
Wave period: 14.0 second

From an engineering viewpoint, the ocean waves for structural design are set to be as follows:

Wave height: 6.1 m
Wave period: 14.0 sec

(4) Soil Conditions

The soil conditions will be discussed reviewing the past soil data of fisheries jetty site. The soil investigation of fisheries jetty was carried out at 8 points in 1982, and the locations and the borehole logs are shown in Figures 2–2–8 and 2–2–9.

The mechanical characteristics discussed in the above investigation was only N blow by means of the penetration test, and the other laboratory tests such as sieve analysis, density test, unconfined compression test and so on were not discussed.

These data yield the following outline of soil conditions:

The most surface layer comprises coral sand and coral fragments of about 10 metres thickness and the N blows is 0 to 29. The portion deeper than 5 meter from the sea bottom is relatively dense, and some boreholes encounter a hard coral rock having N blows of over 50.

To grasp the exact nature of soil property, a full soil investigation is recommended in the future planning and designing stage.

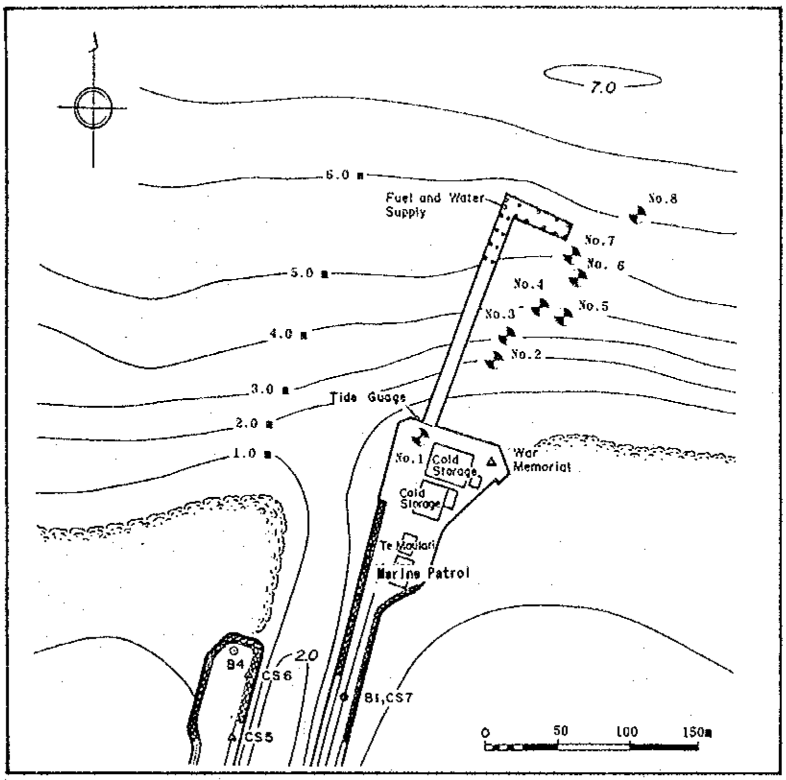


Figure 2-2-8 Locations of Boring Points

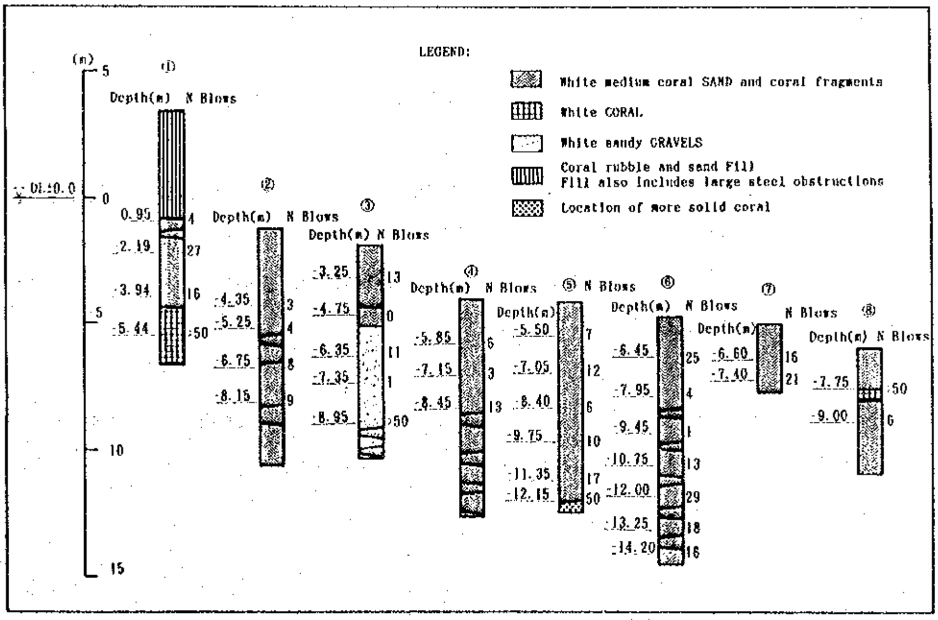


Figure 2-2-9 Borehole Logs
(Source: Fisheries Jetty Construction Survey)

(5) Littoral Drift

1) Survey related to Littoral Drift

The Study Team took surveys on seabed materials and suspended sediment to provide the fundamental information for the engineering evaluation of littoral drift.

The locations of sampling points are shown in Figures 2-2-10 and 2-2-11, and results of laboratory test are shown in Tables 2-2-7 and 2-2-8.

As the medium diameters vary from 0.017 to 1.200 mm and the Uniformity Coefficients vary from 1.75 to 43.80, the data has a large fluctuation depending on the place. Seabed materials in the inner port and the offshore, the points No. 1, 2, 10, 11, 12, 15 and 16, are very fine with the D10 (diameter of 10% passing) being less than 0.001 mm. But those on reef flat and near the reef edge, the point No. 6, 7, 8, 9, 13 and 14 are coarse with the D50 (mean diameter) ranging from 0.130 to 1.200 mm.

Concentration of suspended sediment is about 10 mg/litter, neglecting the data having projected large values that seem to be caused by water turbulence by vessels passing nearby.

2) Outline of Littoral Drift along the South Coast of Tarawa

Waves caused by winds come to the island from east and north directions and wave characteristics in and out of the atoll are different. Wave energy out of the atoll is larger than the energy of the inside. Ocean waves enter the lagoon from western mouth of the atoll.

According to the study by R. D. Gillie on shoreline changes comparing aerophotos taken in 1943 and 1992, the followings are found:

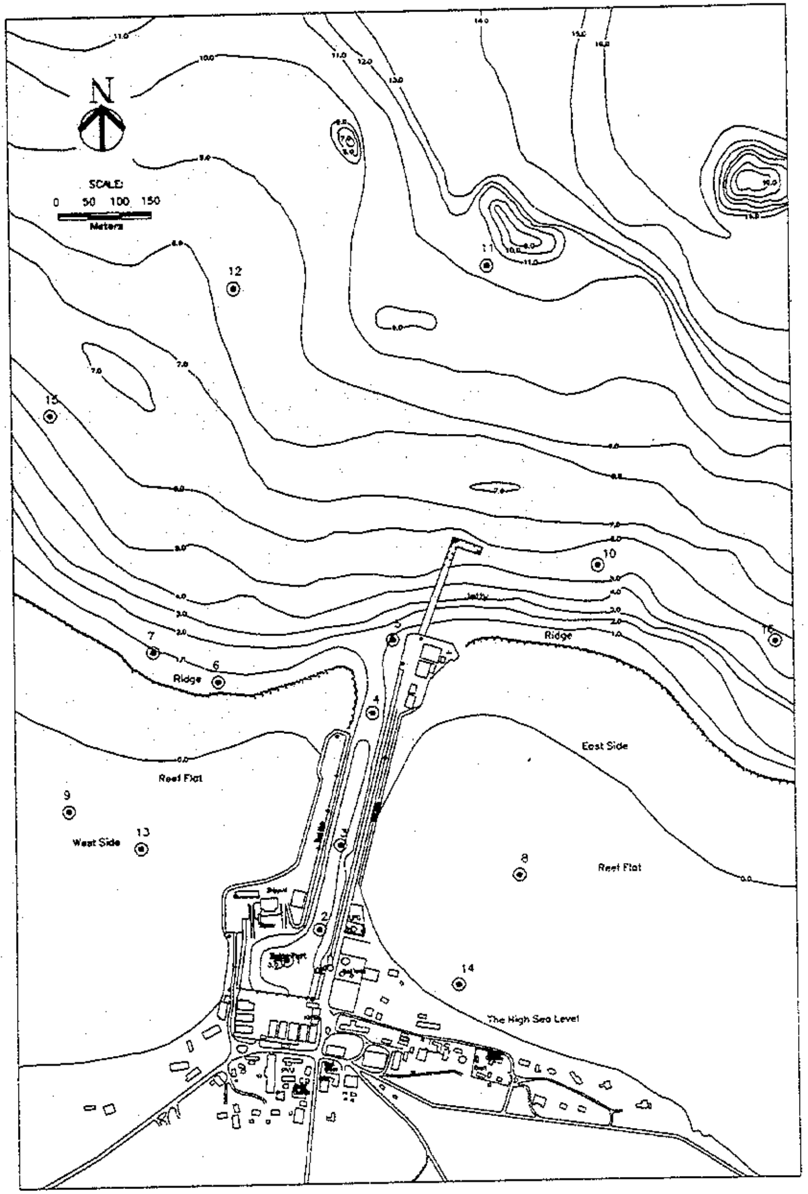


Figure 2-2-10 Locations of Sampling Points of Seabed Materials

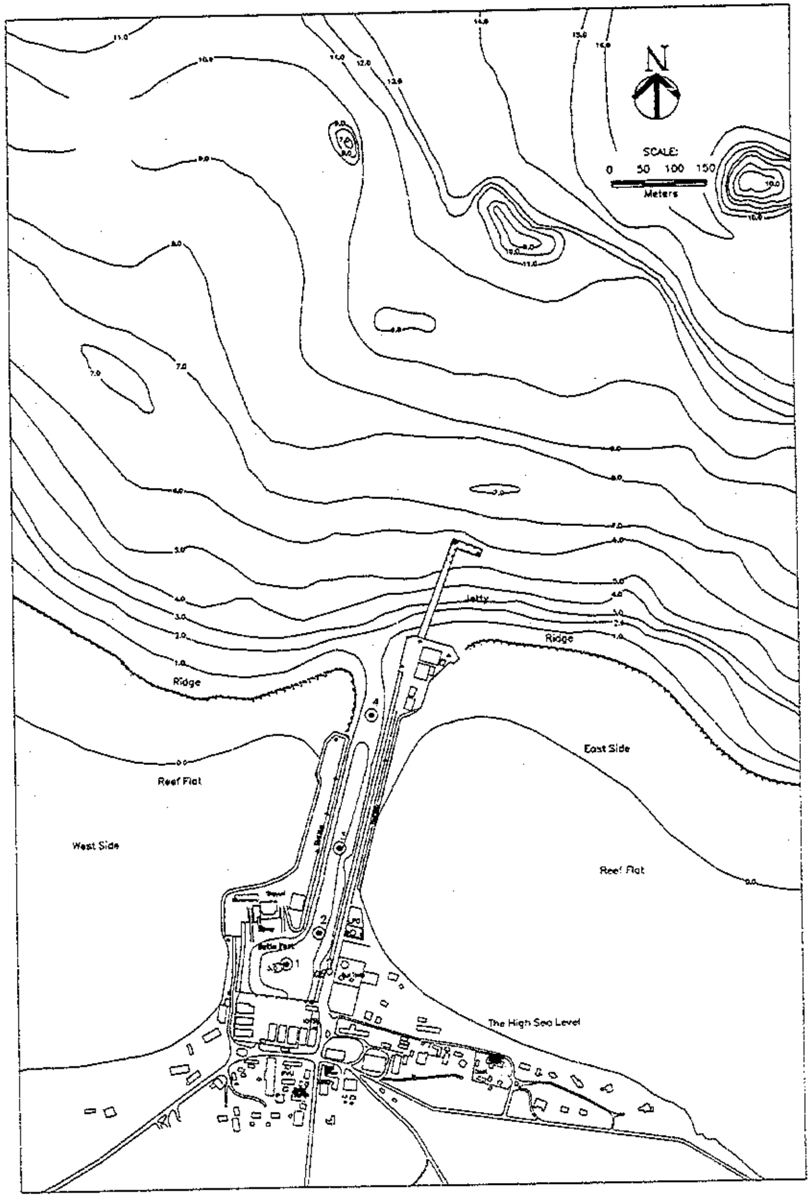


Figure 2-2-11 Locations of Survey Points of Suspended Sediments

Table 2-2-7 Characteristics of Seabed Materials

Sample No.	10 % Diameter D10 (mm)	Median Diameter D50 (mm)	Uniformity Coefficient D60/D10
1	-	0.017	-
2	-	0.020	-
3	0.0073	0.250	43.800
4	0.0045	0.100	28.900
5	0.0027	0.075	32.60
6	0.120	1.200	35.00
7	0.031	0.230	11.30
8	0.080	0.130	1.75
9	0.047	0.250	7.87
10	-	0.067	-
11	-	0.066	-
12	-	0.075	-
13	0.080	0.170	2.62
14	0.022	0.700	37.70
15	-	0.030	-
16	-	0.037	-

Table 2-2-8 Concentration of Suspended Sediments

Sampling Point	Sample No.	Concentration of Suspended Sediments (mg/litter)
4	1	1.5
	2	78.0
	3	1.5
	4	10.2
	5	1.4
	6	2.2
3	7	16.6
	8	26.3
	9	2.1
	10	2.3
	11	2.0
	12	19.7
2	13	19.5
	14	1497.0
	15	10.1
	16	159.9
	17	1.1
	18	21.9
1	19	0.9
	20	3.5
	21	2.6
	22	8.9
	23	1.8
	24	51.3

* Shorelines of the west and north at western end of the Betio islet has moved to offshore with much deposition there.

* Estimates of volume change on these shorelines are summarized below:

Region	Shoreline Area Change (m^2)	Volume Change (m^3)
West End (A)	44,400	88,800
Temaiku (B)	40,900	81,800
A + B	85,300	170,600
East of Port	26,600	53,200

Sand deposition at the regions of A and B were caused by littoral drift along the southern shoreline of the islet. The volume for 49 years is about 170,000 m^3 and annual deposition volume is very small to be about 3,500 m^3.

Volume of littoral drift inside lagoon is estimated to be 53,200 m^3 for the same years and to be 1,100 m^3 annually.

It is concluded that littoral drift is very small along Betio islet, because wave energy is dissipated in reef flats and waves of incident angle orthogonal to the shorelines does not likely cause littoral drift.

3) Sedimentation at Betio Port

The preparatory study team from JICA reported average annual deposition rate in Betio Port as follows:

Region	Water Area (m^2)	Av. Deposition Rate (cm/yr)	Av. Volume of Deposition (m^3/yr)
Basin :	14,400	4.0	576
Harbor Mouth :	8,500	5.0	425
Channel :	15,000	2.5	375
Total	37,900	3.6(Av.)	1,376

Concentration of suspended sediment averages to about 10 mg/ton. Assuming that suspended sediment outside the port flows into the port with tidal change and the suspended sediment deposits, the deposition volume will be calculated to be 200 m^3/yr.

Regarding phenomenon of suspended sediment, concentration of suspended sediment increases sharply with increase of wave heights. Considering that the above measurement was conducted in the sea with wave heights less than 0.5 metres, the above calculation result is in the range of allowance of estimation from an engineering viewpoint.

4) Littoral Drift in Betio Port

As discussed above, volume of littoral drift around Betio islet is very small and serious sand deposition will not occur in a new port, unless facilities of a port capture littoral drift. The layout of a new port is recommended to be open to wave action as much as possible with securing allowable wave conditions for cargo handling.

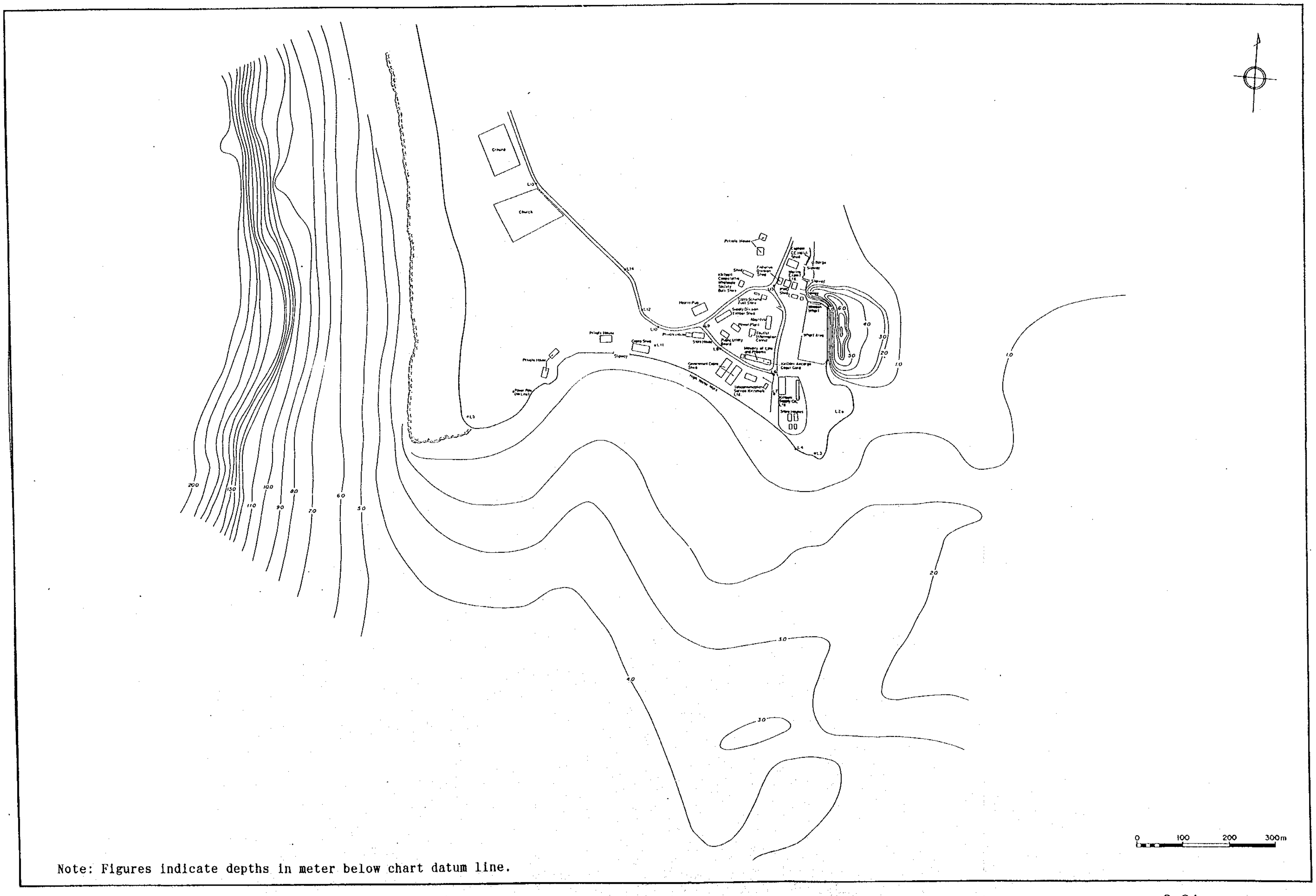
2.2.2 London Wharf

(1) Topography

The island of Christmas is the largest coral atoll in the country, and the land area is 388.39 km^2, accounting for about the half of the total land area of the country.

London Wharf is located at the north-west of the island and faces the lagoon side. But the wharf is close to the ocean connected through the opening of the horse's hoof shaped atoll and is not protected by any facilities such as breakwaters, jetties or groins. Therefore, the front sea area of the wharf has been shoaled up to only one metre depth, except the deeper sea area, approximately 8 metres deep, near the front of the wharf, where the original water depth dredged in 1950's has been partly kept.

The study team executed topographic and sounding surveys and the results are shown in Figure 2-2-12.



Note: Figures indicate depths in meter below chart datum line.

Figure 2-2-12 Topographic Map of London Wharf

(2) Meteorology

Rainfall averages 1,034 mm annually, but it is very variable, registering 3,728 mm (in 1987) and only 243 mm (in 1985) as shown in Figure 2-2-13. Temperatures vary between 24 ° and 30 ° C, humidity averages 70 per cent, and there is a predominant easterly winds, averaging 4.4 m/sec annually. A frequency of occurrence of easterly wind velocity less than 8 m/sec is 98 percent.

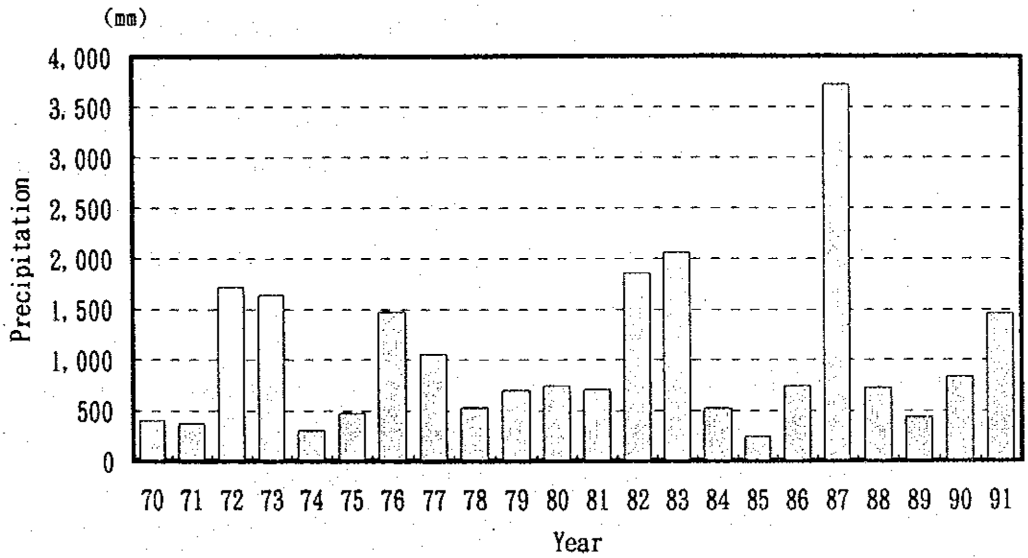


Figure 2-2-13 Annual Rainfall of Christmas, 1970-1991

(3) Sea Conditions

Information on the wave climate at Christmas is difficult to find. One source of data is the U.S. Navy Hindcast Spectral Ocean Wave Model Climatic Atlas, which gives an evaluation of the probable wave climate in an adjacent sector of the ocean. The evaluation is based on a model which uses historical records of North Pacific wind data and simulates the generation and propagation of associated waves. The reference cautions that it is not accurate near the equator because of a lack of records, and the fact that it deals only with northern hemisphere winds. It does, however, give an understanding of Christmas waves. Wave statistics from this reference are shown in Table 2-2-9.

Table 2-2-9 Wave Statistics
Percentage of Time (Wave from SW to N)

Month	Total	Greater Than 1 m	Greater Than 2 m	Greater Than 3 m
December	2	2	1	1
January	18	12	6	1
February	12	11	3	1
March	7	6	2	< 1
April	2	2	–	–
Total Year	3.5	2.7	1.0	0.3

Source: U.S. Navy Hindcast Spectral Ocean Wave Model Climatic Atlas

The table shows that for the major part of the year, waves are from a direction, clockwise north to south-west, which will have no impact on the existing wharf and the proposed jetty site. For a small percentage of time there will be waves affecting the site, with waves greater than 1 metre expected for 2.7 per cent of the year(average 10 days).

On the other hand, for the case of the extraordinary wave conditions, it is discussed in the "Report on Christmas Berthage Evaluation, 1989" that at times when waves do arrive from the north west these can be very large. The same swells which produce good surfing conditions in Hawaii carry on down the Pacific and eventually reach Christmas. At this stage they have decayed considerably but have still been described as twenty feet waves. Typically, these swells could occur an average of five or six times a season and produce difficult conditions for two days at a time. This was borne out by a yachtsman who had experienced three heavy swells in the two months he had been moored off Christmas.

The existing wharf is located at the west end of the opening of the atoll, 1 km away from the west ocean side, and faces the lagoon side. This topographical conditions typify that waves reaching the wharf have characteristics of primary surface wind waves and are occasionally accompanied by ocean waves from the opening. From these wave conditions including wave statistics mentioned above, the front sea area of the wharf is expected to be very calm throughout the year.

The proposed jetty site is located at the west end of the opening of the atoll and faces the ocean side, which means that the site is always directly affected by the ocean waves. Consequently, even though a frequency of occurrence of wave greater than 1 metre is 2.7 per cent, the site can not be considered to be calm because the waves are of a long period, more than 10 seconds. Since during the extraordinary wave conditions the waves of twenty feet could reach the site, consideration will have to be given to the design of the structure.

(4) Littoral Drift

The Study Team took survey on seabed materials to provide the fundamental information for the engineering evaluation of littoral drift.

The locations of sampling points are shown in Figure 2-2-14, and results of laboratory test are shown in Table 2-2-10.

The medium diameters vary from 0.140 to 2.100 mm, the D10 vary from 0.065 to 0.900 mm and the Uniformity Coefficients vary from 1.45 to 10.80. Seabed materials in the most points are very coarse with even the smallest D10 being 0.065 mm and have not a good distribution of grain sizes with the Uniformity Coefficient being less than 10.

Problems on littoral drift at London Wharf are understood as follow:

1) Sand Deposition in front of Wharf

There was once a sand spit in the south of the wharf which blocked incident wave from the ocean. Measures were taken to prevent erosion for many years, however, the spit has disappeared and a beach remains being parallel to the wharf. Incident waves from the ocean carry sediment from the south to the north and supply sand in front of the wharf.

Seabed, several metres away from the wharf, is deeper than 3 metres and this topography seems to be created with external force to the wharf. It is understood that standing waves in front of the wharf are generated by predominant easterly wind waves and that water particles trajectories under standing waves likely create seabed environment of sand deposit very close to the wharf.

Table 2-2-10 Characteristics of Seabed Materials

Sample No.	10 % Diameter D10 (mm)	Median Diameter D50 (mm)	Uniformity Coefficient D60/D10
1	0.350	0.810	4.00
2	0.370	0.900	3.24
3	0.370	0.570	1.68
4	0.280	1.500	6.43
5	0.900	2.100	2.89
6	0.330	0.460	1.45
7	0.130	1.000	10.80
8	0.082	0.190	2.80
9	0.065	0.140	2.77
10	0.093	0.200	2.58

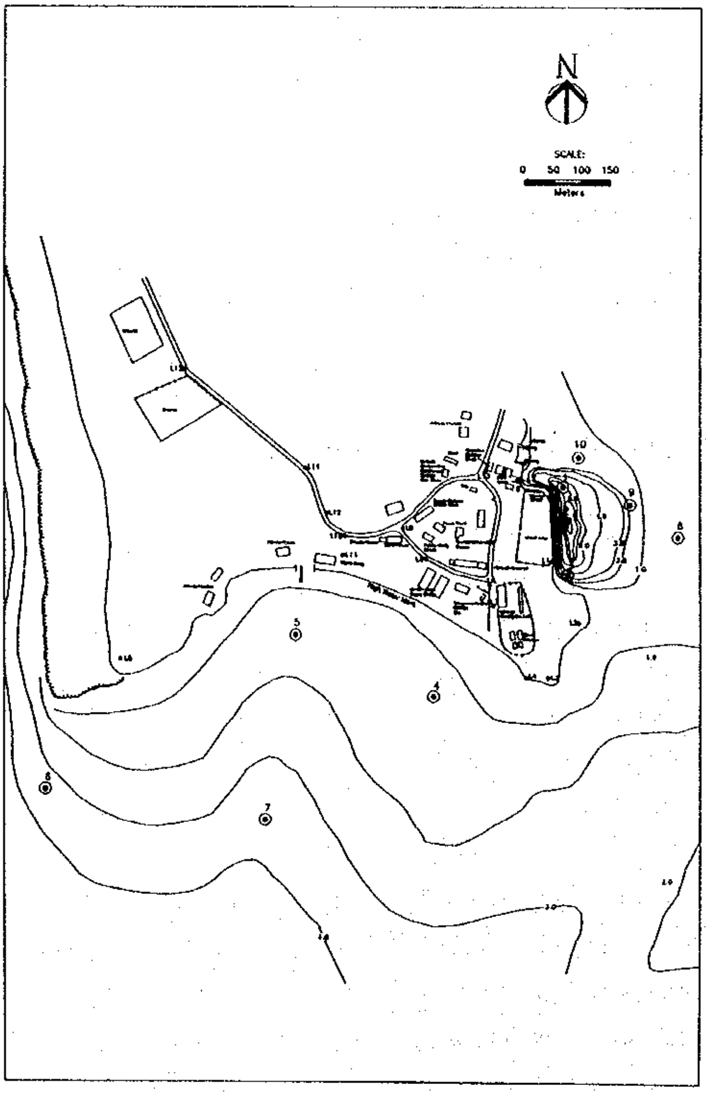


Figure 2-2-14 Locations of Sampling Points of Seabed Materials (London Wharf)

2) Insufficient Depth of the Channel

Large groynes will be required to maintain the channel if dredging is not done. An alternative measure is to plan waterway which will minimize dredging cost. Considering the site conditions, both construction of such groynes and channel dredging to maintain the channel will not be feasible from economical and environmental viewpoints.

2.3 Port Facilities

2.3.1 Existing Port Facilities of Betio Port

(1) General Description of the Betio Port

The Betio Port is located at 1°21.4'N; 172°55.9'W and plays a roll of the main port of Kiribati. The layout of the port is characteristically formed by the breakwaters named East and West Moles.

The East and West Moles protect an approach channel and a basin from waves and siltation.

On the tip of East Mole, buildings of Te Mautari and Marine Patrol are located and a fisheries jetty constructed with assistance from United Kingdom is provided from the Mole end. The jetty serves for fishing vessels, tankers, patrol boats and domestic cargo/passenger vessels. The pipe lines for unloading oil from tankers and bunkering are installed along the jetty from Mobil tank yard.

The old wharf for handling containers is located in the inmost part of the basin, where containers carried with flat barges are landed. The land area at the back of the wharf is used for container stacking and cargo storage.

The shipyard and slipway were constructed opposite the wharf for repair and maintenance services and the slipway was extended to 75 m in 1967/68 with provision of the existing buildings.

The outline of existing facilities at Betio Port is shown in Figure 2-3-1 and the principal facilities of the Betio Port including cargo handling equipment are summarized below and listed in Table 2-3-1.

(2) East and West Moles

The basin and approach channel of the port is made up by the two breakwaters of East and West Moles having a length of 610 m and 305 m respectively. Crown heights of the breakwaters were originally to be 10.3'(3.14 m) and the present heights vary between 2.90 m and 3.00 m.

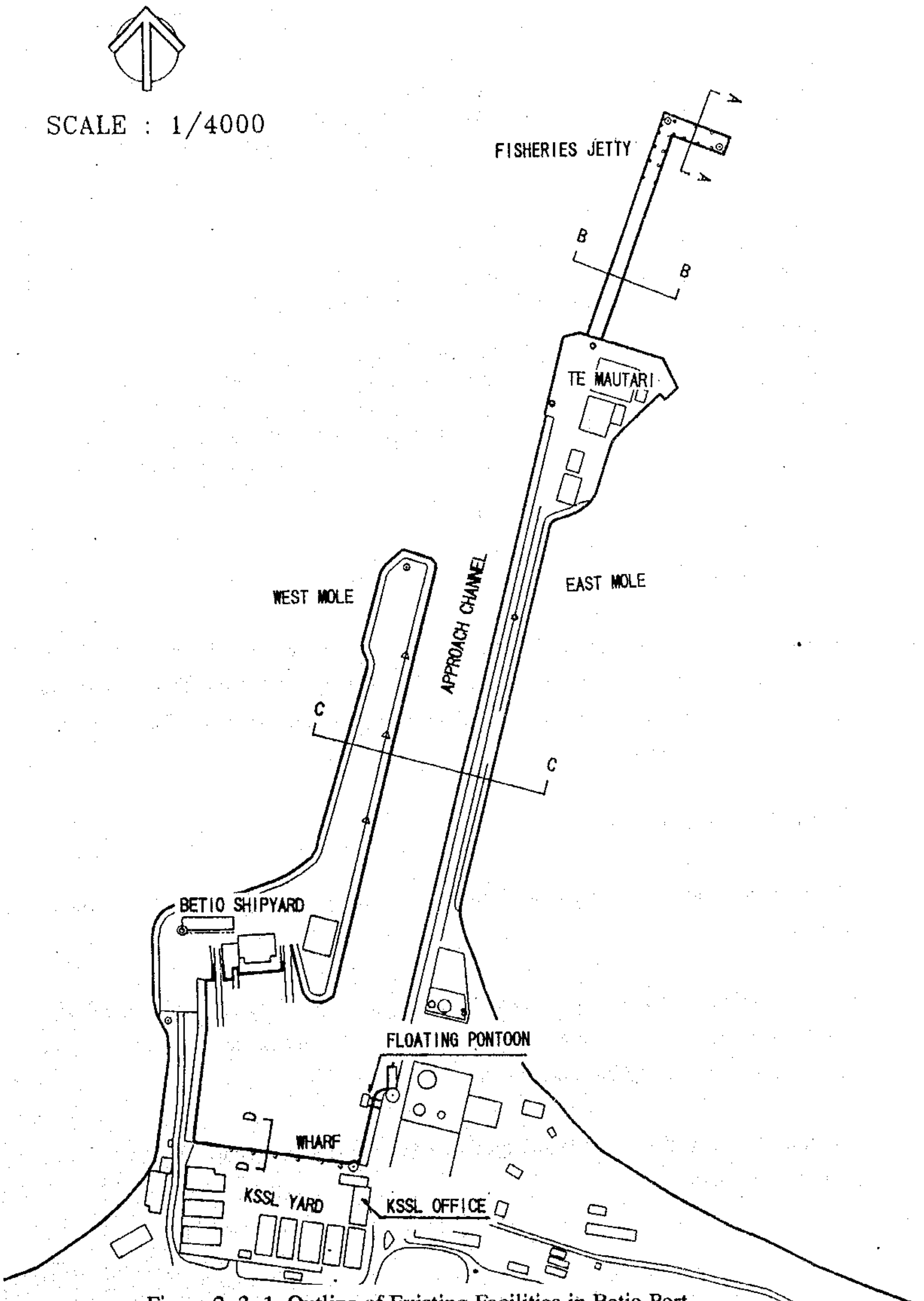


Figure 2-3-1 Outline of Existing Facilities in Betio Port

Table 2-3-1 Port Facilities in Betio Port

Facilities	Number	Remarks
East Mole	1	610m long
West Mole	1	305m long
Fisheries Jetty	1	220m long in total, 4 berths
Wharf	1	130m in total, abt 92m in net wharf length
Betio Light	1	
Buoy	7	
Beacon	7	
Bikeman Is. Beacon	1	
KSSL Office Building	1	534m2 in total floor area
KSSL Shed	7	351m2 × 5, 330m2, 165m2
KCWS Shed	1	351m2
Container Yard	1	3,200m2
Tugboat	3	210HP × 2 boats, (2 × 127HP) × 1 boat
Barge	4	18m × 6.5m × 1.5m, 18.35m × 6.65m × 1.5m 18m × 6.8m × 1.5m, 18.35m × 6.8m × 1.5m
Mobile Crane	1	15t (one sunk in Sept. '94)
Fixed Crane	1	32.5t
Crane Truck	1	3t
Fork Lift	3	2.5t
Chassis Trailer	14	

The structure of the facilities is shown in Figure 2-3-2. The mound slope is 1:1.5 and is protected with bagged concrete, 18" x 13.5" x 4.25" approx. each. The inner slopes of the both breakwaters are covered with the bags but outer slope of West Mole has no special slope protection.

(3) Approach Channel and Basin

The approach channel and basin are calm water areas protected by the above break-waters.

A cross section of the channel is shown on Figure 2-3-3. The original channel was 60'(18.3 m) wide and dredged to 10'(3.05m) below D.L. Since construction of the port the water area in the port has been silted.

The inner basin was originally dredged to 13'(3.96m) and is shallowed to 1 - 3 m deep due to siltation.

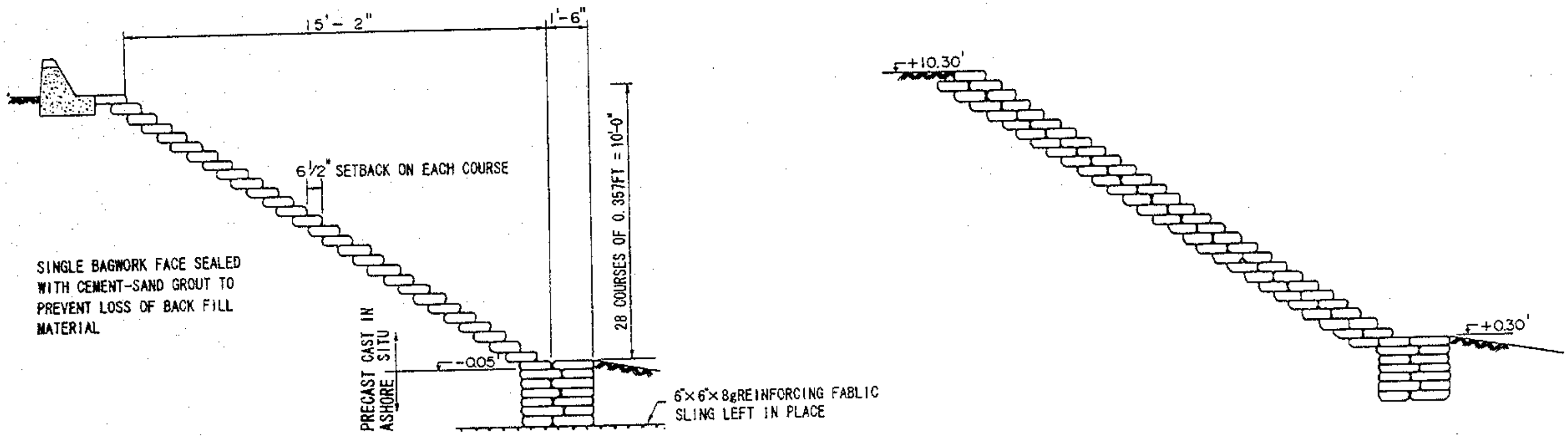


Figure 2–3–2 Typical Cross Section of Seawall (East & West Mole)

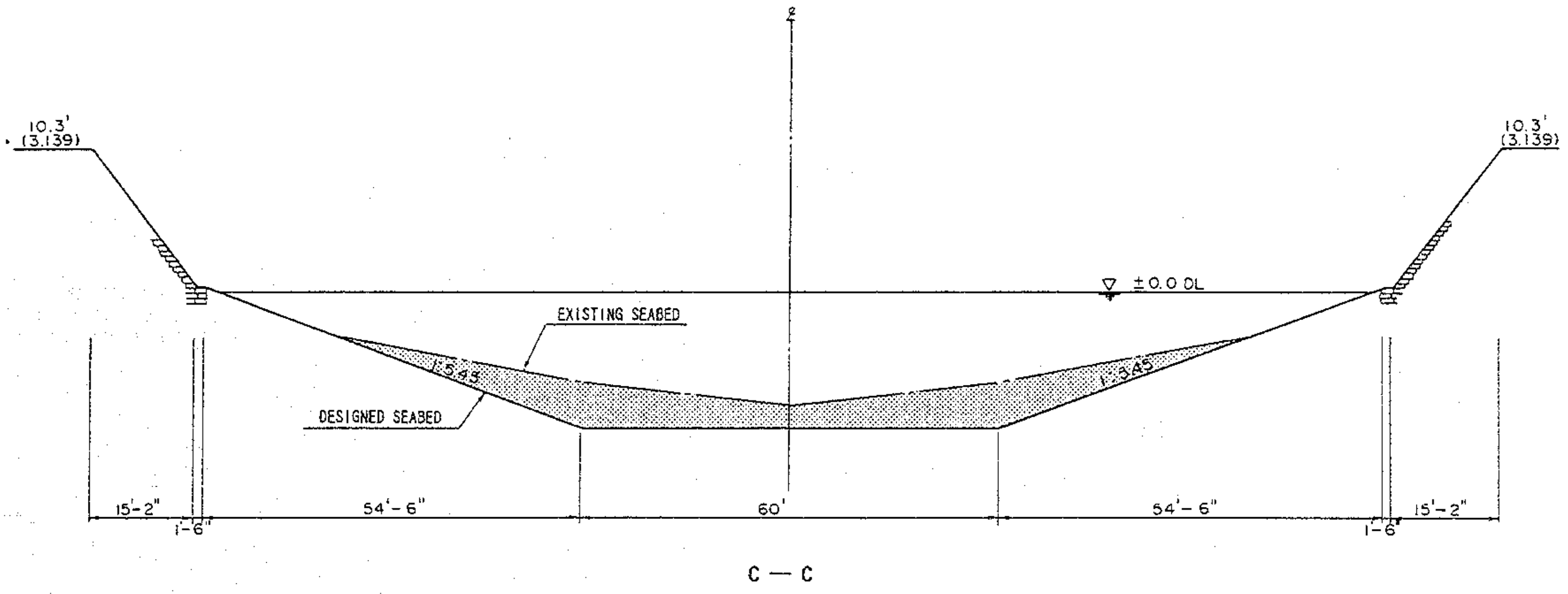


Figure 2-3-3 Typical Cross Section of Access Channel (Betio Port)

(4) Wharf

The wharf for landing container cargoes is located in the inmost part of the basin and is utilized by barges and small crafts.

The wharf measures 130 m and usable length of the wharf is reduced to 92 m because of shallow water depth, seawall slopes of the both ends and stairway at the eastern end of the wharf.

The typical cross section of the wharf is shown in Figure 2-3-4. It shows the structure of the wharf is of steel sheet piles with a concrete anchor wall. Front sheet piles of Frodingham No.3 of 32'-6" long are originally driven to secure water depth of 13'(3.96 m) but the present seabed is shallowed to 1 - 2 m deep due to siltation.

(5) Fisheries Jetty

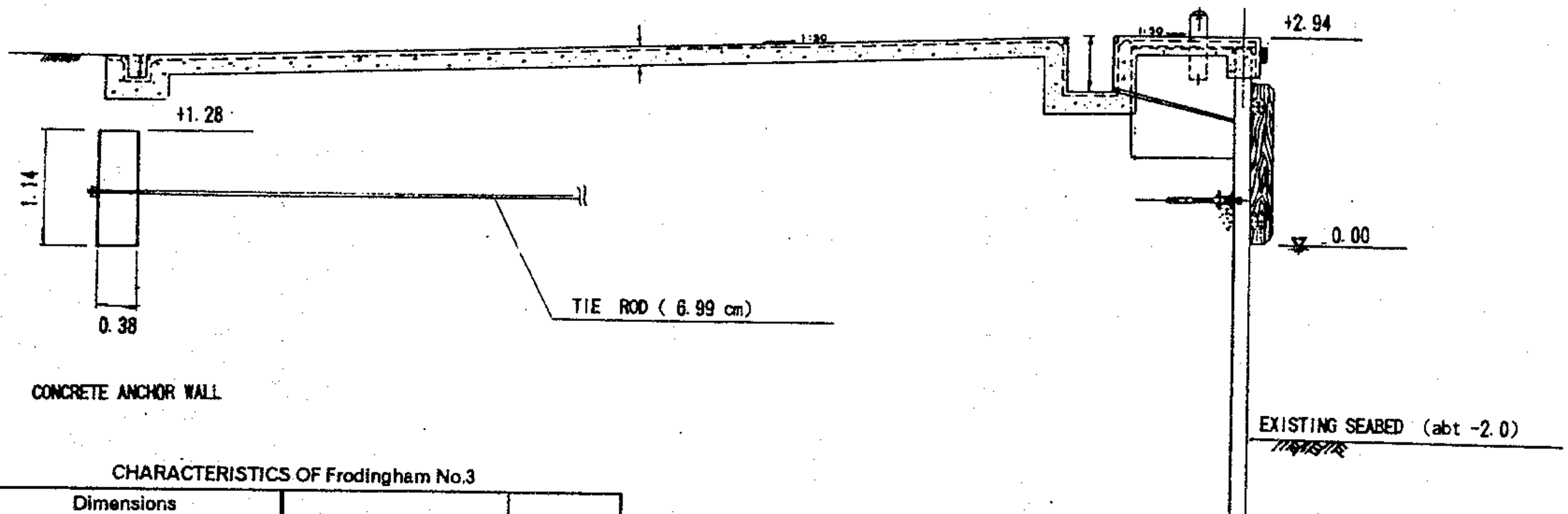
The new jetty was constructed in 1986/87 with UK assistance for promotion of fishery industry, especially Te Mautari.

The facility is outlined in Figure 2-3-5 and provides four berths shallower than 6 metres as follows:

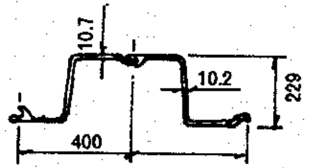
Berth No.1	49.8 m
Berth No.2	45.0 m
Berth No.3	32.6 m
Berth No.4	38.8 m

The structure of the jetty is an open-type pier with steel piles and its concrete superstructure of 10 metres wide deck is used as an apron for cargo handling. An approach trestle to the jetty is 126 m long and pipelines for bunkering, oil unloading and fresh water and electric wires are laid on its west side.

The jetty can not allow container handling, since the jetty is designed for handling only conventional cargo.



CHARACTERISTICS OF Frodingham No.3

Dimensions		
	Area Mass per meter	78.4
	Geometrical Moment of Inertia (cm4/m)	19,300
	Section Modulus (cm3/m)	1,538

D — D

Figure 2-3-4 Design Structure of Existing Wharf in Betio Port

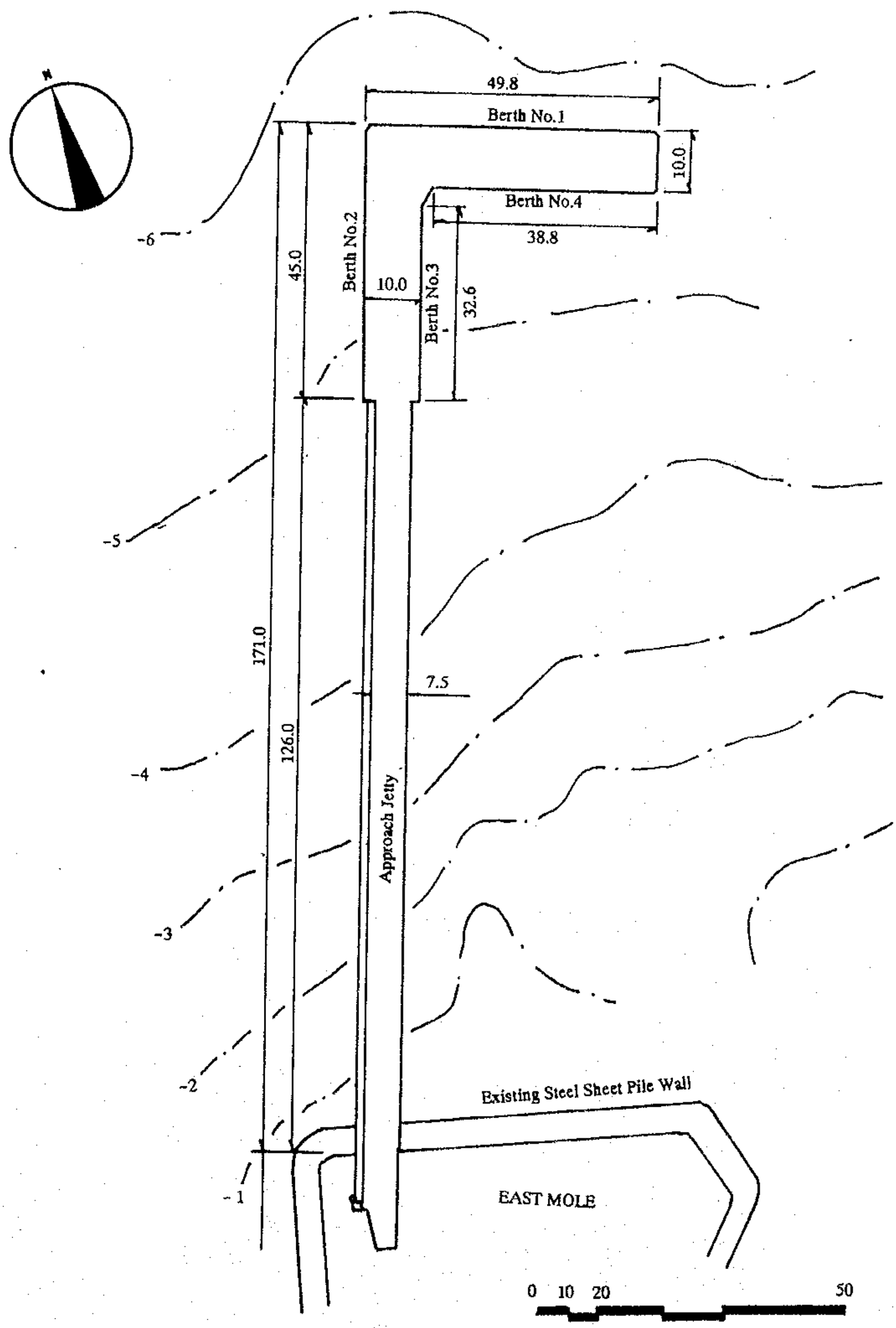


Figure 2-3-5(1) Layout of Fisheries Jetty

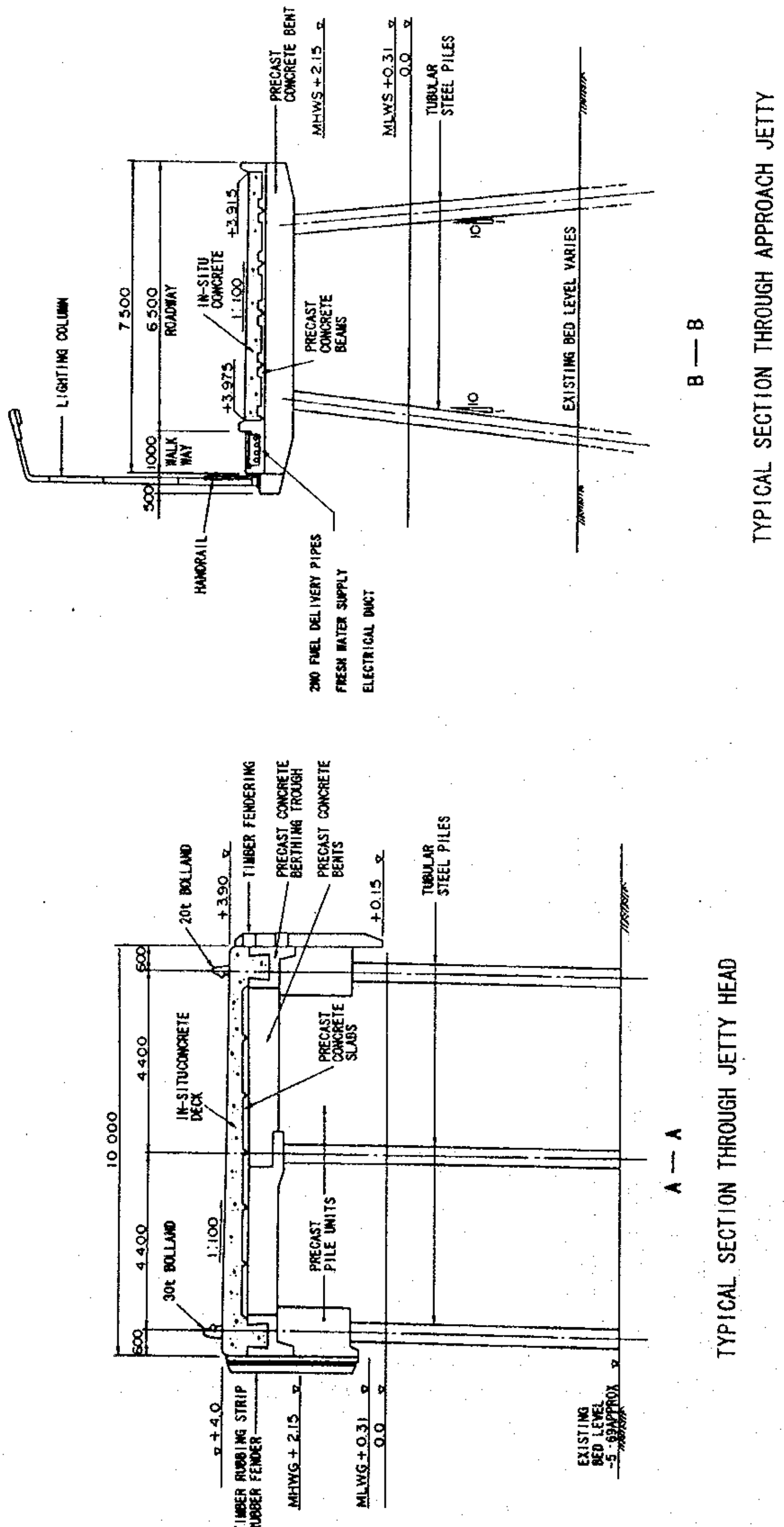


Figure 2-3-5(2) Typical Cross Section of Fisheries Jetty

(6) Open Yard Area, Sheds and KSSL Office

Figure 2-3-6 indicates the present layout of a container yard and sheds.

Both the concrete-paved apron and unpaved yard is used for stacking containers. Due to insufficient cargo handling equipment and storage area, full containers are stacked up to 6 high in the range of safety swing reach of the fixed crane, only on-shore equipment to lift a full container. Empty containers are stacked 3 to 4 high by using a mobile crane outside the fixed crane's swing range. The container yard is about 3000 m^2 but area of stacking slots is limited to about 1000 m^2. The yard is usually congested by vehicles taking delivery of container cargoes. Unstuffing of FCLs is done at ground level (sometimes even at 3rd tier level) where the FCL is located. This is largely prompted by the extreme lack of space.

Fixed lighting system has recently installed for night work.

All the sheds in the yard are listed in Table 2-3-2 with their present states. Three sheds are used for storing copra, three sheds for break bulk cargoes and one shed for cement. KCWS owns a grain shed in the yard also. Some sheds are ex-army sheds, and have not been given any maintenance over the years and are in a poor state of disrepair.

The KSSL office is in a fairly large size building housing its management and other staff on the second floor of 267 m^2 while the ground is used for a store room and workshop.

(7) Navigation Aids

Location and description of navigation aids in the Betio Port are shown in Figure 2-3-7 and Table 2-3-3 respectively. In general most buoys and lights are deteriorated. Charted names are not readable and top marks are damaged. Night navigation is not allowed in the port.

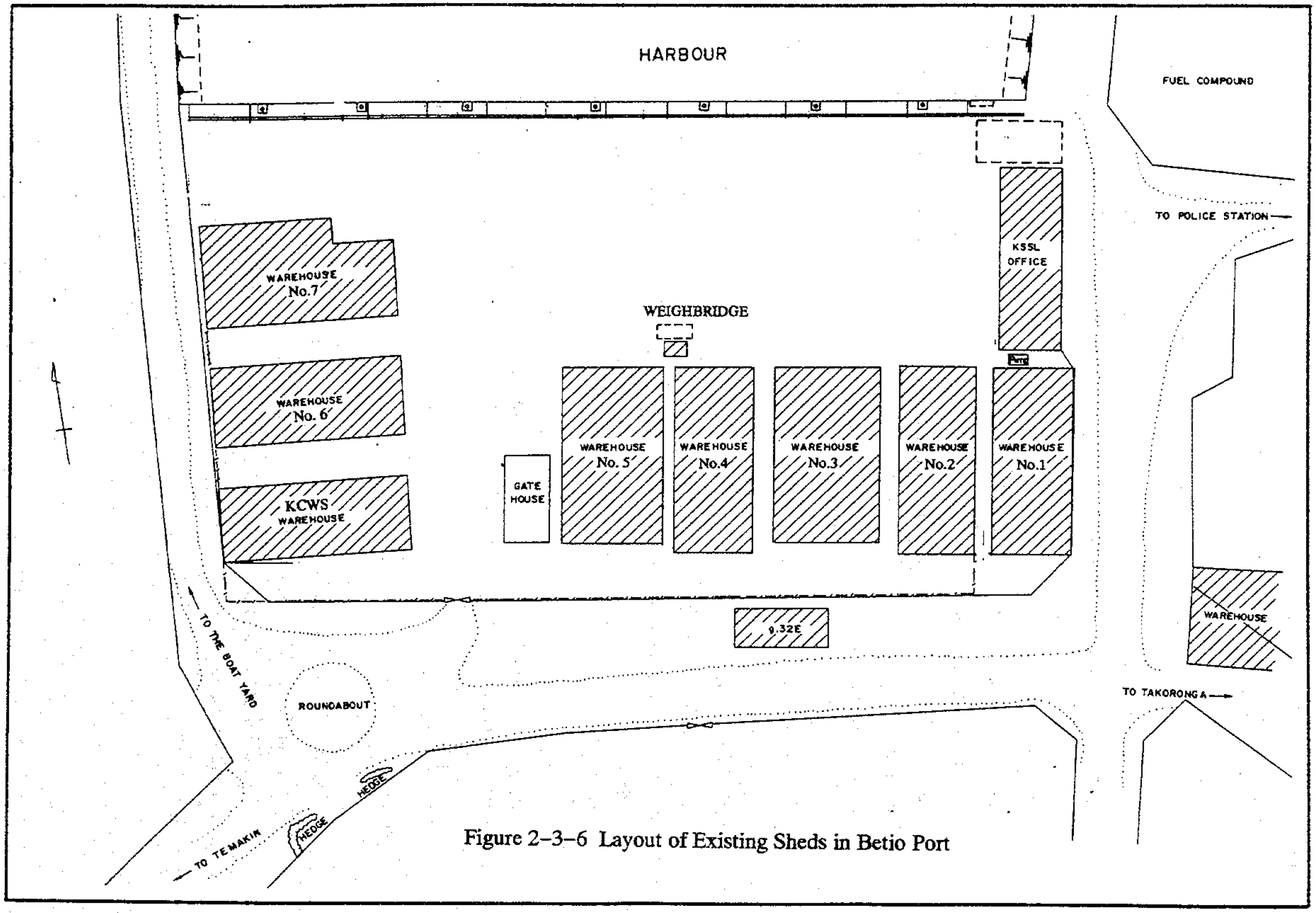


Figure 2–3–6 Layout of Existing Sheds in Betio Port

Table 2-3-2 Existing Sheds in Betio Port

Shed No.	Dimensions & Area	Use	Holding Capacity	Structural Type and State
1	12.2 m x 28.8 m = 351 m2	Copra	1000 t	A "Nissen Huts" type with steel frames in concrete base. No lighting and many leaky plasces in the roof
2	12.2 m x 28.8 m = 351 m2	Copra	1000 t	A "Nissen Huts" type with steel frames in concrete base. No lighting and many leaky places in the roof
3	11.7 m x 28.2 m = 165 m2	Breakbulk	206 t	Steel frames in concrete base. A few lighting tubes available but not satisfactory. Leaky places in the roof and walls
4	12.2 m x 28.8 m = 351 m2	Breakbulk	439 t	A "Nissen Huts" type with steel frames in concrete base. Leaky places in the roof and walls
5	11.2 m x 28.2 m = 330 m2	Breakbulk	413 t	Steel frames in concrete base. A few leaky places in the roof. Poor lighting system.
6	12.2 m x 28.2 m = 351 m2	Copra	1000t	A "Nissen Huts" type with steel frames in concrete base. No lighting and many leaky places in the roof.
7	12.2 m x 28.2 m = 351 m2	Cement	1000 t	Steel frames in concrete base. Many leaky places in the roof.
KCWS	12.2 m x 28.8 m = 351 m2	Grain	1000 t	Steel frames woth corrugated iron sheet. Leaky paces in the roof.

Total Floor Area: 2,601 m^2

KSSL OFFICE BUILDING

Total floor area :	534 m2
Items	
Office floor area :	267 m2
Store area :	267 m2

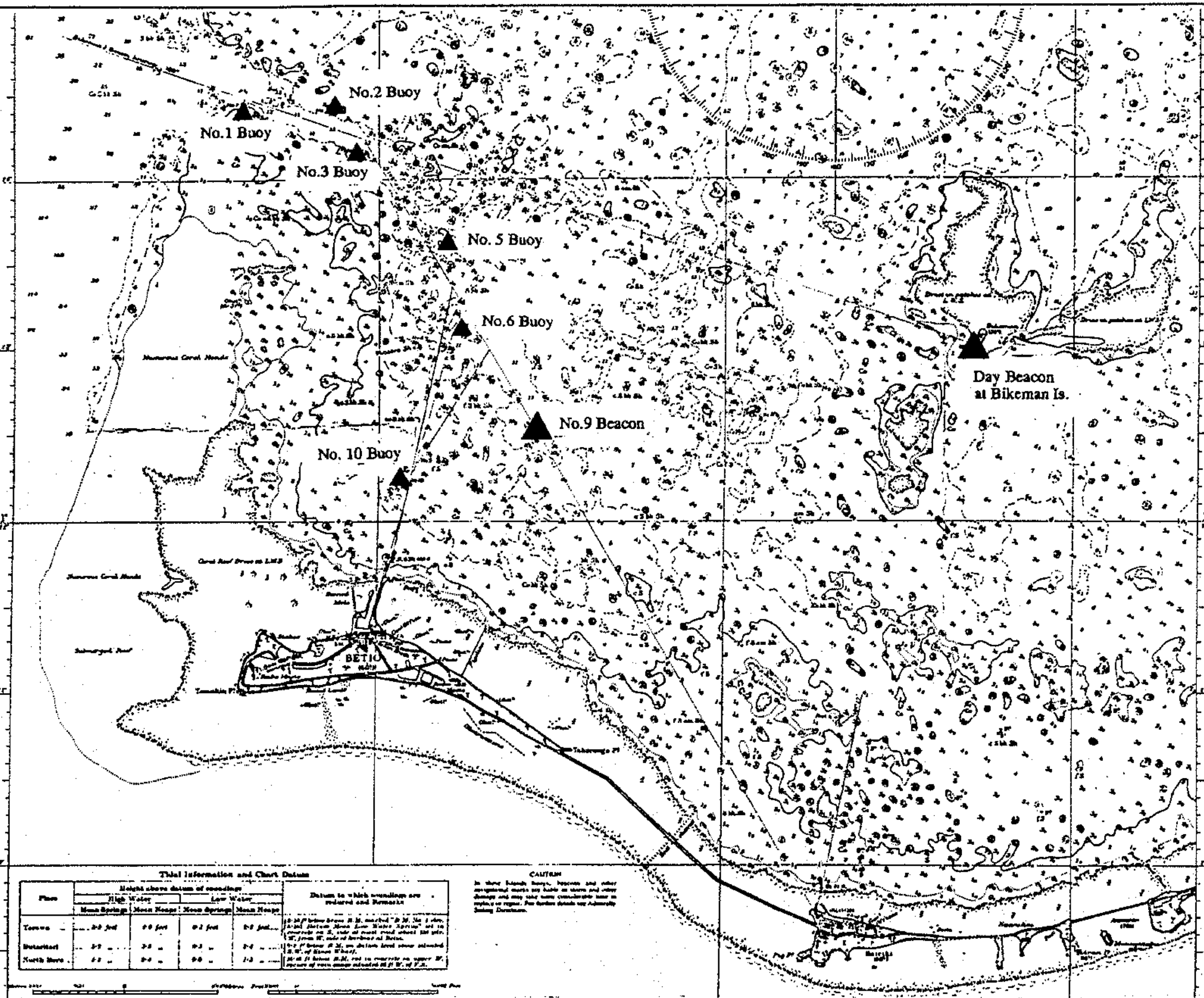


Figure 2-3-7 Existing Fairway and Navigational Aids

Table 2-3-3 Navigational Aids in Betio Port/Anchorage

Charted Name	Aquistion Year	Residual Life	Aquisition Cost (A$)	Present Conditions
No.1 Buoy	Nov. 1993	9	8149	Reflector damaged, No beacon. Rusted chain fron wrecks is used and yearly replaced with the same.
No.2 Buoy	Nov. 1993	9	8149	Reflector & beacon damaged. Wrecks chain is usd and yearly replaced.
No. 3 Buoy	Nov. 1993	9	3000	No reflector & beacon. Wrecks chain is used.
No.4 Buoy				Missing. Replacement of the buoy is recommended.
No. 5 Buoy	Nov. 1993	0		Drifting buoy is installed. Seriously rusted. No reflector & beacon. Wrecks chain is used.
No. 6 Buoy	Jan. 1994	9	2500	No reflector & beacon. Wrecks chain is used.
No.7 Buoy				Missing.
No. 8Buoy				Missing.
No.9 Beacon	1991	5	2900	Tripod composed of steel pipes and unstable. No reflector & beacon.
No. 10 Buoy	Nov. 1993	5	3000	Rusty reflector and damaged. Beacon damaged. Wrecks chain is used.
Day Beacon on Bikeman Is.	abt 30 years ago		3000	Leading marker for approaching No.1 Buoy is not used. Tripod of steel pipes with concrete tripod foundation. No reflector & beacon.

(8) Cargo Handling Equipment and Floating Equipment

Cargo handling equipment owned by KSSL is listed in Table 2-3-4. The fixed crane in the container yard plays a sole role to handle full containers to be landed from barges. The crane was donated by the Australia Government in 1993 and the main structure was manufactured in 1978.

Table 2-3-4(1) KSSL Floating Equipment

Type	Number	Capacity (Dimensions)	Acquisition Year	Manufacturer
Tugboat-Tabuariki	1	210 HP	1976	Betio Shipyard
Tugboat-Riiki	1	210 HP	1976	unkown
Tugboat-Teraoi	1	2 x 127 HP	1978	unkown
Barge (No.6)	1	18.35 m x 6.65 m x 1.5 m	1986	Betio Shipyard (or scrapped)
Barge (No.7)	1	18.00 m x 6.50 m x 1.5 m	1986	unkown
Barge (No.8)	1	18.00 m x 6.80 m x 1.5 m	1988	unkown
Barge (No.9)	1	18.35 m x 6.80 m x 1.5 m	1988	unkown

Table 2-3-4(2) Cargo Handling Equipment of KSSL

Type	Number	Capacity	Acquisition Year
Omega mobile crane	1	15 t	unkown
Favco fixed crane	1	32.5 t	
Crane truck	1	3 t	unkown
Bulldozer	1	D3	unkown
Fork lift	3	2.5 t	1993
Tractor	4		1985
Chassis -trailer	8	5 t	unkown
Chassis - trailer	6		unkown

There is no other equipment for handling full containers in the yard. Insufficient numbers of container handling equipment and small container yard are bottlenecks in improving efficiency of cargo handling.

A sample analysis of the usage time was done for the period 11–30 April 1993 and the results are shown in Table 2-3-5. Although this short period may not fully represent the actual year's position, it is clear that the usage time is very low.

Table 2-3-5 Usage of Cargo Handling Equipment
(April 1994 only)

Equipment	Usage time	Down Time	Idle Time
a. Container Crane	39 %	3 %	58 %
b. Small F/lifts (2.5 t)	31.3 %	–	69 %
c. Tractors (G/C)	24 %	5 %	71 %
d. Tractor/Trailer (Container)	6 %	–	94 %

2.3.2 Deterioration of Facilities of Betio Port

(1) Steel Sheet Pile Wharf

The steel sheet piles of the wharf has been badly corroded in a splash zone with many holes from where backfill soil is escaping. Wooden fenders originally installed in the frontage have all lost allowing further damages by ship's collision.

To access an economical remaining life of the wharf, thickness of steel sheet pile was measured with an ultrasonic thickness-meter and the results are shown on Table 2-3-6. The three measured sheet piles represent the present state of the corrosion. Measurement point No.1 is located at 11 metres from the east end; No.2 is at 46.5 metres from the east end; and No.3 is at 73.6 metres from the east end.

Table 2-3-6 Measurement Results of Steel Sheet Pile Thickness (m/m)

	Elevation		
Point No.	+ 1.0 m	± 0.0 m	- 1.0 m
No.1	-	5.9	8.9
No.2	-	5.4	9.1
No.3	8.2	4.9	-

Note: Blanks mean that measurement failed due to extreme rust

Original thickness of Frodingham No.3 used in a front wall is 10.7 mm. and the table shows original thickness of the sheet piles are considerably reduced.

(2) East and West Mole

East and West moles have been thoroughly inspected (see Figure 2-3-8) and their current conditions are summarized in Table 2-3-7. The slope protection with bagged concrete are damaged in many places and filling sand of the moles are exposed to wind waves.

An urgent repair to the moles are required to prevent further damage and eventual collapse.

Table 2-3-7 State of Seawall Damage in Betio Port

Referece	Description
(a)	Slipway concrete slab sunk with cracks and a cave-in
(b)	11 spots of 2 - 8 sq.m bagwork sunk
(c)	15 sq. m bagwork sunk , partially collapsed.
(d)	3 spots of 10 - 23 sq. m bagwork sunk
(e)	12 sq. m bagwork sunk
(f)	7 spots of 2 - 10 sq.m bagwork sunk.
(g)	30 sq. m bagwork sunk with several cave-ins.
(h)	No bag and filling sand in the area of 25 sq.m.
(i)	20 sq. m bagwork sunk
(j)	18 sq. m bagwork sunk.
(k)	50 sq. m bagwork sunk.
(l)	9 sqw. m bagwork sunk with vertical tilt.
(m)	16 sq. m bagwork sunk .
(n)	20 sq. m bagwork sunk .
(o)	3 spots of 2 -6 sq. m bagwork sunk.
(p)	Connection with coral rocks and bags for surface rotection is seriously deteriorated.

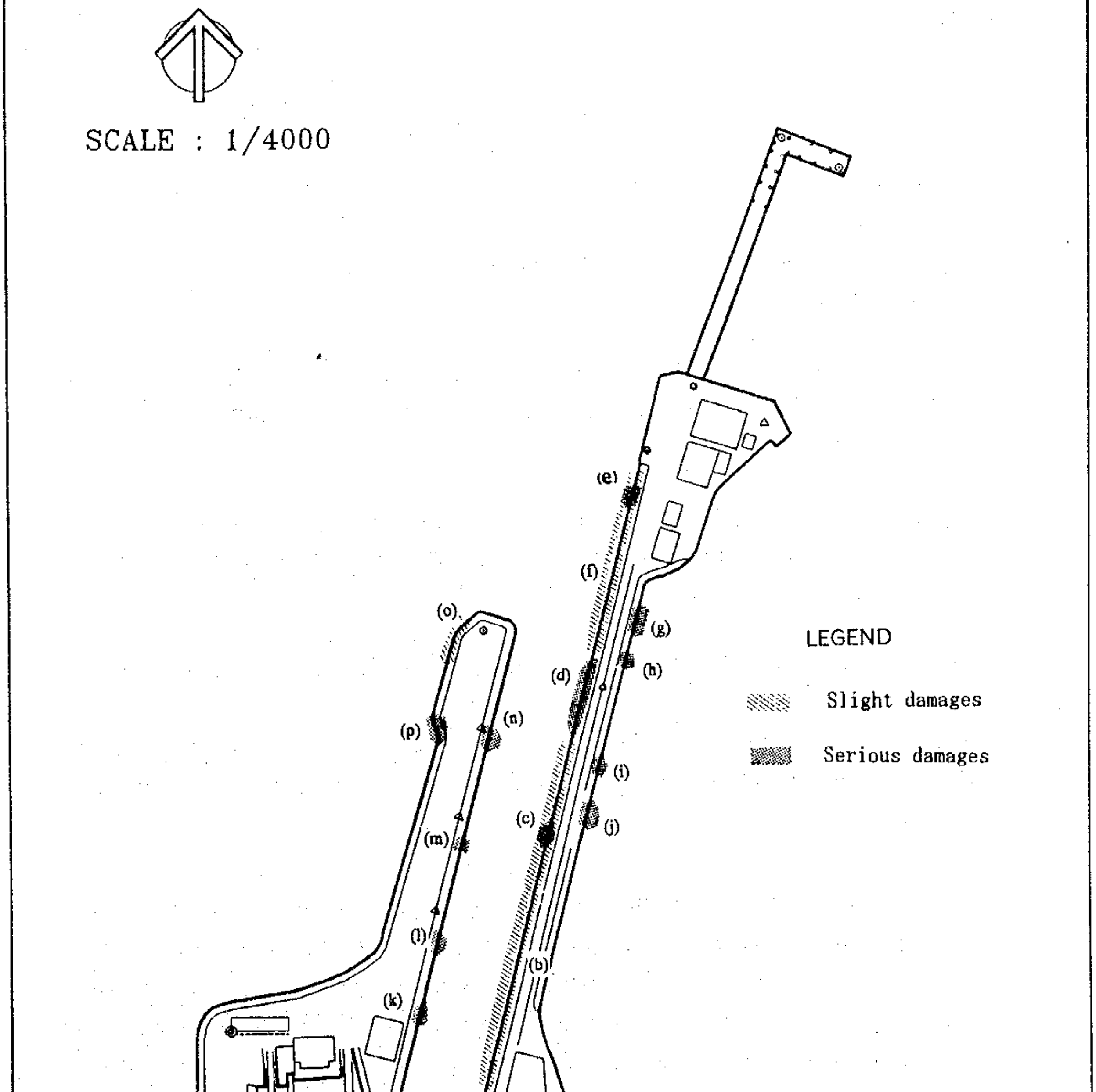


Figure 2-3-8 State of Seawall Damages

2.4 Port Activities

2.4.1 Sea Transport Sector

(1) Foreign Trade

Currently only two main foreign shipping lines have vessels calling at Betio Port :-

i) The Chief Container Service which makes monthly calls and serving New Zealand/Australia and Betio.

ii) The Bali Hai Line (which consists of a consortium of NYK, Mitsui-OSK, and Swire Shipping) makes a call once every two months, and serves Japan/Hong Kong and Betio.

iii) The Bank Line which calls occasionally on charter to load bulk copra. It is understood that a new charter smaller vessel will now replace the Bank Line vessels to export copra to Bangladesh.

iv) The local shipping line (KSSL) has started a feeder service to Tuvalu and Suva.

The inter-island shipping is being serviced by 23 small vessels mostly belonging to KSSL and other small private companies. Local vessels only work when no international ship is in port.

Cargoes imported to Kiribati are carried by three major shipping lines, CCS, KSSL and BHL and their shares are approximately 60%, 30% and 10% respectively. Out of these lines, KSSL has taken over sea transport services connecting Kiribati, Fiji, New Zealand previously done by MV Forum Micronesia by committing MV Arktis Trader. MV Arktis Trader is charactered for a short term from mid 1994 and is scheduled to be replaced with MV Micro Kiss for a long term December 1994.

While CCS has replaced MV Papuan Chief, a main carrier of Australian cargoes to Kiribati, with MV Baltimar Boreas due to unavailability of MV Papuan Chief by accident. MV Baltimar is smaller than MV Papuan Chief calling less ports on her voyage.

Shipping schedules and routes are shown in Tables 2-4-1 (1) to (5) and Figure 2-4-1.

Table 2-4-1(1) CHIEF CONTAINER SERVICE SCHEDULE (Papuan Chief)

DATE: 14/9/94

VESSEL	VOY	MBE	SYD	BNE	POM	ALO	POP	LAE	MAD	WEW	KIM	KAV	RAB	NOR	HON	NOU	VLA	SAN	TAR	FUN	FOE	WAL
CORAL CHIEF	59	15/9	18/9	21/9	24/9			28/9	30/9	1/10												
BALTIMAR BOREAS	9	15/9	19/9	22/9											26/9				30/9(3/10)			
HIGHLAND CHIEF	62	16/9	20/9	22/9							7/10	6/10	5/10		2/10	26/9	27/9	29/9				
PAPUAN CHIEF	39	19/9	21/9	24/9	28/9		1/10	2/10	4/10													
MOANA III	204	N/C	N/C	5/10												9/10	13/10				17/10	18/10
CORAL CHIEF	60	10/10	13/10	16/10	20/10	22/10		24/10														
BALTIMAR BOREAS	10	10/10	13/10	16/10											21/10				26/10(29/10)			
PAPUAN CHIEF	40	12/10	15/10	18/10							1/11	31/10	30/10		27/10	21/10	22/10	24/10				
HIGHLAND CHIEF	63	15/10	18/10	21/10	25/10			29/10	31/10	1/10												
MOANA III	205	N/C	N/C	31/10												4/11					9/11	10/11
CORAL CHIEF	61	2/11	5/11	8/11	12/11		15/11	16/11	18/11													
BALTIMAR BOREAS	11	(2/11)	6/11	10/10											15/11				20/11(27/11)			
PAPUAN CHIEF	41	8/11	11/11	14/11							30/11	29/11	28/11		25/11	18/11	20/11	22/11				
HIGHLAND CHIEF	64	10/11	13/11	16/11	20/11	22/11		24/11	26/11	27/11												
CORAL CHIEF	62	25/11	28/11	1/12	5/12			9/12	11/12													

Table 2-4-1(2) CHIEF CONTAINER SERVICE SCHEDULE (Baltimar Boreas)

DATE: 26/4/94

VESSEL	VOY	MBE	SYD	BNE	POM	ALO	POP	LAE	MAD	WEW	KIM	KAV	RAB	NOR	HON	NOU	VLA	SAN	TAR	FUN	FOE	WAL	FUT
BALTIMAR BOREAS	4	SLD	28/4	SLD	8/5										4/5								
PAPUAN CHIEF	36	SLD	28/4	30/4							18/5	17/5	16/5			5/5	6/5	8/5	12/5(20/5)				
CORAL CHIEF	54	3/5	5/5	8/5	12/5		15/5	16/5	18/5				20/5		22/5								
BALTIMAR BOREAS	5	N/C	14/5	18/5				23/5															
HIGHLAND CHIEF	58	14/5	17/5	20/5	24/5	26/5		28/5	30/5	31/5													
MOANA III	199	N/C	N/C	20/5												24/5						31/5	30/5
PAPUAN CHIEF	37	26/5	29/5	1/6							18/6	17/6	16/6			4/6	6/6	8/6	11/6(15/6)				
CORAL CHIEF	55	29/5	1/6	4/6	8/6			12/6							15/6								
MOANA III	200	N/C	N/C	10/6												14/6	17/6					22/6	21/6
HIGHLAND CHIEF	59	9/6	10/6	15/6	19/6		22/6	23/6	25/6	26/6													
CORAL CHIEF	56	22/6	25/6	28/6	2/7	4/7		6/7	8/7						11/7								
MOANA III	201	N/C	N/C	2/7												6/7						12/7	11/7
PAPUAN CHIEF	38	27/6	30/6	3/7							20/7	19/7	18/7			6/7	8/7	10/7	13/7				
HIGHLAND CHIEF	60	4/7	7/7	10/7	14/7			18/7	20/7	21/7													
CORAL CHIEF	57			24/7	28/7		31/7	1/8							5/8								
PAPUAN CHIEF	39	28/7	/7	3/8					20/8	19/8	18/8					6/8	8/8	10/8	13/8				

Table 2-4-1(3) KIRIBATI SHIPPING SERVICES LTD, SCHEDULE (Arktis Trader)

ISSUE: 0900 12/09/94

VESSEL	VOY. NO.	TARAWA ETD	FUNAFUTI	SUVA	FUNAFUTI	TARAWA	MAJURO
ARKTIS TRADER	04S/05N	-	-	-	-		KWAJALEIN SLD 08/09 AM
	AUCK-SLD 16/08		-	-	-	-	-
	VILA-SLD 22/08		-	-	-	IMPORT	-
	SANTO-SLD 24/08		-	SLD 29/08	NAURU SLD 4/9	11/09	MAJ SLD 10/09
ARKTIS TRADER	05S/06N	13/09	16/09	19/09	-	-	(MAJURO) 15-16/10
	AUCK 30-31/09		-	-	-	-	-
	NOU 29-30/09		-	-	-	-	-
	VILA 01-02/10		-	05/10	NAURU 11-12/10	18/10	-
ARKTIS TRADER	6S/ 7N	19/10	22/10	25/10	-		(MAJURO) 22-23/11
	AUCK 30-31/10		-	-	-	-	-
	NOU 04-05/11		-	-	-	-	-
	VILA 06-07/11		-	-	-	-	-
	SANTO 08-09/11		-	12/11	NAURU 18-19/11	25/11	-
ARKTIS TRADER	7S/ 8N	26/11	29/11	02/12	-	-	(MAJURO) 28-29/12
	AUCK 07-08/12		-	-	-	-	-
	NOU 12-13/12		-	-	-	-	-
	VILA 14-15/12		-	18/12	NAURU 24-25/12	31/12	-

NOTE : 1. CALLS TO SANTO EVERY ALTERNATIVE VOYAGES FROM AUCKLAND.
2. NOUMEA CALLS AS FROM "ARKTIS TRADER" V06 EX. AUCKLAND

Table 2-4-1(4) BALI HAI LONG TERM SCHEDULE (AS OF 12/SEP/94)

VSL	CI/29	PI/80	CI/30	PI/81	CI/31	PI/82
HKG	SLD	18-18/09	22-23/10	-	18-18/12	18-18/01
KAO	SLD	19-20	24-24	-	18-18	19-20
BSN	SLD	22-23	27-27	14-26/11 (D/DOCK)	23-24	23-24
(TKM)	-	-	-	-	-	-
KOB	SLD	25-26/09	29-31/10	28-28/11	26-27/12	26-27/01
NGO	SLD	27-27	01-01/11	29-29	28-28	19-20
YOK	SLD	28-28	02-02	30-30	29-30	31-31
TRW	-	06-08/10	-	08-10/12	-	08-10/02
LTK	21-21/09	12-12	14-14/11	14-14	11-11/01	14-14
SUV	22-22	13-13	15-15	15-15	12-12	15-15
APA	23-24	14-15	16-17	16-17	13-14	16-17
PGO	24-24	16-16	18-18	18-18	15-15	18-18
PAP	28-28	20-20	22-22	22-22	19-19	22-22
NUK	04-04/10	26-26	28-28	28-28	25-25	28-28
NOU	07-09	29-01/11	01-03/12	31-03/01	28-01/02	03-04/03
VIL	10-10	02-02	04-05	04-04	02-03	05-06
STO	11-11	03-03	06-06	05-05	04-04	07-07
HON	-	-	-	-	-	-

PI: MV Pacific Islander
CI: MV Coral Islander

Table 2-4-1(5) KIRIBATI SHIPPING SERVICES LTD. SCHEDULE (N. Matagare)

ISSUE: 0900 12/09/94

VESSEL	VOY. NO.	TARAWA ETD	FUNAFUTI	SUVA	FUNAFUTI	TARAWA	MAJURO	KANTON	KIRITIMATI (INCLUDING ALL LINE IS)
N. MATANGARE	08	SLD	SLD 05/09	SLD 8/9 2100HRS	SLD 12/09	15/09	-	-	-
N. MATANGARE	09	16/09	-	22/09	25/09	28/09	-	-	-
N. MATANGARE	10	30/09	03/10	-	-	23/10	-	06/10	10-16/10
N. MATANGARE	11	26/10	29/10	01/11	04-05/11	08/11	-	-	-
N. MATANGARE	12	10/11	-	16/11	19/11	22/11	-	-	-
N. MATANGARE	13	24/11	27/11	30/11	03-04/12	07/12	-	-	-

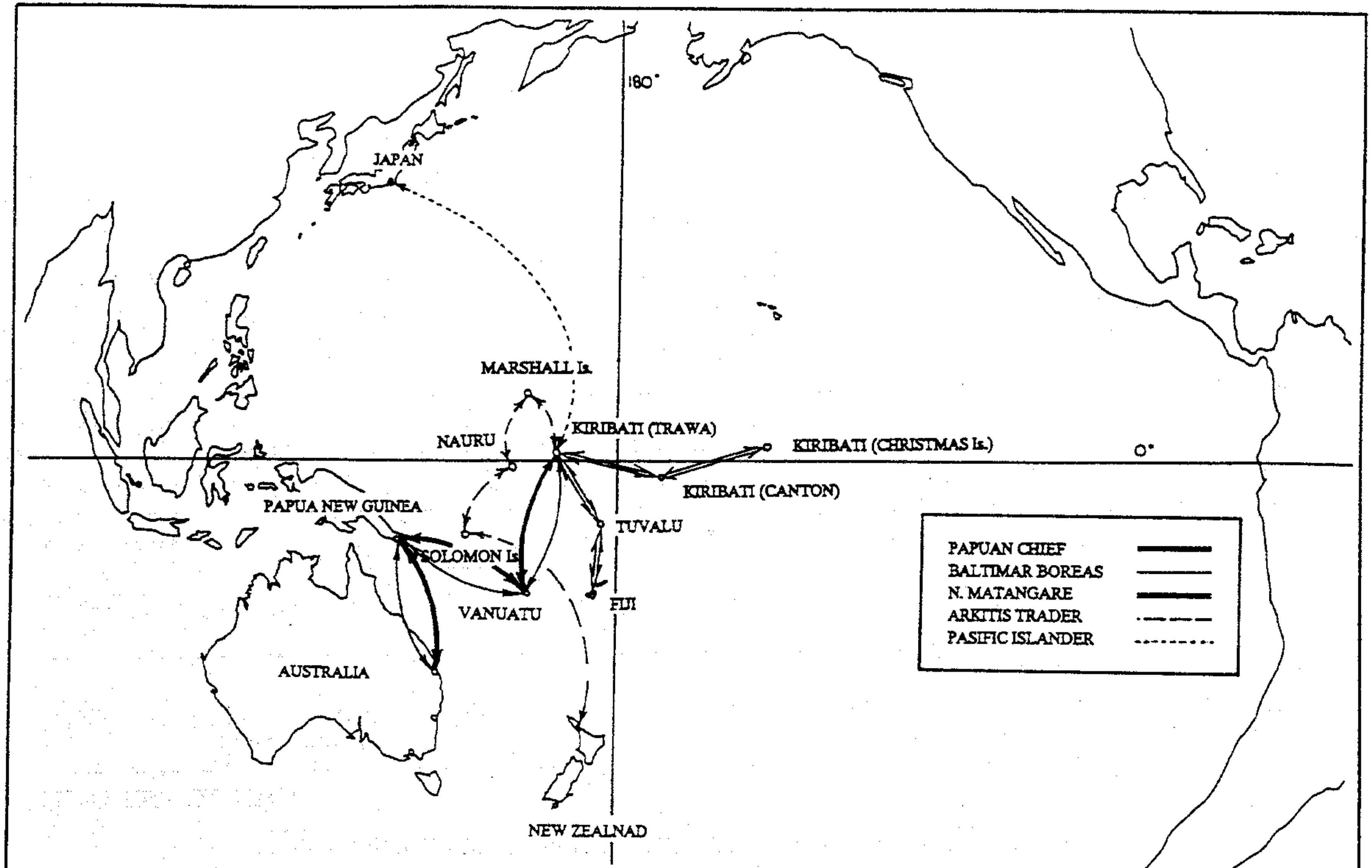


Figure 2-4-1 Shipping Routes of Major Container Carriers

(2) Domestic Trade

Domestic cargoes in Kiribati are transported by three sectors, namely KSSL, private ship operators and informal sector. KSSL was established in 1991 as a private self financial organization from a former semi-governmental "Shipping Corporation of Kiribati" (DCK) and occupies about 70% in domestic sea transportation. Private ship operators include three privately operated shipping companies, Waysam Kum Kee, Fern and Mat, while informal sector consists of church or provincial office operating small inter-island ships. Sailing distance of domestic trade is shown in Table 2-4-2.

2.4.2 Ships' Call

Table 2-4-3 shows ships' call at the Betio Port by ship's type for the period of 1989 to 1993. It shows that a average number of vessels calling at the port is 60 a year. A sharp increase of ship's call in 1993 is due to ships calling the port for refuge from tropical storms.

Tables 2-4-4(1) and (2) shows call and port time of such ships rendering regular services as Papuan Chief, Pacific Islander, Matangare, etc.

Papuan Chief renders monthly regular services and Pacific Islander once in two months. Forum Micronesia has been now replaced by Arktis Trader chartered by KSSL, for services between Kiribati, Fiji and New Zealand. Feder service from Kiribati to Funafuti commenced by Matangare in 1993.

Table 2-4-5 shows arrival draft and DWT of principal vessels called the port in 1993. Matangare recorded its arrival draft in the range between 4.5 m and 3.6 m. Maximum draft was 8.4 metres for Moraybank and Ivybank, copra carriers.

Table 2-4-6 and Figure 2-4-2 shows accumulated distribution of arrival draft excluding fishing vessels using the Fisheries Jetty. It shows that vessels not larger than Matangare shared 54% of total number of ship's call at the Betio Port.

Table 2-4-7 shows dimensions of domestic ships owned by KSSL, private ship operators and informal sector.

Table 2-4-2 Sailing Distance of Domestic Trade

NAURU	NAURU																																	
BANABA	164	BANABA																																
MAJURO	551	498	MAJURO																															
MAKIN	431	326	271	MAKIN																														
BUTARITARI	413	305	278	33	BUTARITARI																													
MARAKEI	417	290	350	79	70	MARAKEI																												
ABAIANG	401	259	353	105	82	30	ABAIANG																											
TARAWA	382	245	382	121	103	48	23	TARAWA																										
MAIANA	378	236	399	144	126	71	46	25	MAIANA																									
KURIA	395	240	450	191	179	114	98	79	61	KURIA																								
ARANUKA	406	248	463	202	189	122	108	91	72	15	ARANUKA																							
ABEMAMA	419	277	450	183	172	104	92	82	65	31	26	ABEMAMA																						
NONOUTI	450	288	534	256	250	182	172	155	139	81	68	82	NONOUTI																					
TABNORTH	472	310	570	294	282	216	192	198	178	117	105	117	39	TABNORTH																				
TABSOUTH	493	328	597	321	318	251	227	233	203	149	138	153	73	34	TABSOUTH																			
ONOTOA	522	360	615	346	338	271	248	254	231	181	168	171	105	63	32	ONOTOA																		
BERU	547	384	606	334	328	264	260	252	233	182	169	172	110	89	59	42	BERU																	
NIKUNAU	578	415	607	353	348	285	282	277	259	210	196	198	140	119	88	67	34	NIKUNAU																
TAMANA	556	399	640	397	386	321	315	302	273	229	216	224	152	112	82	55	73	76	TAMANA															
ARORAE	609	450	692	431	425	360	353	345	325	276	259	265	129	152	129	101	97	82	53	ARORAE														
FUNAFUTI	890	762	1058	823	805	726	755	724	711	650	618	640	582	532	502	472	479	480	430	373	FUNAFUTI													
CANTON	1281	1122	1191	1002	1000	943	960	958	940	920	908	900	861	858	810	780	750	720	752	686	645	CANTON												
GARDNER	1130	980	1131	902	898	828	850	830	810	792	758	760	728	700	660	616	610	580	598	533	443	203	GARDNER											
HULL	1248	1101	1221	1006	1010	994	970	950	938	912	884	886	850	830	790	743	736	700	720	670	574	107	144	HULL										
SYDNEY	1299	1154	1275	1061	1052	1010	1020	1008	1000	971	942	943	908	878	851	808	790	760	782	727	625	106	197	56	SYDNEY									
CHRISTMAS	2142	1985	1902	1729	1800	1743	1768	1770	1752	1740	1721	1718	1690	1676	1651	1620	1600	1564	1621	1570	1510	903	1102	970	930	CHRISTMAS								
FANNING	2040	1872	1821	1680	1690	1630	1652	1650	1648	1640	1630	1620	1608	1578	1562	1534	1510	1480	1530	1460	1462	832	1040	920	870	162	FANNING							
WASHINTON	1994	1828	1730	1590	1606	1578	1604	1620	1590	1600	1578	1562	1551	1540	1578	1488	1470	1430	1487	1401	1420	802	1010	908	852	240	81	WASHINTON						
SUVA	1414	1325	1687	1445	1426	1375	1345	1325	1307	1255	1235	1260	1195	1157	1124	1105	1117	1125	1063	1045	685	1145	965	1027	1065	1896	1855	1845	SUVA					
VILA	1087	1066	1570	1305	1290	1227	1202	1190	1170	1121	1105	1150	1082	1068	1050	1068	1085	1118	1020	1670	871	1500	1280	1380	1451	2311	2170	2250	623	VILA				
SANTO	962	943	1422	1210	1182	1122	1110	1102	1080	1034	1022	1070	1011	982	980	970	1011	1040	964	1002	860	1508	1274	1383	1470	2313	2174	2247	718	160	SANTO			
HONIARA	694	822	1256	1120	1100	1082	1060	1032	1042	1027	1030	1040	1034	1042	1040	1070	1112	1180	1170	1130	1223	1802	1550	1680	1171	2600	2520	2510	1353	858	600	HONIARA		
NUKUALOPA	1623	1514	1836	1610	1602	1530	1582	1512	1490	1451	1411	1440	1380	1338	1320	1288	1301	1302	1262	1240	862	1112	1020	1021	1040	1730	1772	1780	410	1014	1120	1654	NUKUALOPA	
PAGOPAGO	1502	1392	1580	1385	1378	1335	1329	1360	1388	1260	1271	1289	1195	1163	1180	1091	1082	1070	1059	1018	622	707	654	610	508	1260	1258	1292	680	1262	1350	1760	504	PAGOPAGO

Table 2-4-3 Number of Foreign Ships' Call

Year	Container Carrier	General Cargo Ship	Tanker	Copra Carrier	Fishing Boat	Others	Total
1989	25	23	9	3	2	1	63
1990	33	10	7	2	5	2	59
1991	31	7	10	2	1	1	52
1992	30	6	14	4	9	2	65
1993	29	15	11	5	9	23	92

Table 2-4-4 (1) Number of Principal Cargo Vessels, 1993

Ship's Name	Nos. of Call	Type of Service
Papuan Chief	11	Regular service from Australia
Pacific Islander	6	Regular service from Japan
Forum Micronesia	3	Regular service stopped
Matangare	10	Regular service for/from Suva & Funafuti
Moraybank	2	Copra carrier
Ivybank	2	Copra carrier
Momi	2	Irregular service
Mataburo	2	Irregular service
Moanaraoi	1	Irregular service

Table 2-4-4(2) Ships' Call and Port Time, 1993

Ship's Name (Container, G/C, Copra)	Nos. of Call	Waiting Time (hours)	Handling Time (hours)	Total Port Time (hours)
Foreign				
Papuan Chief	11	85.75	445.25	531.00
Pacific Islanders	6	72.00	173.00	245.00
Forum Micronesia	3	24.15	49.50	73.65
Ms Baltimar	1	80.00	20.00	100.00
Matangare	10	595.00	277.25	872.25
Mataburo	2	48.00	31.50	79.50
Momi	2	48.00	90.50	138.50
Moanaraoi	1	24.00	15.50	39.50
Capt. Cook	1	32.00	26.50	58.50
Moray Bank	2	30.50	210.00	240.50
Baltimar Euros	1	49.25	26.75	76.00
Ivy Bank	2	51.25	186.00	237.25
Paleisgracht	1	20.50	51.00	71.50
Aalsmeergracht	1	14.75	76.50	91.25
Blue Comet	1	3.50	21.00	24.50
MS Karaganda	1	15.00	69.50	84.50
Total	46	1,193.65	1,769.75	2,963.40
Domestic (KSSL)				
Tituabine	33	3,212.00	* 956.00	4,168.00
Nimanoa	20	1,770.00	* 527.00	2,297.00
Moanaraoi	9	2,075.25	606.75	2,682.00
Matangare	6	643.00	247.00	890.00
Momi	16	1,797.50	325.50	2,123.00
Mataburo	10	1,226.75	237.25	1,464.00
Total	94	10,724.50	2,899.50	13,624.00

Remarks * Estimation by Consultant

Overseas 46 calls Handling time 74 d (1,769.75 h)
Port time 124 d (2,963.40 h)

Domestic 94 calls Handling time 121 d (2,899.50 h)
Port time 568 d (13,624.00 h)

Table 2-4-5(1) Dimensions & Arrival Draft of Principal Ships, 1993

VESSEL	LOA	ARRIVAL DRAF	DWT	NRT	HNDG HRS	IN-PORT TIME
KARAGANDA	151.00	7.00	7,475.00	5,378.21		
B. TAURUS	91.00	4.20	3,200.00	1,104.00	20.00	100.00
P. ROVER	80.00	3.50	1,963.00	719.32		
F. MICRO	79.07	4.00	3,500.00	1,035.00	18.00	22.50
P. CHIEF	130.00	7.50	10,683.20	4,379.00	28.50	36.50
SUNRISE	48.32	3.50	508.90	165.27		
MOMI	42.00	3.00	361.51	143.00	62.50	62.50
SOLEIL Z	61.40	4.60	545.00	201.40		
P. ISLANDER	144.93	7.40	15,567.00	4,724.93	20.00	56.50
P. EXPLORER	72.00	3.00	1,688.00	595.61		
CAPT. COOK	100.00	5.60	7,726.75	1,140.87		
P. CHIEF	130.00	7.10	10,683.20	4,379.00	37.00	41.00
MATABURO	42.50	4.00		143.00		
P. TRADER	70.10	3.50	1,644.00	516.81		
F. MICRO	79.07	4.00	3,500.00	1,035.00	12.50	26.00
MORAYBANK	161.65	8.40	16,016.00	4,366.07	23.50	63.00
P. CHIEF	130.00	7.00	10,683.20	4,379.00	23.50	54.50
P. ISLANDER	144.93	6.10	15,567.00	4,724.93	16.50	21.00
F. MICRO	79.07	4.00	3,500.00	1,035.00	19.00	25.15
P. CHIEF	130.00	7.00	10,683.20	4,379.00	34.50	35.00
B. ENROS	91.00	3.60	3,200.00	1,104.00	26.75	76.00
MATABURO	42.50	2.90	431.60	143.00	15.75	39.75
P. TRADER	70.00	2.00	1,644.00	516.81		
IVYBANK	161.00	7.10	16,016.00	4,366.07	79.50	116.00
LOMOR	31.50	2.12				
MATANGARE	68.00	3.80	1,295.00	518.00	42.50	54.50
P. EXPLORER	72.00	3.50	1,668.00	595.61		
P. CHIEF	130.00	7.00	10,683.20	4,379.00	37.50	39.50
MATANGARE	68.00	4.00	1,295.00	518.00	45.00	45.00
DON JUAN	60.90	3.40	935.00	591.00		
P. ISLANDER	144.93	6.80	15,567.00	4,724.93	51.00	57.50
MARGARET	63.20	4.00	964.00	620.00		
JM. MARTINAC	66.10	5.00	1,230.00	886.00		
F. EXPLORER	116.50	4.60	5,083.52	2,053.02		
MILAGROS	60.00	5.00	1,014.00	674.00		
KASSANDRA Z	66.10	5.40	1,230.00	886.00		
MARISA Z	63.20	3.90	964.00	620.00		
S-PANAMA	91.19	5.40	4,273.00	1,592.80		
P. TRADER	70.00	2.50	1,644.00	516.91		
JM. MARTINAC	66.10	5.00	1,230.00	886.00		
LAURA Z	65.10	4.00	1,187.00	843.00		
P. CHIEF	130.00	7.10	10,683.20	4,379.00	63.00	68.50
MATANGARE	68.00	4.50	1,295.00	518.00	38.00	38.00
P. EXPLORER	80.00	4.50	1,688.00	595.61		
MOMI	42.00	3.00			28.00	28.00
RAT. GRACHT	129.00	6.00	11,850.00	4,160.00		

Table 2-4-5(2) Dimensions & Arrival Draft of Principal Ships, 1993

VESSEL	LOA	ARRIVAL DRAF	DWT	NRT	HNDG HRS	IN-PORT TIME
P. MARINER	75.00	4.00	2,140.00	696.00		
MATANGARE	68.00	4.00	1,295.00	518.00	30.75	30.75
P.CHIEF	130.00	7.10	10,683.20	4,379.00	46.50	53.00
P. ISLANDER	144.93	7.20	15,670.00	4,724.93	20.00	34.00
MATANGARE	68.00	4.20	1,295.00	518.00	48.00	264.00
P. EXPLORER	80.00	2.00	1,668.00	595.61		
AAL-GRACHT	129.00	3.00	11,850.00	4,160.00		
P. CHIEF	130.00	6.90	10,683.20	4,379.00	44.50	50.00
P. TRADER	70.00	2.50	1,664.00	516.81		
O. EXPRESS	107.31	5.90	4,559.90	2,847.00		
IVYBANK	161.65	8.40	16,016.00	4,366.07		
SOLEIL Z	61.40	4.00	545.00	201.40		
COSMOS KIM	61.34	5.00	713.00	369.50		
JAPAN STAR	116.42	7.60	5,123.00	2,237.99		
SPICA	117.80	6.00	7,000.53	2,893.00		
KASSANDRA	66.10	5.10	1,230.00	886.00		
MILAGROS Z	60.00	4.50	1,018.00	674.00		
F. EXPLORER	80.00	2.90	1,668.00	595.61		
MATANGARE	68.00	3.20	1,259.00	518.00	31.00	31.00
B. COMET	97.20	4.90	5,318.90	1,842.00		
MATANGARE	68.00	3.50	1,295.00	518.00		
P. ISLANDER	144.93	7.00	15,670.00	4,724.93	20.50	25.00
P. CHIEF	130.00	7.00	10,683.20	4,379.00	44.50	50.00
P. EXPLORER	80.00	3.00	1,668.00	595.61		
MOMI	42.00	2.00		143.00		
CHLOE Z	69.40	4.20	856.00	512.00		
C. MONARCH	150.60	5.50	15,291.00			
P. TRADER	70.00	2.00	1,664.00	516.81		
MATANGARE	68.00	4.00	1,295.00	518.00	7.00	49.00
MATANGARE	68.00	3.60	1,295.00	518.00	35.00	76.00
USS GERMANTOWN	185.80	6.70	15,988.00			20.00
P. CHIEF	130.00	7.10	10,683.20	4,379.00	45.00	49.00
MORAYBANK	161.45	8.00	16,016.00	4,366.07	121.50	141.50
MARGARET	63.20	4.40	964.00	620.00		
MOANARAOI	60.00	3.90	1,072.00	392.00	15.50	15.50
JAPAN STAR	116.42	4.60	5,123.00	2,237.99		
P. ISLANDER	144.00	7.10	15,567.00	4,724.93	45.00	51.00
P. TRADER	70.00	2.50	1,664.00	516.81		
MATANGARE	68.00	3.90	1,295.00	518.00		
P. EXPLORER	80.00	3.00	1,668.00	595.61		
P. CHIEF	130.00	6.40	10,683.20	4,379.00	40.25	74.00
MATANGARE	68.00	4.50	1,295.00	518.00		

Table 2-4-6 Accumulated Arrival Draft of Ships, 1993

Range of Draft	Nos. of Vessels	Accumulated Nos. of Vessels (Nos.)	Accumulated Nos. of Vessels (%)
2.0 - 2.5	7	7	11.5
2.6 - 3.0	7	14	23.0
3.1 - 3.5	5	19	31.1
3.6 - 4.0	12	31	50.8
4.1 - 4.5	5	36	59.0
4.6 - 5.0	2	38	62.3
5.1 - 5.5	0	38	62.3
5.6 - 6.0	2	40	65.6
6.1 - 6.5	2	42	68.9
6.6 - 7.0	7	49	80.3
7.1 - 7.5	9	58	95.1
7.6 - 8.0	1	59	96.7
8.1 - 8.5	2	61	100.0

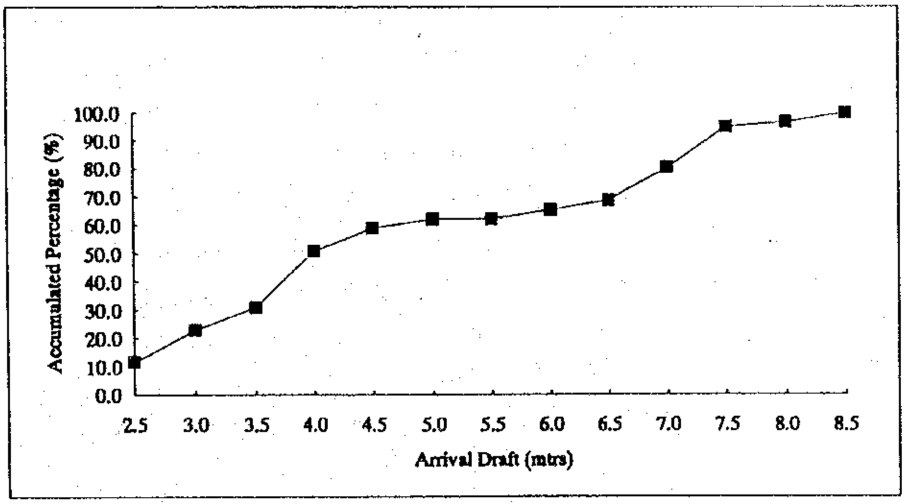


Figure 2-4-2 Accumulated Number of Vessels Calling at Betio Port

Table 2-4-7 Registered Vessels in Kiribati

		CLASS	GRT	LENGTH	BREATH	DRAUGHT(FULL LOAD)	
MV	MOANARAOI	DII	721.00mt	59.92m	9.61m	40.14m	SCK
"	NEI MOMI	DII	450.46"	42.50"	9.60"	3.00"	"
"	NEI MATABURO	DII	524.00"	42.50"	9.61"	3.201"	"
"	NEI TITUABINE	CI	57.00"	21.50"	6.10"	1.32"	"
"	NIMANOA	CI	78.00"	23.02"	6.10"	1.04"	"
"	TERAOI	CI	65.00"				"
"	RIKI	BII	19.00"	11.54"	3.68"	1.95"	"
"	NEI TEWENEI	CI	34.00"	10.00"	3.00"	1.08"	FISHERIES DIV.
MFV	NEI MOAIKA	CI	24.00"	25.00"	6.04"	1.95"	TEM
MV	TABUARIKI	BII	19.00"	11.54"	3.68"	1.95"	SCK
"	MATANGARE	DII	1291.00"	68.64"	11.80"	4.02"	SCK
FV	KAO NO1	DII	1015.00"	56.75"	11.40"	6.88"	KB-JP Joint
MV	TETAUU	DII	1957.00"	75.00"	13.04"	6.00"	KB-GOVT.TANKER
"	NEI TERINTARAWA	BII	5.00"	28.00ft	6.00ft	0.05"	
"	TEITINRAOI	CI	20.00"	17.01m	4.71m	1.29"	WKK
MFV	NEI TAEANG	CI	67.00"	9.45"	3.47"	0.95"	Norman.T.M
MV	NEI TEKIBOI	BII	5.00"	4.00"	1.02"	1.05"	KBC Protestant
"	NEI BWAE	BII	20.45"	12.19"	6.65"	1.24"	Lbaiang I.C.C
"	MAT 1	DI	727.00"	40.52"	7.04"	2.50"	Mat Shipping
"	MOAMOA	DI	608.00"	52.45"	9.00"	4.00"	Mautari
MFV	BAEAO	CI	34.00"	25.00"	6.04"	1.95"	"
"	TETIAROA	CII	32.00"	16.60"	3.62"	1.50"	"
"	NEI KANEATI	CII	129.00"	24.95"	5.40"	2.45"	"
MV	SANTO ANTONIO	BII	10.00"	12.15"	4.06"	1.04"	CM Abaiang
"	KABANEBANE	BII	5.00"	28.00ft	6.00"	0.05"	
"	JUDY SIERS	BII	20.45"	12.19m	6.65"	1.24"	
	MOAIKA		80.00"	20.15"	6.04"	Depth 2.33"	MAUTARI
	MARTHA		3.50"	11.00"	6.10"	" 1.00"	FERN
	TEIKARAOI		7.29"	10.22"	3.75"	" 2.45"	FERN
	ANGIRAOI		Laid up				NEREAU SHIPPING

2.4.3 Cargo Handled

(1) Foreign Cargo

Foreign cargo statistics are summarized in Table 2-4-8 and Figure 2-4-3 (1). Past trend shows steady increase with significant fluctuation. Total tonnage increased from 38,300 ton in 1983 to 61,950 ton in 1993 at an annual growth rate of about 5 %. In 1993, Betio Port handled total cargoes of about 61,950 ton comprising import container cargoes 50%, import break bulk cargoes 16%, import bulk fuels 15%, export copra 14% and export general cargoes 5%.

1) Export Cargo

Remarkable feature of export cargo is, as shown in Figure 2-4-3 (2), overwhelming share of copra and its fluctuation. Production of copra is controlled by rainfall and the production drops after the year of small rainfall. In the past 10 years, the largest export volume was recorded at 10,189 ton in 1984, while the smallest in 1986 at 3,490 ton being about one third of the largest. The other export cargoes total in order of from 1,000 to 3,000 ton in recent years consisting of fish, seaweed, etc. and also shows considerably high fluctuation.

Table 2-4-8 Export/Import Cargo Statistics, 1983-1993, Betio Port

Year	Import						Export			G. TOTAL
	CONT'	TEU	B.BULK	TOTAL	B.FUEL	IM. TOTAL	COPRA	G.CARGO	EX. TOTAL	
1983	11,561.5	625	11,656.2	23,217.7	6,999.4	30,217.1	5,854.9	2,232.5	8,087.4	38,304.5
1984	13,485.7	687	8,924.7	22,410.4	6,572.8	28,983.2	10,189.0	1,522.4	11,741.4	40,724.6
1985	15,083.9	784	5,019.8	20,103.7	5,091.2	25,194.9	8,516.5	563.7	9,080.2	34,275.1
1986	14,511.4	733	17,562.0	32,073.4	5,295.2	37,368.6	3,490.2	682.3	4,172.5	41,541.1
1987	18,880.5	982	10,095.8	28,976.3	6,311.4	35,307.7	3,898.0	807.6	4,705.6	40,013.3
1988	18,845.4	932	8,299.1	26,784.5	7,125.9	33,910.4	8,778.0	764.8	9,542.8	43,453.2
1989	22,638.7	1,243	7,000.0	29,638.7	6,605.1	36,243.8	8,622.0	1,390.8	10,012.8	46,256.6
1990	29,044.6	1,547	7,417.1	36,461.7	7,569.2	44,030.9	3,664.0	1,283.7	4,947.7	48,978.6
1991	26,196.6	1,373	4,636.0	30,832.6	8,910.2	39,742.8	5,308.0	1,043.5	6,351.5	46,094.3
1992	25,380.9	1,294	6,949.4	32,330.3	9,463.8	41,794.1	9,907.0	823.1	10,730.1	52,524.2
1993	31,079.9	1,549	9,704.3	40,784.2	9,125.2	49,909.4	8,587.0	3,454.1	12,041.1	61,950.5

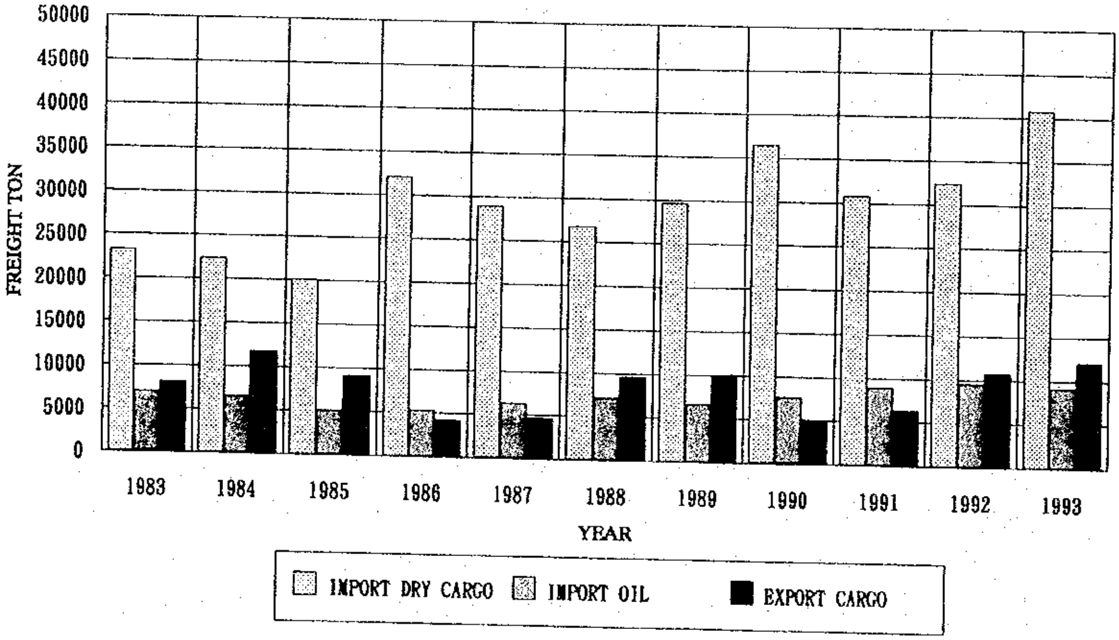


Figure 2-4-3(1) Overseas Cargo, 1983-1993, Betio Port

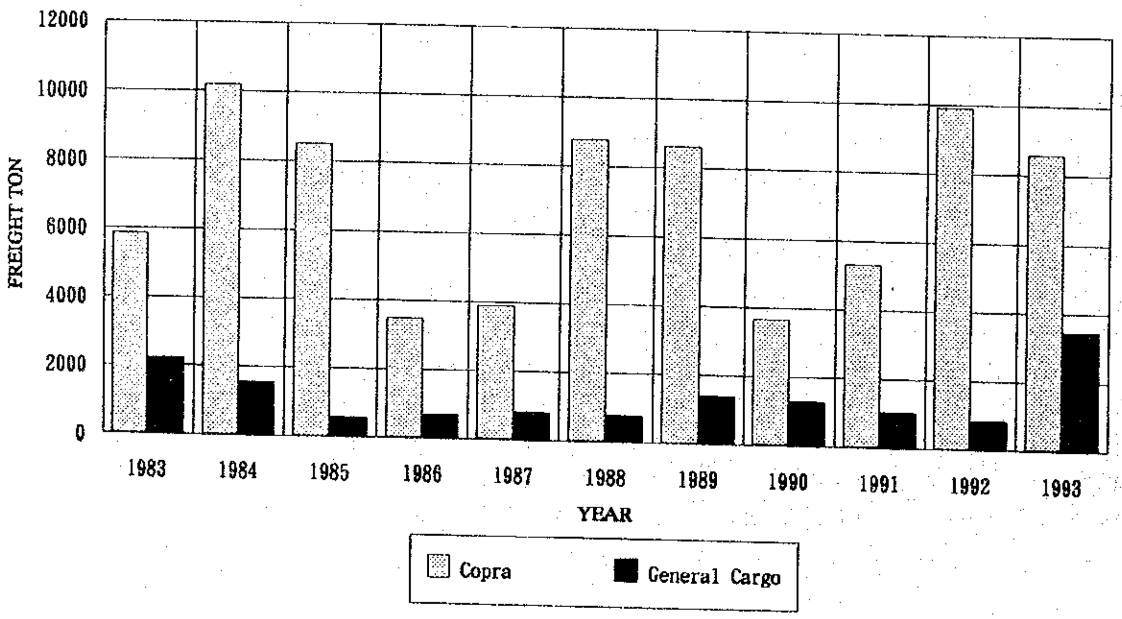


Figure 2-4-3(2) Export Cargo, 1983-1993, Betio Port

2) Import Cargo

Major import cargoes are containerized foodstuff and other daily requirements and bulk fuel imported from Fiji. Containerized cargoes have been increasing with comparatively small fluctuation, while the volume of break bulk cargoes increases when a large project requiring break bulk construction materials is implemented as shown in Figures 2-4-3 (3) and (4).

Bulk fuel does not show significant yearly fluctuation falling in order of 5,000 to 9,000 ton.

Containerization rate has shown steady increase from about 60% in mid eighties to 80% after 1990.

3) Transship Cargo

Until mid 1993, when KSSL commenced transship service to Tuvalu by MV Nei Matangare, almost all the imported cargoes have been locally consumed. Thereafter, the import cargoes are broadly classified into three categories, namely cargoes consumed in South Tarawa, cargoes transshipped to Outer Islands and cargoes transshipped to Tuvalu. The cargoes of the first category do not need any secondary sea transportation, while the cargoes of the second and third categories are transshipped by domestic and foreign carries respectively.

(2) Domestic Cargo/Passenger

Statistics of domestic cargo and passenger carried by private ship operators and informal sector are not recorded and whole picture of domestic cargo and passenger movement is estimated by the record kept by KSSL.

1) Domestic Cargo

Domestic cargoes carried by KSSL ships are shown in Table 2-4-9 (1) and Figure 2-4-4(1). In 1993, domestic cargoes totaled at about 14,500 ton with outward general cargo accounting for 63%, inward general cargo for 8% and inward copra for 29%.

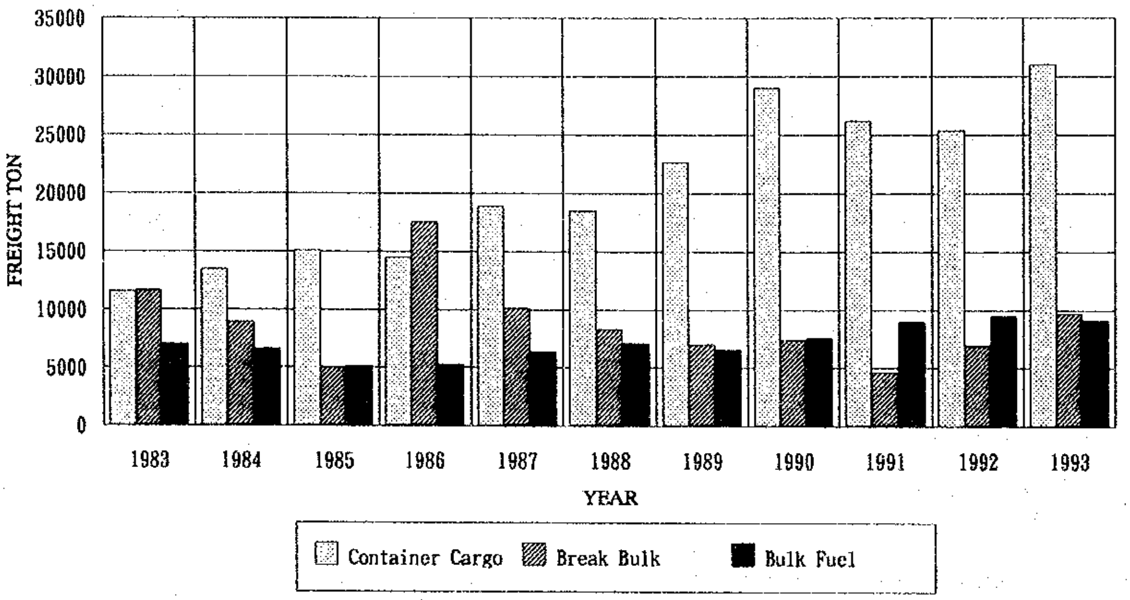


Figure 2-4-3(3) Import Cargo, 1983-1993, Betio Port

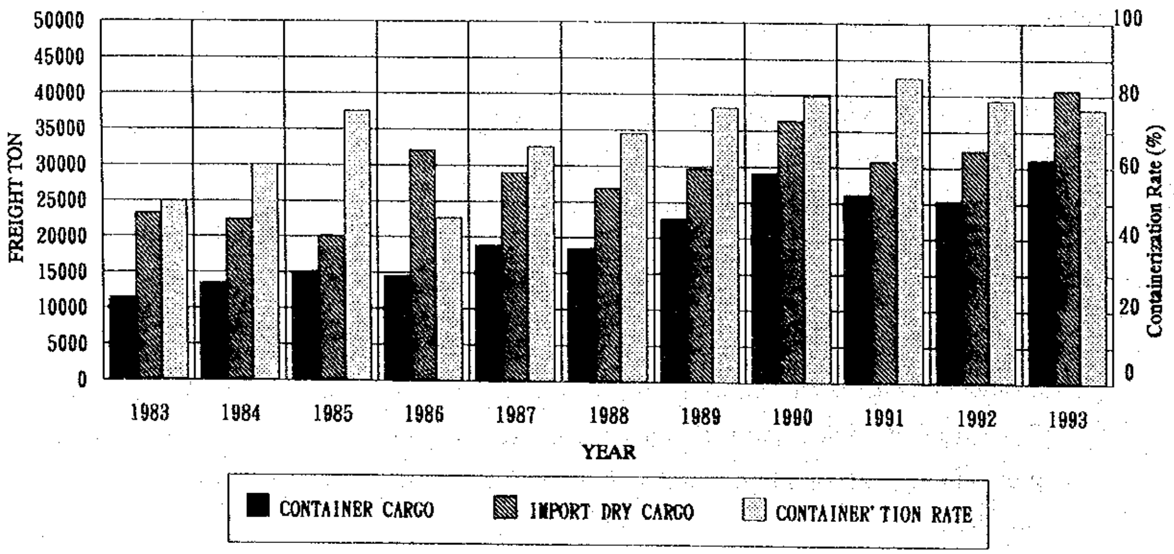


Figure 2-4-3(4) Container Cargo, 1983-1993, Betio Port

2) Domestic Passenger

Table 2-4-9 (2) and Figure 2-4-4(2) show domestic passenger statistics. In 1993, KSSL ships carried about 10,800 persons. Numbers of inward and outward passengers are almost the same and interisland passenger account for about 10 % of total. In 1991 and 1992, passenger traffic exceeded the past trend due to transport of a large number of immigrants to Line Islands.

2.4.4 Cargo Handling Operation

(1) Container and General Cargo

Betio is currently a lighterage port, and cargo is transferred from vessel to shore or vice-versa by using a barge towed by tug. Larger international vessels anchor off-shore and inter-island vessels of the Kiribati Shipping Services Ltd. anchor near to the port. Containers ex foreign vessels are handled in the same manner, which is cumbersome, slow and costly with double handling.

To transfer the containers and general cargo from ship to shore or vice-versa, the stevedores go on board the foreign/local vessels, and using the ship's gear, discharge the containers/general cargo onto 3 flat top barges which are then towed one by one to the wharf.

A fixed tower (second-hand) crane on shore is used to unload the full FCLs onto the stack at the wharf side. This stacking area is heavily congested as it was not meant for container stacking hence the FCL containers are sometimes stacked 6 high in a block in a very tight area (approx. 75m x 35m) leaving hardly any room for handling general cargo. There is practically no wharf apron.

A mobile crane is used to unload general cargo from the barges onto trailers for transfer to open storage or in the sheds. Sometimes this mobile crane is used to transfer empty containers from stack at the wharf to the barges for eventual export.

Table 2-4-9(1) Domestic Cargo Statistics, 1983-1993

Year	OUTGOING	INCOMING	COPRA	TOTAL
1983	4,543.3	444.3	3,038.6	8,026.2
1984	5,892.6	867.0	5,536.9	12,296.5
1985	5,942.9	1,044.6	4,334.1	11,321.6
1986	5,722.9	1,109.7	2,758.6	9,591.2
1987	6,427.4	827.4	2,806.1	10,060.9
1988	8,908.3	942.3	8,717.8	18,568.4
1989	7,380.4	1,246.7	6,648.4	15,275.5
1990	7,134.5	1,267.7	3,249.1	11,651.3
1991	9,498.1	1,661.3	4,085.7	15,245.1
1992	11,624.9	2,038.2	5,049.2	18,712.3
1993	9,081.5	1,153.7	4,032.7	14,267.9

Table 2-4-9(2) Passenger Statistics, 1983-1993

YEAR	OUTGOING	INTER IS.	INCOMING	TOTAL
1983	2,362	663	1,856	4,881
1984	2,603	687	2,319	5,609
1985	2,314	1,241	2,863	6,418
1986	3,505	687	2,900	7,092
1987	4,375	498	3,910	8,783
1988	4,486	496	4,038	9,020
1989	4,356	1,227	4,150	9,733
1990	4,589	576	4,078	9,243
1991	7,887	950	5,530	14,367
1992	8,093	1,051	5,032	14,176
1993	4,696	863	5,199	10,758
AVERAGE	4,479	813	3,807	9,098

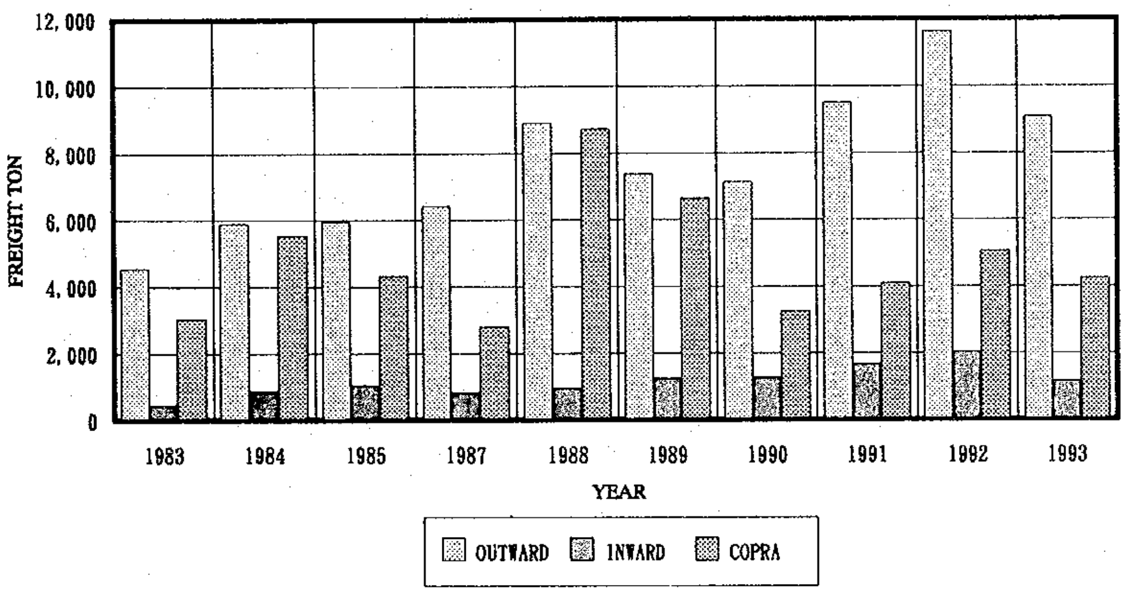


Figure 2-4-4(1) Domestic Cargo, 1983-1993, Betio Port

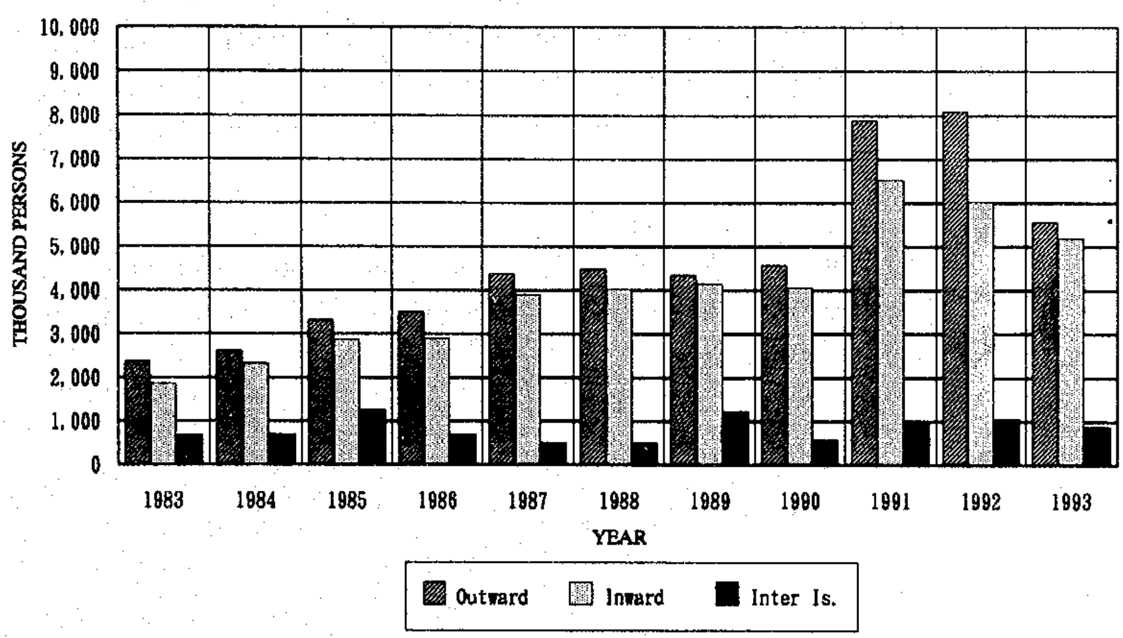


Figure 2-4-4(2) Domestic Passenger, 1983-1993, Betio Port

Besides the slow cumbersome double handling, tallying is carried out at shipside, at wharfside and in the warehouses. These activities further slow down work in an already inefficient operation.

A flow chart showing the seaward and landward activities is given in Figure 2-4-5.

(2) Cycle Time of Ship to Shore Operations

The study team have inspected cargo handling operation on both ship and shore in order to clarify the bottle neck causing inefficient operation. Ships inspected include "Baltimar Boreas (CCS)" on April 14-15, 1994, Mat 1 (Private Ship)" on April 17, 1994, "Arktis Sun (PFL)" on April 18, 1994 and "Papuan Chief (CCS)" on May 7th, 1994. At the same time, on-shore cargo handling operation was inspected to complete an entire flow of cargo handling.

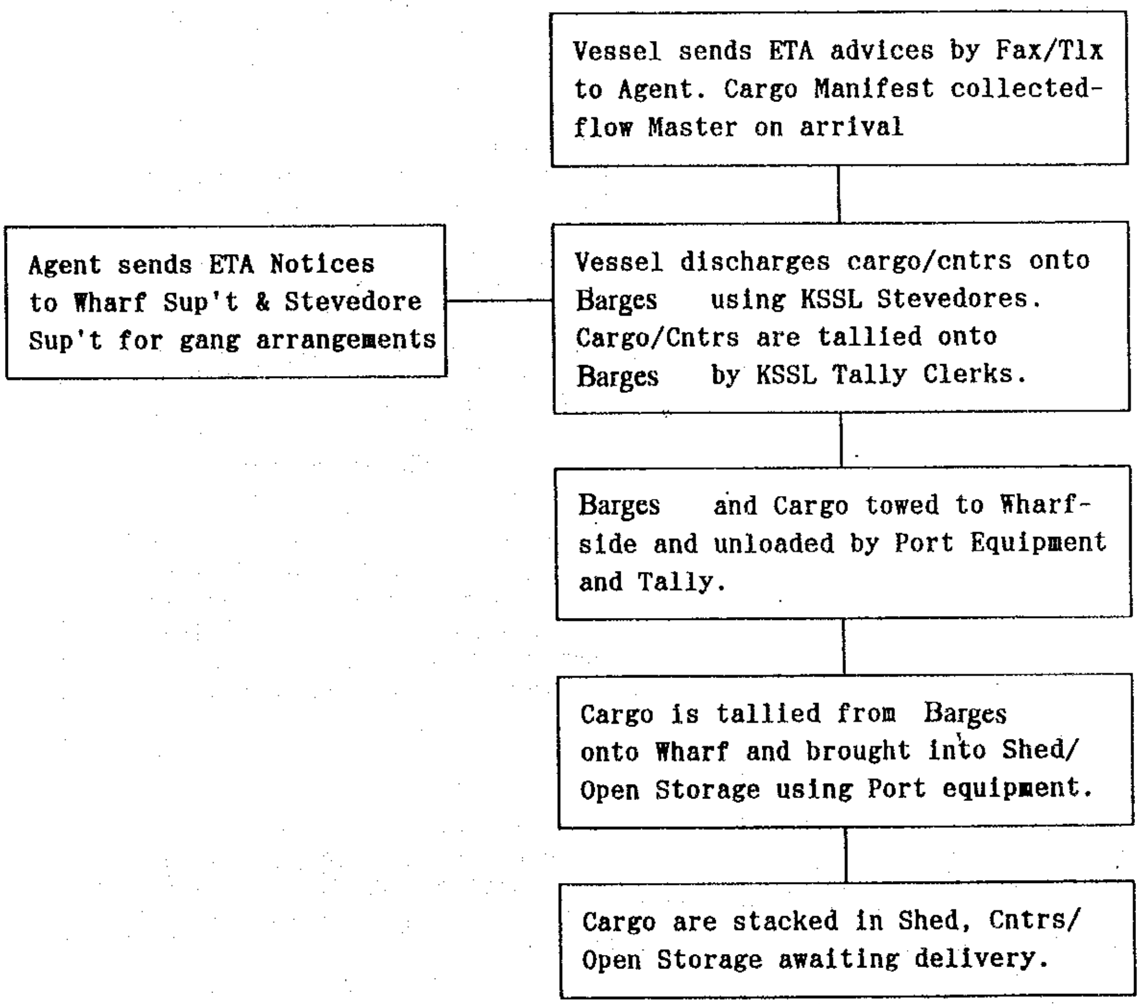
1) Container Cargo Handling

Time required for towing barge between wharf and ship varies depending on towing power, load, wind, etc. The towing time measured averaged at 12 min. one way. Time for loading and un-loading container to/from barge measured at 4-5 min/piece. The on-shore fixed crane requires about 8 min/piece consisting of gross handling time of 2-4 min/piece and remainder for temporary repositioning operation of unintended container. The on-shore mobile crane is used for handling empty container and required operation time is almost the same as that of the fixed crane.

The actual number of Containers in the Stacks is not recorded daily, but it is estimated that there are about 230 TEUs of which 161 are FCLs and the balance of 70 are empties.

Figure 2-4-5 Existing Documentary and Cargo Clearance Flow-Chart of KSSL

A. Shipping Activities



B. Land-side Activities

Consignee receives from Shipper or Bank Original/Copies of B/L and Invoices and confirm with Agent goods actually arrived.

Consignee takes both Invoice and B/Lading to Customs for payment of Duty. Customs retains Original Invoice with copy of B/L.

Consignee presents both Customs Entry Form with Original B/L to KSSL Agent. KSSL collects charges and endorse Original B/L and Entry with "OK TO RELEASE".

Consignee presents both Customs Entry Form with Original B/L to Port Shed for cargo collection. Customs, KSSL Tally Clerk and Consignee examine cargo prior delivery

If in order Consignee signs Release Note and takes delivery of goods, KSSL Port Agent retains original B/L and Entry.

If shortage is discovered, a claim is loadged to investigate & ships owner is informed. Ship sends Tracers to load ports and port of call.

Lorry is checked at Gate by Port Guards & Customs.

After investigation, inform Consignee or settle claim.

Note: FCL/LCL are unpacked inside the Port in presence of Customs, Consignees & KSSL Tally Clerks for Tallying and checking. After un-stuffing m/ts are transferred to m/ts stack according to shipping line.

2) Copra Handling

Major export cargo of copra is transported by both KSSL and private ships. Copra is handled in gunny bag each weighing 50 kg and from ship they are lifted by rope 15 bags in one hook. Cycle time of one lifting operation is about 3-5 minutes depending on efficiency of ship's gear giving handling rate of 9-15 t/h. In a copra shed, about 20 labourers are employed to unload copra from truck and the handling rate is measured at about 15 t/h.

3) Non-containerized Cargo Handling

The operations for non-containerized cargo are carried out in similar fashion as container from ship to wharf, but are put on trailers when they reach the wharf, and then transferred to sheds storage or open yard. There is also serious congestion in the open yard for open storage because cargo-owners are not charged to the common practice of charging storage rental (say) 3 days after completion of discharge. Obviously cargo-owners take advantage of this unusual way of charging storage rental and leave the cargo in the sheds until the last moment.

The productivity of general cargo (including bundled timber) is comparatively slow at about 10-12 tons per gross gang hour. Lack of suitable equipment is part of the cause.

Handling rates are summarized as below:

<Container Cargo>

	Ship	Tug/Barge	Wharf
Handling Time	4-5 min/TEU	12 min/trip	12 min/TEU

<Non-containerized Cargo>

	Ship>Shed
Handling Rate	10-12 t/h

<Copra>

	Ship>Wharf	Truck>Shed
Handling Rate	9-12 t/h	12 t/h

(3) Ships' Turnround Time

Ships' turnround times (including waiting time) are not properly summarized for management information and control, although basic data are recorded. Night pilotage is not available, but international vessels enjoy priority in servicing as they are serviced until their containers/general cargo fully unloaded or loaded. Local inter-island vessels suffer the low priority. Even with this priority privilege, international vessels take 2-3 days to unload FCLs and load Empties for repositioning as exports are almost non-existent except seaweed, and copra in bulk. This imbalance of import FCLs and export FCLs is one reason why the freights on Kiribati cargoes are considerably high.

KSSL also acts as an agent for all international shipping besides managing their own feeder and inter-island vessels.

(4) Working Hours

The working hours for the various staff are as follows:-

1) Monday-Sunday
   Operations (Cargo Handling) Staff - overseas vessels
   0800 hours -1615 hours = 7 1/4 plus 3 3/4 hours overtime
   = 11 hours, 2 shifts

2) Monday-Friday
   Operations (Cargo Handling) - Domestic ships
   0800 hours -1615 hours = 7 1/4 hours

3) Monday-Friday
   Office (non-operations) staff
   0800 hours -1615 hours = 7 1/4 hours

(5) Maintenance and Repairs (KSSL)

An Engineer is responsible for maintaining all port equipment with 3 technicians and a workshop which is not properly equipped. major repairs have to be sent to an outside private workshop or carried out by the PVU workshop. Tugs are repaired by Betio Shipyard, which is the only place available, but repair costs are high.

It is necessary for the Port to be able to handle most of the maintenance and repair work for the F/Lifts and mobile cranes except major overhauls. Steps should be taken to equip the workshop accordingly.

A stock of spare parts is being maintained and no difficulty in obtaining spares has been experienced.

2.4.5 Problems and Constraints

(1) Container Handling Operation

A tug and barge operation incurs otherwise unnecessary additional handling cost, but is , if efficiently operated with enough number and capacity of equipment, not a system lowering cargo handling productivity of a port. A tug and barge system can be economically adopted in the case where construction of a deep water berth requiring high capital investment may not be justified with a small volume of port cargoes and a tug. Betio Port, favoured with calm and wide water area inside a lagoon, handles relatively small volume of port cargoes with a tug and barge system. Container cargoes have increased in recent years to the extent that the cargo handling capacity has been saturated allowing any further increase of cargo without considerably high increase of handling cost due mainly to insufficient area of container yard.

The flow of present container cargo handling between ship and wharf is, based on the observed data, schematically outlined below;

- Handling equipment are; one ship's crane, one onshore fixed crane and three trains of tugs and barges plying between ship anchoring offshore and wharf.

Ship	3 Barges 3 Tugs	Wharf
1 crane		1 crane

- Handling efficiencies are:

	Sailing time (one way)	
4.5 min/TEU	12 min	8 min/TEU

Overall handling efficiency is controlled by slower wharf operation as 8 min/TEU. Idle time of ship is 3.5 min/TEU if sufficient number of tugs and barges are provided. The required number of tug and barge are calculated as below;

One barge carries 6 containers and working time required for ship and shore is:

Ship	Tug and barge	Wharf
27 min	12 min 12 min	48 min

Required number of tugs and barges = (48+27+12+12)/48
= 2.06 ..3 sets

The above calculation clearly shows the bottleneck of the existing port operation.

(2) Existing yard

Layout of the existing container yard is shown in Figure 2–4–6 and as shown most of the yard area is occupied by custom and KSSL offices and seven cargo sheds. Open yard area is fully packed up with container and non–container cargo storage area and passage which is too small to permit smooth and efficient yard operation. Total area including office, shed and storage yard is 80 x 130 = 10,400 m^2 and an effective area for stacking container and passage is only 40 x 80 = 3,200 m^2. There are 50 slots stacked 5 high within the reach of the fixed crane installed at the center and 28 slots stacked 4 high by a mobile crane on both sides of the fixed crane. The total storage capacity of the existing container yard is calculated as follows;

Area within the fixed crane	50 slots x 5 tiers =	250 TEU
Area handled by mobile crane	28 slots x 4 tiers =	112 TEU
	Total	362 TEU

Stacking density of container is:

3,200/362 = 8.8 m^2/TEU

This density is too high when compared with a normal figure about 15 m^2/TEU of container yard. Average time for handling containers stacked at random four high is about double that for containers stacked two high due to time consuming moving operation of containers stacked low.

The other factor lowering the handling efficiency is unavailability of a temporary working area and equipment on a wharf apron. The fixed onshore crane bears double functions of unloading containers from barge and stacking those in the yard. Entire apron area is used for stacking containers. Even if the existing wharf could accommodate a container ship alongside, the cargo handling efficiency would not be improved much without expanding the area of container yard. Insufficient area of container yard does not allow effective means for improving cargo handling efficiency of introducing such yard equipment of large crane, forklift, etc.

The above problems will be given a thorough consideration in planning, development and improvement of Betio Port in subsequent chapters.

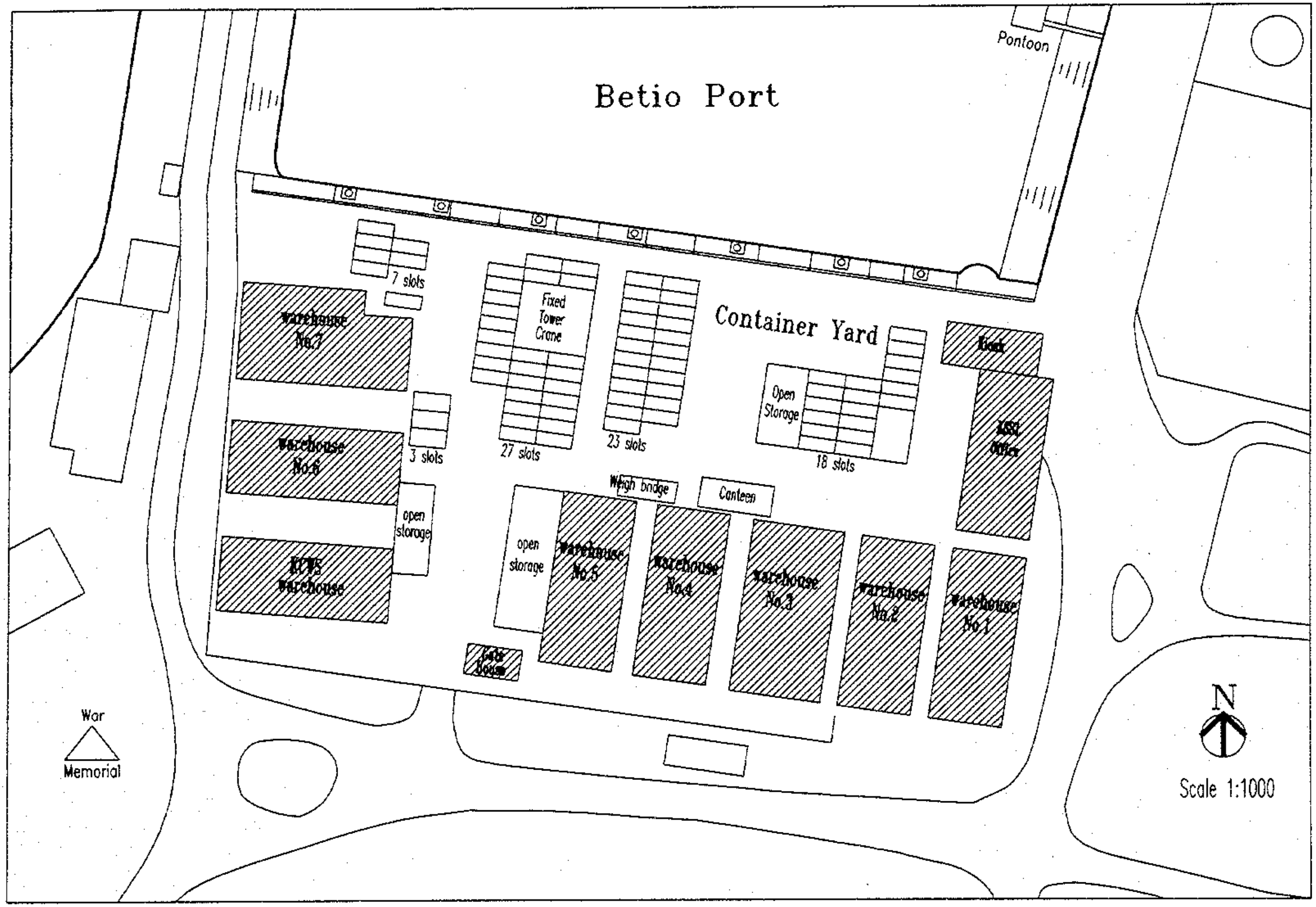


Figure 2-4-6 Container Stacking Slots Allocation

2.5 Ports in Outer Islands

2.5.1 London Wharf

(1) Port Facilities

1) Wharf

The wharf of 112 m long was constructed by the American engineers during the war and the depth of 26'(7.92 m) was secured to accommodate small destroyers of US Navy. Even during the war, the wharf was shallowed by littoral drift and the seabed elevation is now from 0 to −5 metres below Chart Datum.

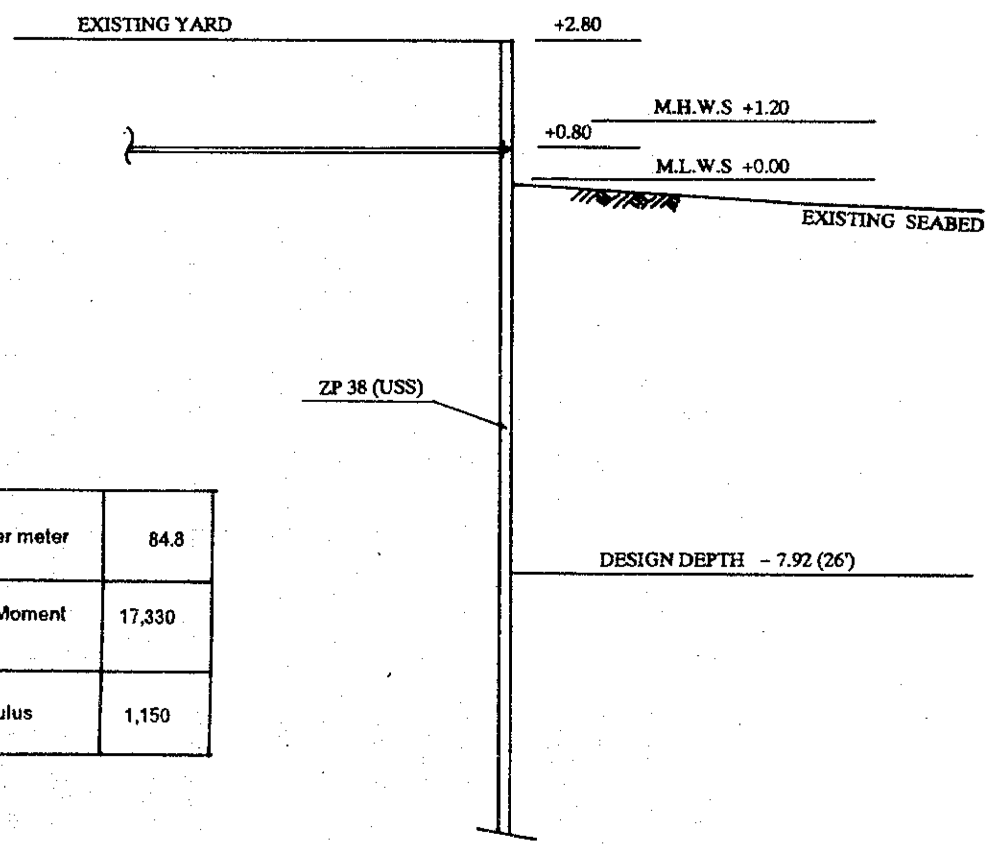
The wharf structure, as shown in Figure 2−5−1, is steel sheet piles of US Steel ZP−38 and they are completely rusted out with holes at around Chart Datum on each pile. Almost sheet piles thicken due to heavy corrison. It is found that tie rods are mostly pulled out by about 1 meter bent close to the pile surfaces. The apron of the wharf is partially repaired by the government.

The southern corner of the wharf was undermined and filling material behind the wharf subsided.

Northern side of the wharf collapsed before and was repaired with steel plates for water tanks. This part is provided with an open shed used for embark/disembark for passengers from barges and elevation of the deck is +1.9 m from Chart Datum.

The tide gauges of University of Hawaii are set at the corner of the northern end of the wharf.

Total port area is about 6,700 m^2 and a mobile crane hired from a private firm is used for handling cargoes when a ship comes in.



CHARACTERISTICS OF ZP-38

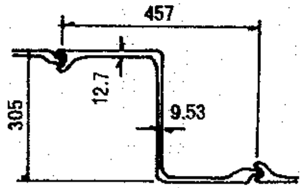
Dimensions		
	Area Mass per meter	84.8
	Geometrical Moment of Inertia	17,330
	Section Modulus	1,150

Figure 2-5-1 Existing Wharf Structure in London Wharf

2) Shed

There are several warehouses to store general cargoes and copra outside the port area.

These sheds accommodate general cargoes imported and copra for export, and their capacities are shown below:

* Government shed : 630 m^2 x 2
* Copra shed : 600 m^2
* KCWS shed : 120 m^2
* Abamakoro shed : 280 m^2

Total 2,260 m^2

(2) Port Activities

1) Ships' Call

Table 2-5-1 shows number of ship's call at London Wharf. Clear trend of increasing number of ship's call is not found in any type of ship. Number of cargo ships calling the wharf remains under 35 in 1993 and number of call of other ships fluctuated in a small range. It is understood that number of ship's call almost remains constant.

2) Cargo Handled

i) Cargo Volume

As shown in Table 2-5-2 with figures, past trend does not show significant increase of total incoming cargo and total volume of cargo into Christmas Island remains about 2000 ton. Containerized cargoes have increased to replace bulk cargoes except year 1992.

Outgoing general cargo volume is relatively small, being less than 1000 ton. Average shipment volume of outgoing copra is less than 500 ton but in 1991 about 1,600 ton of copra was shipped.

Table 2-5-1 Number of Ships' Calling in Christmas

	Cargo Ships		Yachts etc.	Total
1989	20	18	21	59
1990	37	50	31	118
1991	31	45	35	111
1992	18	24	20	62
1993	34	42	35	111

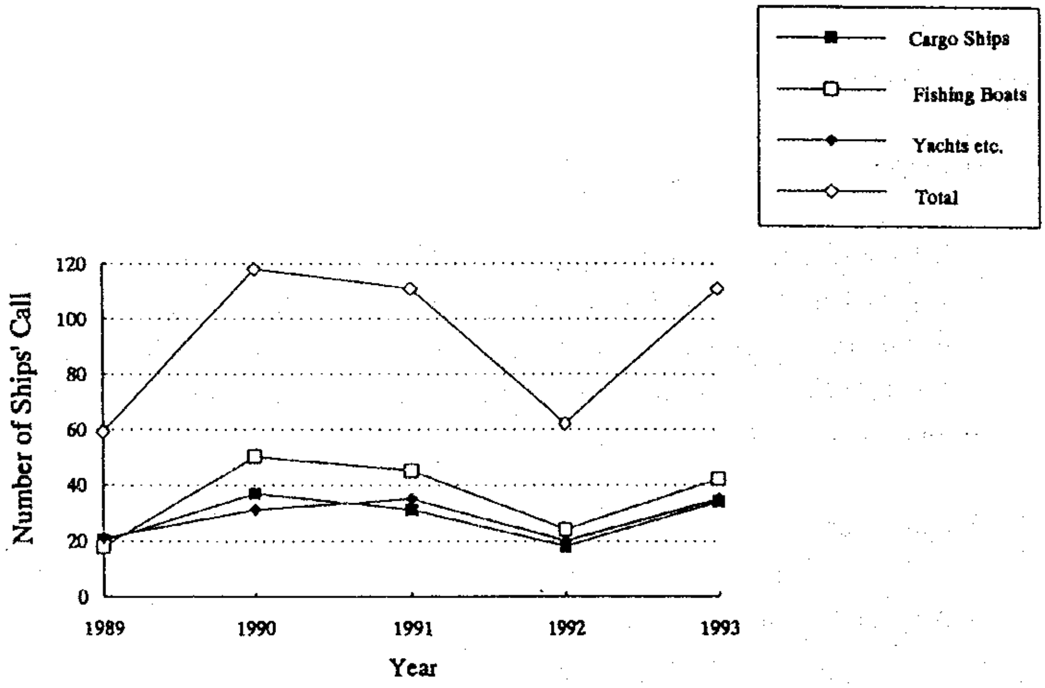
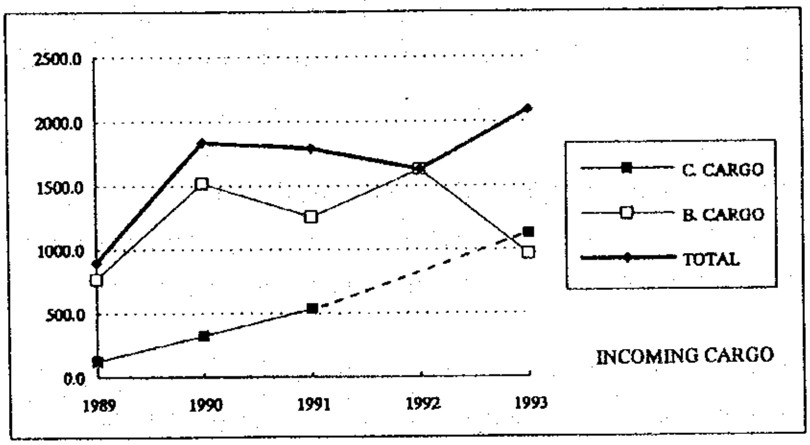
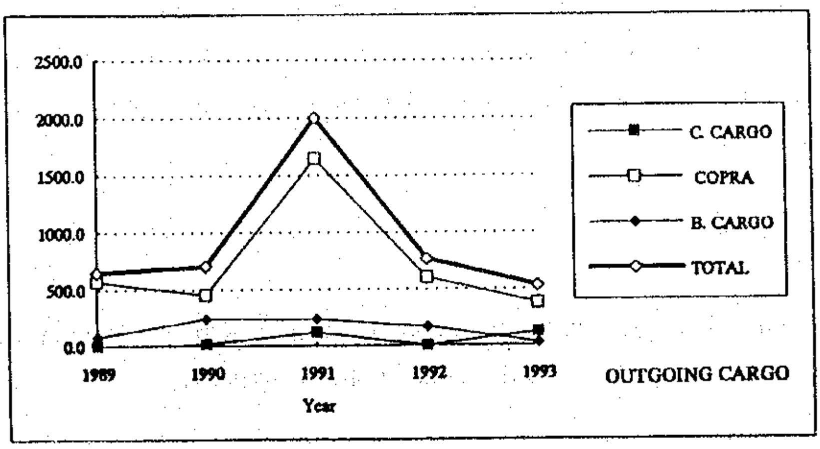


Table 2-5-2 Volume of Cargo Handled

YEAR	INCOMING CARGO (TON)				OUTGOING CARGO (TON)			
	TEU	C. CARGO	B. CARGO	TOTAL	C. CARGO	COPRA	G. CARGO	TOTAL
1989	3.0	128.0	769.3	897.3	N.A.	576.1	78.5	654.6
1990	21.0	321.3	1,515.7	1,837.0	16.32	447.6	283.1	747.0
1991	31.0	534.0	1,254.1	1,788.1	119.86	1646.6	235.3	2,001.8
1992	N.A.	N.A.	1,625.2	1,625.2	N.A.	600.9	162.3	763.2
1993	63.0	1,125.8	963.9	2,089.7	125.24	375.2	28.7	529.1
TOTAL				8,237.3				4,641.7
AVERAGE				1,647.5				928.3





ii) Passenger

Table 2-5-3 shows passenger statistics for Line and Phoenix Group and annual passenger traffic in Christmas is in order of about 400 except 1991 and 1992. Any significant increasing trend of passengers is not recognized from the table.

2.5.2 Other Ports

(1) Butaritari

1) Outline of the Island

The island of Butaritari belongs to the Gilbert Islands and is situated at approximately 150 km north of Tarawa being close to Makin island. The land is a narrow strip running from north-east to south-west of the atoll with land area of only 13 km^2, but the lagoon has widely developed towards the east. Population in 1992 is given as 3,774, being the third largest in the country. The island has a large rainfall among the Gilbert Islands and the land is fertile growing bananas, papayas and watermelon.

Rainfall is very large averaging 3,221 mm annually. Temperature vary between 25 and 31 degree C, and there is a predominant easterly wind, and the frequency of occurrence of easterly wind velocity more than 8 m/sec is 95 per cent.

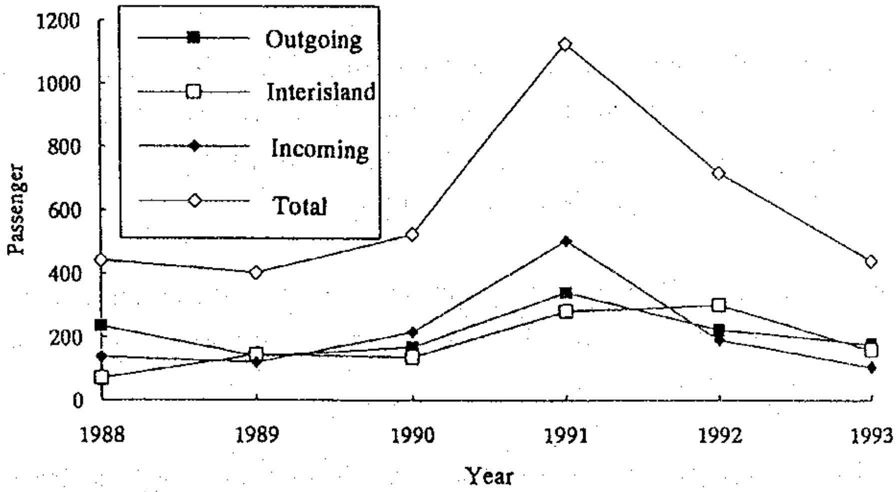
The island is a typical coral atoll having a horse's hoof shape with the opening in the west. The main port is named Kings Wharf, which is located at the south of the atoll. The wharf faces the lagoon side and have no affect from the ocean wave actions, but the front sea area is only one metre deep because of the long term siltation. The tidal range is relatively large with the mean high water spring being 1.68 metres.

2) Port Facilities

A jetty named Kings Wharf is the main port facility which is located inside of the lagoon and connected to the main island with a causeway.

Table 2-5-3 Passenger Statistics in London Wharf

	Outgoing	Interisland	Incoming	Total
1988	234	71	138	443
1989	139	145	120	404
1990	170	138	217	525
1991	341	283	503	1127
1992	224	302	191	717
1993	177	158	105	440



The wharf was constructed by the Japanese army during the war. The wharf is of concrete bags protecting the slope with concrete foundation on the existing beach. Due to collapse of the slope, back filling were washed away and settlement of the ground is caused. In addition to the above, sedimentation was caused in front of the wharf, depth of which is about 1 metre. The situation terminated usage of the facility.

3) Cargo Handling

Only landing crafts can approach to the wharf to transport cargoes from the cargo vessels. Cargoes on the land are handled by manpower. Total volume of cargo recorded 914 ton in 1993.

(2) Abemama

1) Outline of the Island

The island of Abemama is situated at the centre of the Gilbert Islands, 150 km south-east of Tarawa, being close to the island of Kuria and Aranuka. The land area is approximately 27 km^2. Population in 1990 is given as 3,218, being the fifth largest in the country. The main product is copra.

Rainfall averages 1,559 mm annually, but it is very variable registering 3,026 mm in 1958 and only 314 mm in 1955. The other climatic elements are unknown because of lack of data.

The island is a typical coral atoll having a horse's hoof shape with the opening in the west. The main port is located at the north of the atoll. The port faces the lagoon side and are surrounded by the reef, which protects the port area from the ocean waves. But the boat basin and the approach channel have been shoaled up to 0.5 to 1.0 meter depth due to the long term siltation. Tidal range is relatively large with the mean high water spring being 1.74 metres.

2) Port Facilities

The breakwater constructed by US Navy during the war protects basin and channel of about 1 metre deep from easterly wind waves. The structure was of simple walls with stacked-up steel drums and filling dredged spoil.

After breakage of the top part of the breakwater, easterly wind waves transported sediment to the channel and basin to be shallowed to 0.5 metre deep.

There are two copra sheds with area of 120 m^2 and 180 m^2 respectively.

3) Cargo Handling

Cargoes are transported from a ship anchoring offshore by a landing craft. Shortage of equipment and shallow water are bottlenecks for efficient handling. Total cargo volume in 1993 was 1,220 ton.

(3) Beru

1) Outline of the Island

The island of Beru is situated about 250 km south-east of Abemama and is a small island with the land area of only 18 km^2. The lagoon area is relatively small. Population in 1990 is given as 2,909, being the next scale to Abemama. The main product is copra.

Rainfall averages 1,309 mm annually, and it is very variable registering 3,104 mm in 1987 and only 247 mm in 1950. Temperatures vary between 25 and 32°C, and there is a predominant easterly wind and the frequency of occurrence of easterly wind velocity less than 8 m/sec is 99 per cent.

The island is a long and slender shaped coral atoll and runs from the north-east to south-west with a total length of approximately 15 km. The main port is located at the north facing the lagoon side, but it is very close to the ocean because the reef flat is very small, approximately 200 metres wide. The boat basin in front of wharf is found to be shoaled with rough coral sand brought by the ocean wave force. Tidal range is 1.26 metres in mean high water spring.

2) Port Facilities

The port facilities were constructed, opening a channel with blasting coral reef and directly face an entrance of the channel. This layout of the port facilities caused deposition of sand and pieces of coral in the basin.

Tidal current is fast around the channel and water area of the southern side of the seawall.

There are two old sheds for copra and foodstuff which are insufficient for storing cargoes.

3) Cargo Handling

System of cargo handling in the island is the same as the other outer islands stated above. Total cargoes handled at this port is 1031 ton in 1993.

CHAPTER 3

CONCEPTUAL PORTS DEVELOPMENT PLAN

3. CONCEPTUAL PORTS DEVELOPMENT PLAN

3.1 Basic Concept of Port Development

3.1.1 Role and Function of Port

Given the isolation and dispersal of Kiribati, sea transportation is critical means for economic activities. Transport facilities are essential for international/domestic trades and social interaction of people.

In DP7 the following objectives have been set up in developing the sea transport sector;

- To improve the safety, efficiency and seaworthiness of shipping operation and services for trade and transport needs.
- To upgrade the shipping and cargo handling services and facilities to ensure a reliable and least cost beneficent inter-island shipping services.
- To provide training (in-country and overseas) for I-Kiribati shipping personnel to upgrade their skills in shipping services.
- To adopt institutional measures to improve the fiscal management to enable the Government owned shipping company to become self-financing.

To achieve the above objectives, the following strategies are considered;

- Concentration of import and export traffic in Betio Port
- Independent operation and management of Betio Port
- Expansion of wharf area with traffic management systems, and construction of new warehouse
- Acquisition of new cargo handling equipment for increasing containerization
- Provision of navigational aids and proper maintenance of such aids
- Proper garbage disposal and observance of strict environmental protection
- Improving technical management and maintenance through training

Betio Port is assigned either an important role of main sea gate for both foreign and domestic cargoes. Main import cargoes are foodstuff carried in container which are distributed by sea to the outer-islands from the port while main export cargo of copra is collected from the outer-islands and shipped in bulk. Thus, geographic nature of the country imposes double duties of import/export and domestic distribution/collection on Betio Port. Worldwide trend of contain–

er handling facilities regardless of volume of cargo handled. Betio Port, with a shallow berthing area and insufficient container yard, is obliged to do costly cargo handling operation by barge and inefficient crane operation. Inefficient port operation reflects high handling cost on port cargo eventually weakening the country's economy.

The above objectives for developing infrastructure of sea transport basically follow the conclusions recommended in "Inter-island Transport Study Report" April 1991, ADB and are adopted as a basic development policy in this particular project in planning future port facilities.

3.1.2 Improvement and Rehabilitation of Facilities

Betio Port needs both improvement and rehabilitation to the port facilities. The rehabilitation works are required due to lack of adequate maintenance to the port facilities in the past. Major improvement works include, as described in the previous chapter, expansion of a container yard and minimization of barge operation. While the rehabilitation works include a repair to the existing corroded wharf, silted channel and basin, damaged east and west moles, deteriorated sheds, etc.

(1) Improvement of Port Facilities

1) Expansion of Container Yard

Small container yard is unquestionably the major constraint for efficient and safe on-shore cargo handling operation as discussed in the previous chapter. This situation has long been recognized and remains to be so for long time due to unavailability of land area for expansion in a densely populated area near the port. Limited reach of the fixed container crane and unavailability of a large forklift result in high stacking of containers. If a heavy duty forklift is introduced to move containers lifted by the crane, a stacking height can be considerably reduced. However, this is not the case in the Betio Port due to insufficient container yard not allowing free movement of a large yard equipment. The limited reach of the crane gives another constraint of no space of temporary operation area on a wharf apron, rather containers are stacked very close to a wharf front. Lack of a temporary operation area considerably worsens efficiency of cargo handling operation between barge and crane. The westernmost area of the yard is not fully utilized, because the area is out of fixed crane's reach and a forklift of 25 t is not available.

Insufficient area of container yard also hampers efficient container cargo handling operation due to congested yard with containers, bulk cargoes, yard equipment and consignee/consigner trucks.

2) Minimization of Barge Operation

Water area inside the Tarawa lagoon is deep and calm allowing a cargo handling operation by barge without an expensive deep water wharf. Cargo handling by barge does not necessarily delay dispatch of ship much if well organized, however, it necessitates a costly double handling of cargoes. Further, in an inclement weather, a barge operation at offshore anchorage can be dangerous lowering efficiency and safety.

3) Reinforcement of Cargo Handling Equipment

Main cargo handling equipment in the port is the fixed tower crane. Given the limited lifting reach, higher stacking is an easy and effective way to maximize efficiency and capacity of yard operation. However, high stacking necessitates otherwise unnecessary double, triple shifting of container to reach the intended container. Further, it needs frequent blind handling of low stacked containers which is time consuming and dangerous.

4) Inadequate Navigation Buoy

The existing navigation aids are properly aligned and they are enough in number but inadequate in structure. Some ships calling the port are old and poor in maneuverability and therefore an adequate navigation system is an absolute necessity to secure safe navigation in an inclement weather and at night. Some buoys are equipped with lanterns but not with radar reflectors. Old anchor chains of ship are used to fix the floating buoys and they are often broken at high waves. For safe navigation of ships in the approach channel running through shallow reef flat, upgrading and improvement of the navigation aids are required.

5) Provision of Office

As will be discussed in the subsequent sections, a port authority will be established for adequate port operation and management and an office space to accommodate the port management staffs will be required.

(2) Rehabilitation of Port Facilities

1) Corroded Steel Pile of Wharf

The steel sheet pile of the existing wharf is badly corroded to the extent that the backfill soil is escaping from holes endangering structural stability. Urgent rehabilitation work is required.

2) Damaged East and West Moles

Both east and west moles have been badly damaged on their concrete bag slopes with many bags displaced allowing the backfill to escape. Urgent repair work to prevent further damage and eventual collapse is required.

3) Unpaved Container Yard

The existing container yard is concrete paved in the front half while the back half unpaved. Storm water drain and duct for water pipe run along both ends of pavement. Cover plates/slabs for them are missing or damaged in some places. These hamper smooth yard operation requiring adequate maintenance.

4) Deteriorated Sheds

All the sheds in the port premises are deteriorated on their roofs and walls. Shed No. 7 storing cement is badly damaged on its roof and needs urgent repair to prevent damage to cement by rainwater.

5) Silted Channel and Basin

The existing channel and basin have been silted hampering efficient and safe navigation of ships and barges. The channel between two moles does not allow passing of tugs towing barges due to silted narrow water and poor maneuverability of barge towed by tug. The inner basin is also silted affecting not only port traffic but also ships to be repaired in Betio Shipyard. The slipway of the shipyard is not fully utilized due to limitation of ship's draft in the basin. When the main wharf is congested, a private ship has to anchor in the basin and land cargo and passenger on the seawall on west side.