MINISTRY OF FOREIGN AFFAIRS,
ENVIRONMENT, TRADE, LABOUR
AND TOURISM,
GOVERNMENT OF TUVALU

THE STUDY FOR ASSESSMENT OF ECOSYSTEM, COASTAL EROSION AND PROTECTION/REHABILITATION OF DAMAGED AREA IN TUVALU

FINAL REPORT
[Volume III : Supporting Report]
No.1: Part I –Part II

JANUARY 2011

JAPAN INTERNATIONAL COOPERATION AGENCY

KOKUSAI KOGYO CO., LTD.
and
FISHERIES ENGINEERING CO.,LTD.

GED
JR
11-096

< Structure of Report >

Volume I
Summary Report

Volume II
Main Report

Volume III
Supporting Report

1 FJ$ = 48.9 Yen

(As of November 2010)

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF FOREIGN AFFAIRS, ENVIRONMENT, TRADE,
LABOUR AND TOURISM, GOVERNMENT OF TUVALU

THE STUDY
FOR
ASSESSMENT OF ECOSYSTEM, COASTAL EROSION AND
PROTECTION/REHABILITATION OF DAMAGED AREA
IN
TUVALU

<FINAL REPORT>

Volume III: Supporting Report

Table of Contents

PART I: COLLECTION AND ANALYSIS OF EXISTING DATA

Section 1: (Supporting Report)

Section 2: (Data Book)

PART II: FIELD RECONNAISSANCE AND FIELD SERVEY IN SEA AND COASTAL AREAS FOR BASIC STUDY

Section 1: (Supporting Report)

Section 2: (Data Book)

Data of field observations in sea and coastal areas for basic study were stored in DVD attached.

PART III: FIELD SERVEY FOR FEASIBILITY STUDY

Section 1: (Supporting Report)

Section 2: (Data Book)

Data of field survey for feasibility study were stored in DVD attached.

PART IV: INTERVIEW SERVEY FOR COASTAL VULNERABILITY OF FONGAFALE ISLET

Section 2: (Data Book)

PART V: CONSENSUS BUILDING

Section 1: (Supporting Report)

PART VI: EXAMINATION AND DESIGN OF COASTAL PROTECTION MEASURES

Section 1: (Supporting Report)

Section 2: (Data Book)

PART VII: FINANCIAL & ECONOMIC ANALYSES

Section 2: (Data Book)

PART VIII: MINUTES OF MEETING

Section 1: (Supporting Report)

PART I: COLLECTION AND ANALYSIS OF EXISTING DATA

Section 1: Supporting Report

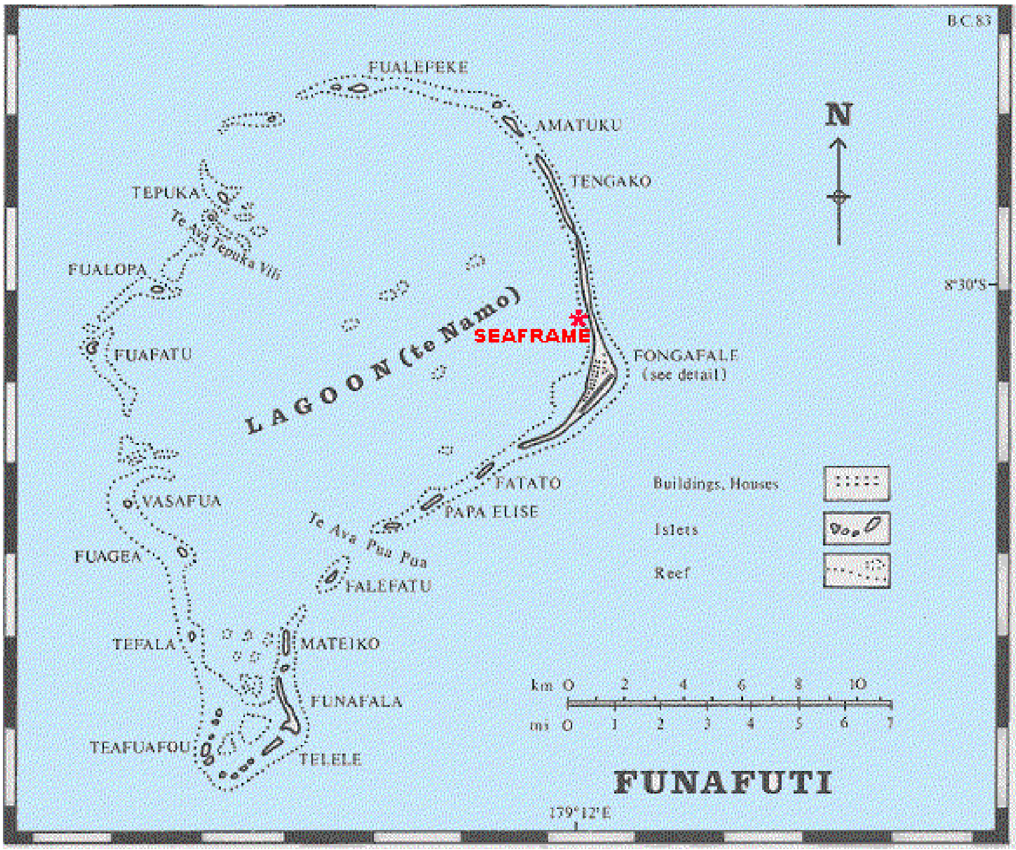
1. Natural Conditions

1. Natural Conditions

The characteristics of natural conditions such as meteorological and oceanographic phenomena and topographic and geological features at Fongafale Island in Funafuti Atoll will be shown as the following sections.

1.1 Meteorological Phenomena

As part of the AusAid-sponsored South Pacific Sea Level and Climate Monitoring Project for the south pacific region, a SEAFRAME (Sea Level Fine Resolution Acoustic Measuring Equipment) gauge was installed in Funafuti, Tuvalu, in March 1993. SEAFRAME gauges not only measure sea level by two independent means, but also a number of ancillary variables– air and water temperature, wind speed, wind direction and atmospheric pressure. The time used for SEAFRAME is a Universal Time Coordinated (UTC), therefore the local time can be obtained by minus 12 hours.



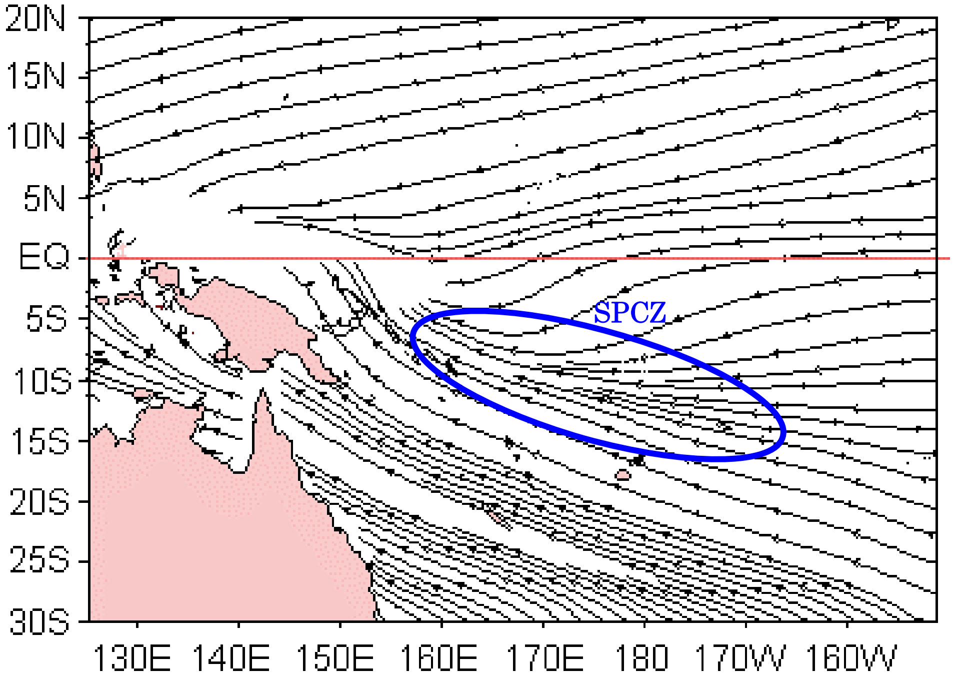
Source: SOPAC

Figure 1.1 Location Map of SEAFRAME at Funafuti, Tuvalu

(1) Winds

a) General Description

The streamlines of mean surface wind shown in Figure 1.2 shows how the Tuvalu region is dominated by easterly trade winds. In the Southern Hemisphere the Trades blow to the northwest and in the Northern Hemisphere they blow to the southwest. The streamlines converge, or crowd together, along the "South Pacific Convergence Zone (SPCZ)".



Source: Pacific Country Report, Tuvalu

Figure 1.2 Streamlines of Mean Surface Wind

b) Wind Speeds and Winds Directions

The wind data observed at the SEAFRAME station in Funafuti are provided in "Data Book" attached to this report as "Monthly Joint Frequency of Occurrence of Wind Speed and Wind Direction (1999- 2008)", "Monthly Wind Rose (1999- 2008)" and "Monthly Wind Speed (1994- 2009)".

The annual wind data show the wind in Fongafale to be seasonal. We divided the wind conditions in the region into 4(four) seasons, i.e. Summer/Wet Season from December to

February, Winter/Dry Season from May to September, and two Transit Seasons from March to April and from October to November. The seasonal wind data are summarized in Table 1.1 to Table 1.5 as "Joint Frequency of Occurrence of Wind Speed and Wind Direction (1999- 2008)" and in Figure 1.3 to Figure 1.7 as "Wind Rose (1999- 2008)".

The annual frequency of occurrence of wind speed and direction during 1999 to 2008 shows that the wind speed less than 2.0 m/sec occurs at 32.0 % and the wind speed more than 8.0 m/sec at 2.2 %. Annual winds are predominant from easterly direction, i.e. 53.3 % from ENE to SE directions. Stronger winds than 14.0 m/sec are observed from westerly direction of SW to NW (refer to Table 1.1 and Figure 1.3).

From December to February during the summer season, north-easterly winds from N to ENE are predominant with 45.5 % occurrence. The south-easterly and north-westerly winds compete with low occurrence percentages. Strong westerly winds reaching more than 15 m/sec are observed in this season including March (refer to Table 1.2 and Figure 1.4).

From May to September during the winter season, the easterly to south-easterly winds not exceeding almost 6 m/sec are dominant, i.e. 52.0 % from ESE to SE directions. In this season, strong winds more than 10 m/sec are very rare cases, only 12 times during 10 years (refer to Table 1.4 and Figure 1.6).

Wind characteristics in the transit seasons from March to April and from October to November show the intermediate conditions between the summer and winter seasons or the winter and summer seasons (refer to Table 3.3, Table 3.5 and Figure 1.5, Figure 1.7).

Table 1.1 Joint Frequency of Occurrence of Wind Speed and Wind Direction
Annual : January to December for 1999 – 2008

Site	Funafuti	Regulation	87672
Term	1999/ 1/ 1/ 0:00– 2008/ 12/ 31/ 23:00 (Annual)	Observation	87428 (99.7)
		Error	244 (0.3)

(m/sec)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum	Accum. Sum
0.0 – 0.4	121 (0.1)	154 (0.2)	124 (0.1)	143 (0.2)	170 (0.2)	233 (0.3)	214 (0.2)	180 (0.2)	129 (0.1)	98 (0.1)	90 (0.1)	87 (0.1)	107 (0.1)	87 (0.1)	100 (0.1)	110 (0.1)	2147 (2.5)	2147 (2.5)
0.5 – 1.9	1210 (1.4)	2094 (2.4)	2461 (2.8)	3244 (3.7)	2855 (3.3)	5223 (6.0)	4087 (4.7)	1291 (1.5)	485 (0.6)	408 (0.5)	286 (0.3)	328 (0.4)	412 (0.5)	436 (0.5)	459 (0.5)	546 (0.6)	25825 (29.5)	27972 (32.0)
2.0 – 3.9	2700 (3.1)	3359 (3.8)	3343 (3.8)	6204 (7.1)	1803 (2.1)	6240 (7.1)	9251 (10.6)	2408 (2.8)	630 (0.7)	386 (0.4)	217 (0.2)	301 (0.3)	479 (0.5)	573 (0.7)	774 (0.9)	908 (1.0)	39576 (45.3)	67548 (77.3)
4.0 – 5.9	1582 (1.8)	702 (0.8)	1219 (1.4)	1414 (1.6)	255 (0.3)	1561 (1.8)	3174 (3.6)	1139 (1.3)	273 (0.3)	128 (0.1)	108 (0.1)	181 (0.2)	367 (0.4)	425 (0.5)	679 (0.8)	859 (1.0)	14066 (16.1)	81614 (93.3)
6.0 – 7.9	562 (0.6)	59 (0.1)	176 (0.2)	124 (0.1)	27 (0.0)	96 (0.1)	289 (0.3)	240 (0.3)	77 (0.1)	38 (0.0)	109 (0.1)	158 (0.2)	370 (0.4)	390 (0.4)	578 (0.7)	588 (0.7)	3881 (4.4)	85495 (97.8)
8.0 – 9.9	93 (0.1)	4 (0.0)	14 (0.0)	12 (0.0)	3 (0.0)	5 (0.0)	14 (0.0)	21 (0.0)	18 (0.0)	24 (0.0)	41 (0.0)	98 (0.1)	156 (0.2)	229 (0.3)	295 (0.3)	257 (0.3)	1284 (1.5)	86779 (99.3)
10.0 – 11.9	9 (0.0)		1 (0.0)	1 (0.0)			1 (0.0)	3 (0.0)	8 (0.0)	7 (0.0)	15 (0.0)	48 (0.1)	69 (0.1)	105 (0.1)	159 (0.2)	62 (0.1)	488 (0.6)	87267 (99.8)
12.0 – 13.9	1 (0.0)		1 (0.0)						2 (0.0)	1 (0.0)	2 (0.0)	8 (0.0)	20 (0.0)	31 (0.0)	49 (0.1)	15 (0.0)	130 (0.1)	87397 (100.0)
14.0 – 15.9											1 (0.0)	2 (0.0)	1 (0.0)	11 (0.0)	12 (0.0)		27 (0.0)	87424 (100.0)
16.0 – 17.9														1 (0.0)	2 (0.0)		3 (0.0)	87427 (100.0)
18.0 – 19.9													1 (0.0)				1 (0.0)	87428 (100.0)
20.0 ≦																		87428 (100.0)
Sum	6278 (7.2)	6372 (7.3)	7339 (8.4)	11142 (12.7)	5113 (5.8)	13358 (15.3)	17030 (19.5)	5282 (6.0)	1622 (1.9)	1090 (1.2)	869 (1.0)	1211 (1.4)	1982 (2.3)	2288 (2.6)	3107 (3.6)	3345 (3.8)	87428 (100.0)	* *

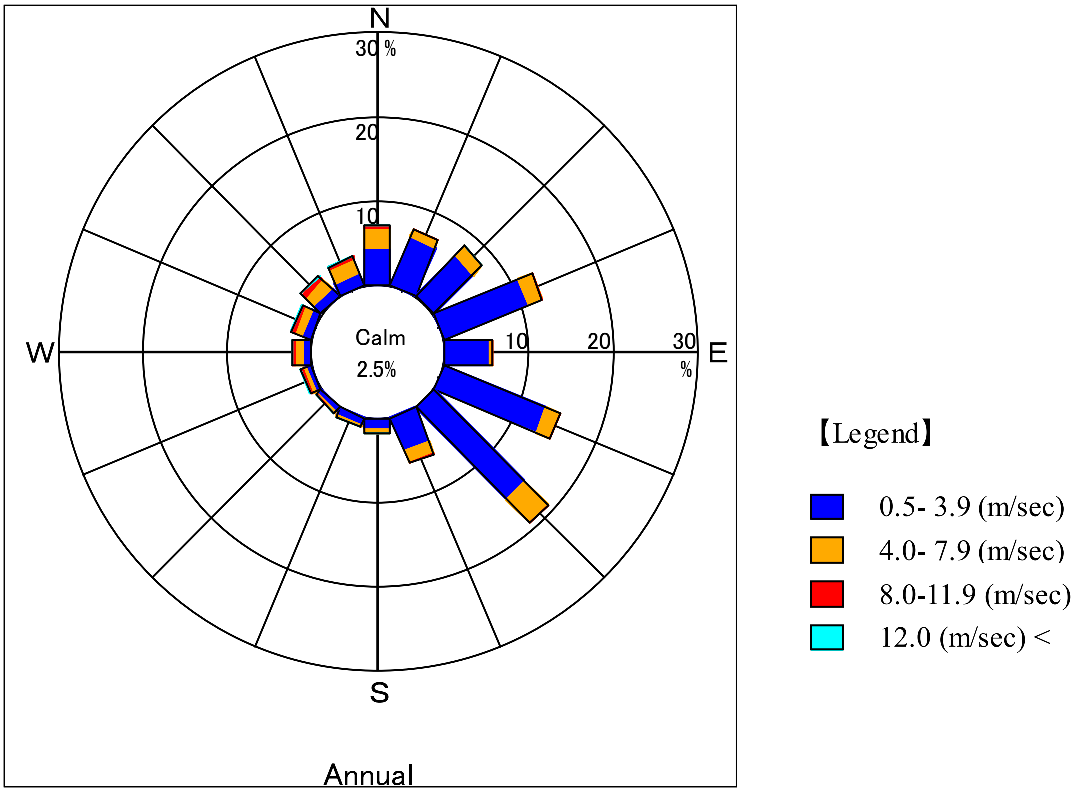


Figure 1.3 Wind Rose : Annual (1999 - 2008)

Table 1.2 Joint Frequency of Occurrence of Wind Speed and Wind Direction Summer/Wet Season : December to February for 1999 – 2008

Site	Funafuti		
Term	1999/ 1/ 1/ 0:00- 2008/ 12/ 31/ 23:00[Summer(December to February)]		
Regulation	21672		
Observation	21648	(99.9)	
Error	24	(0.1)	

(m/sec)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum	Accum. Sum
0.0 – 0.4	28 (0.1)	42 (0.2)	34 (0.2)	37 (0.2)	36 (0.2)	53 (0.2)	53 (0.2)	51 (0.2)	38 (0.2)	31 (0.1)	22 (0.1)	26 (0.1)	32 (0.1)	28 (0.1)	25 (0.1)	28 (0.1)	564 (2.6)	564 (2.6)
0.5 – 1.9	370 (1.7)	646 (3.0)	626 (2.9)	589 (2.7)	436 (2.0)	614 (2.8)	543 (2.5)	272 (1.3)	132 (0.6)	131 (0.6)	102 (0.5)	131 (0.6)	151 (0.7)	167 (0.8)	171 (0.8)	200 (0.9)	5281 (24.4)	5845 (27.0)
2.0 – 3.9	1146 (5.3)	1267 (5.9)	1015 (4.7)	1126 (5.2)	330 (1.5)	373 (1.7)	646 (3.0)	334 (1.5)	147 (0.7)	106 (0.5)	87 (0.4)	155 (0.7)	251 (1.2)	288 (1.3)	357 (1.6)	381 (1.8)	8009 (37.0)	13854 (64.0)
4.0 – 5.9	863 (4.0)	378 (1.7)	620 (2.9)	406 (1.9)	69 (0.3)	48 (0.2)	59 (0.3)	74 (0.3)	54 (0.2)	44 (0.2)	60 (0.3)	137 (0.6)	261 (1.2)	265 (1.2)	387 (1.8)	455 (2.1)	4180 (19.3)	18034 (83.3)
6.0 – 7.9	407 (1.9)	34 (0.2)	98 (0.5)	37 (0.2)	4 (0.0)	4 (0.0)	2 (0.0)	10 (0.0)	19 (0.1)	16 (0.1)	76 (0.4)	139 (0.6)	314 (1.5)	294 (1.4)	392 (1.8)	400 (1.8)	2246 (10.4)	20280 (93.7)
8.0 – 9.9	68 (0.3)	2 (0.0)	5 (0.0)	3 (0.0)	2 (0.0)			2 (0.0)	7 (0.0)	14 (0.1)	37 (0.2)	90 (0.4)	128 (0.6)	166 (0.8)	220 (1.0)	165 (0.8)	909 (4.2)	21189 (97.9)
10.0 – 11.9	4 (0.0)		1 (0.0)					1 (0.0)	1 (0.0)	5 (0.0)	14 (0.1)	42 (0.2)	54 (0.2)	74 (0.3)	101 (0.5)	45 (0.2)	342 (1.6)	21531 (99.5)
12.0 – 13.9									1 (0.0)		2 (0.0)	4 (0.0)	14 (0.1)	24 (0.1)	41 (0.2)	6 (0.0)	92 (0.4)	21623 (99.9)
14.0 – 15.9												2 (0.0)		8 (0.0)	12 (0.1)		22 (0.1)	21645 (100.0)
16.0 – 17.9														1 (0.0)	2 (0.0)		3 (0.0)	21648 (100.0)
18.0 – 19.9																		21648 (100.0)
20.0 ≦																		21648 (100.0)
Sum	2886 (13.3)	2369 (10.9)	2399 (11.1)	2198 (10.2)	877 (4.1)	1092 (5.0)	1303 (6.0)	744 (3.4)	399 (1.8)	347 (1.6)	400 (1.8)	726 (3.4)	1205 (5.6)	1315 (6.1)	1708 (7.9)	1680 (7.8)	21648 (100.0)	* *

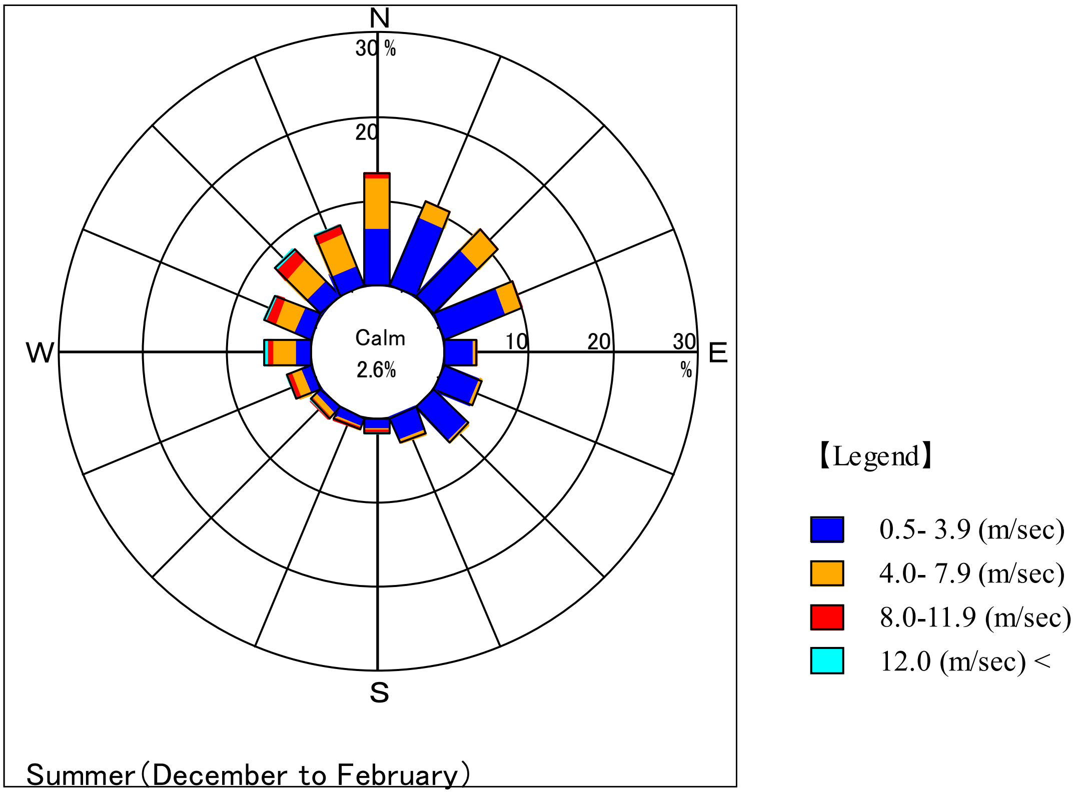


Figure 1.4 Wind Rose : Summer Season (December to February)

Table 1.3 Joint Frequency of Occurrence of Wind Speed and Wind Direction Transit Season : March & April for 1999 – 2008

Regulation	14640
Observation	14600 (99.7)
Error	40 (0.3)

Site: Funafuti
Term: 1999/ 1/ 1/ 0:00- 2008/ 12/ 31/ 23:00[Transit(March & April)]

(m/sec)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum	Accum. Sum
0.0 － 0.4	25 (0.2)	28 (0.2)	16 (0.1)	31 (0.2)	38 (0.3)	43 (0.3)	34 (0.2)	42 (0.3)	35 (0.2)	16 (0.1)	16 (0.1)	20 (0.1)	15 (0.1)	15 (0.1)	21 (0.1)	22 (0.2)	417 (2.9)	417 (2.9)
0.5 － 1.9	302 (2.1)	423 (2.9)	487 (3.3)	711 (4.9)	560 (3.8)	1035 (7.1)	837 (5.7)	219 (1.5)	73 (0.5)	74 (0.5)	33 (0.2)	58 (0.4)	86 (0.6)	62 (0.4)	105 (0.7)	127 (0.9)	5192 (35.6)	5609 (38.4)
2.0 － 3.9	611 (4.2)	676 (4.6)	661 (4.5)	1151 (7.9)	290 (2.0)	858 (5.9)	1213 (8.3)	232 (1.6)	54 (0.4)	40 (0.3)	21 (0.1)	43 (0.3)	97 (0.7)	107 (0.7)	186 (1.3)	206 (1.4)	6446 (44.2)	12055 (82.6)
4.0 － 5.9	356 (2.4)	86 (0.6)	175 (1.2)	224 (1.5)	54 (0.4)	76 (0.5)	205 (1.4)	50 (0.3)	10 (0.1)	10 (0.1)	10 (0.1)	18 (0.1)	49 (0.3)	75 (0.5)	148 (1.0)	161 (1.1)	1707 (11.7)	13762 (94.3)
6.0 － 7.9	80 (0.5)	5 (0.0)	35 (0.2)	21 (0.1)	1 (0.0)	6 (0.0)	6 (0.0)	5 (0.0)	5 (0.0)	1 (0.0)	6 (0.0)	3 (0.0)	26 (0.2)	55 (0.4)	113 (0.8)	105 (0.7)	473 (3.2)	14235 (97.5)
8.0 － 9.9	12 (0.1)		4 (0.0)	4 (0.0)						3 (0.0)	1 (0.0)	5 (0.0)	17 (0.1)	48 (0.3)	60 (0.4)	69 (0.5)	223 (1.5)	14458 (99.0)
10.0 － 11.9	3 (0.0)								1 (0.0)		1 (0.0)	3 (0.0)	9 (0.1)	31 (0.2)	47 (0.3)	16 (0.1)	111 (0.8)	14569 (99.8)
12.0 － 13.9													5 (0.0)	7 (0.0)	8 (0.1)	5 (0.0)	25 (0.2)	14594 (100.0)
14.0 － 15.9											1 (0.0)		1 (0.0)	3 (0.0)			5 (0.0)	14599 (100.0)
16.0 － 17.9																		14599 (100.0)
18.0 － 19.9													1 (0.0)				1 (0.0)	14600 (100.0)
20.0 ≦																		14600 (100.0)
Sum	1389 (9.5)	1218 (8.3)	1378 (9.4)	2142 (14.7)	943 (6.5)	2018 (13.8)	2295 (15.7)	548 (3.8)	178 (1.2)	144 (1.0)	89 (0.6)	150 (1.0)	306 (2.1)	403 (2.8)	688 (4.7)	711 (4.9)	14600 (100.0)	* *

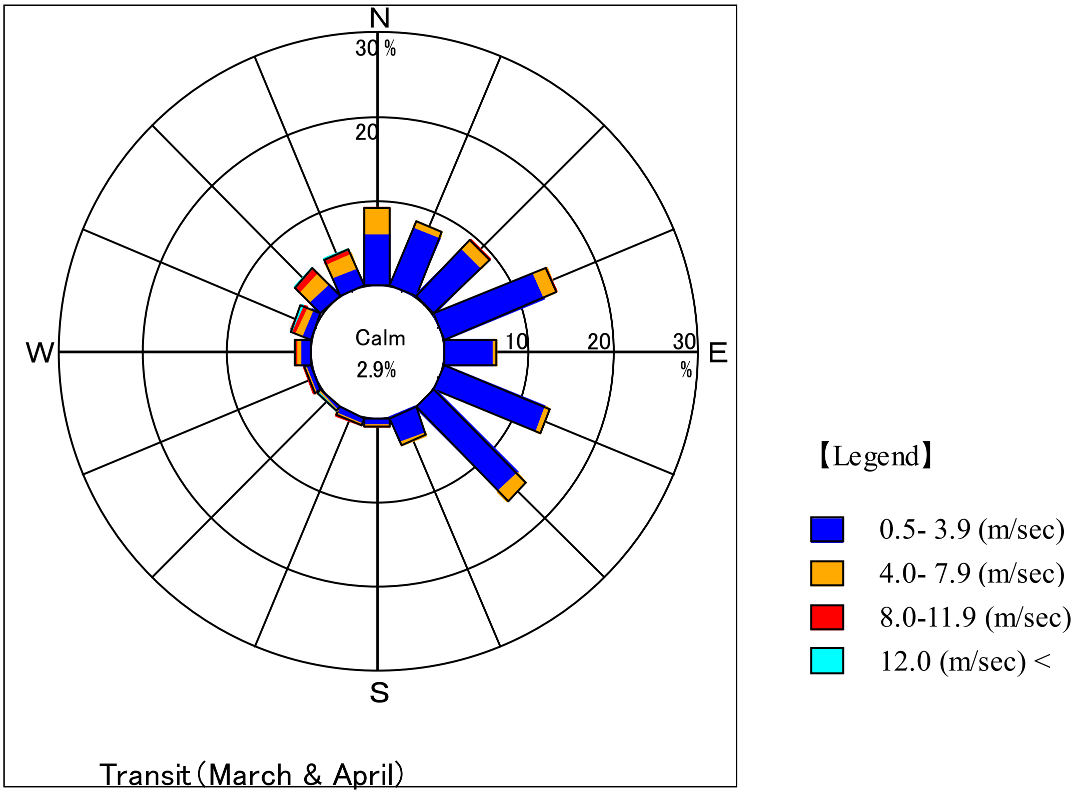


Figure 1.5 Wind Rose : Transit Season (March & April)

Table 1.4 Joint Frequency of Occurrence of Wind Speed and Wind Direction Winter/Dry Season : May to September for 1999 – 2008

Regulation	36720	
Observation	36554	(99.5)
Error	166	(0.5)

Site	Funafuti
Term	1999/ 1/ 1/ 0:00– 2008/ 12/ 31/ 23:00[Winter(May to September)]

(m/sec)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum	Accum. Sum
0.0 – 0.4	41 (0.1)	45 (0.1)	45 (0.1)	47 (0.1)	68 (0.2)	86 (0.2)	66 (0.2)	52 (0.1)	26 (0.1)	26 (0.1)	26 (0.1)	24 (0.1)	39 (0.1)	25 (0.1)	33 (0.1)	32 (0.1)	681 (1.9)	681 (1.9)
0.5 – 1.9	321 (0.9)	607 (1.7)	858 (2.3)	1340 (3.7)	1379 (3.8)	2804 (7.7)	2003 (5.5)	534 (1.5)	172 (0.5)	114 (0.3)	87 (0.2)	85 (0.2)	101 (0.3)	127 (0.3)	108 (0.3)	128 (0.4)	10768 (29.5)	11449 (31.3)
2.0 – 3.9	442 (1.2)	642 (1.8)	999 (2.7)	2795 (7.6)	939 (2.6)	4154 (11.4)	5797 (15.9)	1292 (3.5)	288 (0.8)	136 (0.4)	79 (0.2)	56 (0.2)	70 (0.2)	105 (0.3)	134 (0.4)	159 (0.4)	18087 (49.5)	29536 (80.8)
4.0 – 5.9	131 (0.4)	90 (0.2)	240 (0.7)	615 (1.7)	106 (0.3)	1275 (3.5)	2454 (6.7)	743 (2.0)	141 (0.4)	43 (0.1)	26 (0.1)	18 (0.0)	26 (0.1)	41 (0.1)	76 (0.2)	112 (0.3)	6137 (16.8)	35673 (97.6)
6.0 – 7.9	28 (0.1)	7 (0.0)	22 (0.1)	51 (0.1)	19 (0.1)	76 (0.2)	256 (0.7)	191 (0.5)	39 (0.1)	10 (0.0)	14 (0.0)	11 (0.0)	8 (0.0)	11 (0.0)	25 (0.1)	32 (0.1)	800 (2.2)	36473 (99.8)
8.0 – 9.9	2 (0.0)		3 (0.0)	5 (0.0)		4 (0.0)	11 (0.0)	17 (0.0)	6 (0.0)	2 (0.0)	1 (0.0)		4 (0.0)		5 (0.0)	9 (0.0)	69 (0.2)	36542 (100.0)
10.0 – 11.9				1 (0.0)					5 (0.0)	2 (0.0)					2 (0.0)		10 (0.0)	36552 (100.0)
12.0 – 13.9			1 (0.0)							1 (0.0)							2 (0.0)	36554 (100.0)
14.0 – 15.9																		36554 (100.0)
16.0 – 17.9																		36554 (100.0)
18.0 – 19.9																		36554 (100.0)
20.0 ≦																		36554 (100.0)
Sum	965 (2.6)	1391 (3.8)	2168 (5.9)	4854 (13.3)	2511 (6.9)	8399 (23.0)	10587 (29.0)	2829 (7.7)	677 (1.9)	334 (0.9)	233 (0.6)	194 (0.5)	248 (0.7)	309 (0.8)	383 (1.0)	472 (1.3)	36554 (100.0)	* *

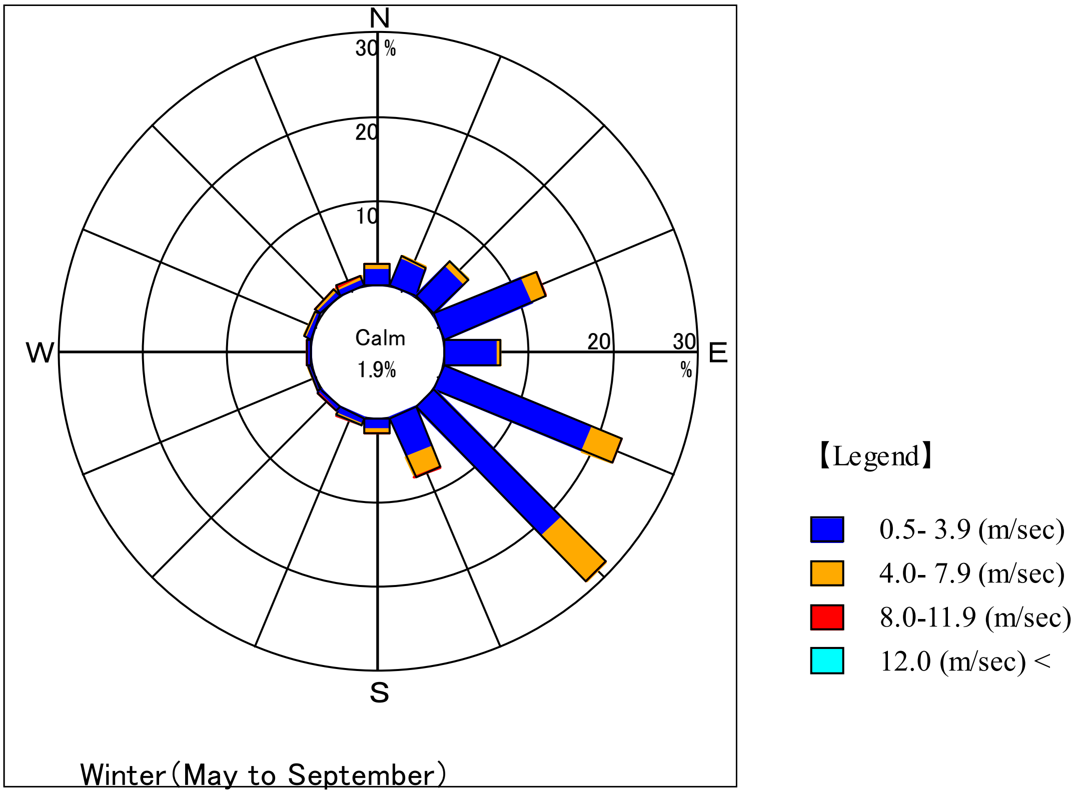


Figure 1.6 Wind Rose : Winter Season (May to September)

Table 1.5 Joint Frequency of Occurrence of Wind Speed and Wind Direction Transit Season : October to November for 1999–2008

Regulation	14640
Observation	14626 (99.9)
Error	14 (0.1)

Site	Funafuti
Term	1999/ 1/ 1/ 0:00- 2008/ 12/ 31/ 23:00[Transit(October & November)]

(m/sec)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum	Accum. Sum
0.0 – 0.4	27 (0.2)	39 (0.3)	29 (0.2)	28 (0.2)	28 (0.2)	51 (0.3)	61 (0.4)	35 (0.2)	30 (0.2)	25 (0.2)	26 (0.2)	17 (0.1)	21 (0.1)	19 (0.1)	21 (0.1)	28 (0.2)	485 (3.3)	485 (3.3)
0.5 – 1.9	217 (1.5)	418 (2.9)	490 (3.4)	604 (4.1)	480 (3.3)	770 (5.3)	704 (4.8)	266 (1.8)	108 (0.7)	89 (0.6)	64 (0.4)	54 (0.4)	74 (0.5)	80 (0.5)	75 (0.5)	91 (0.6)	4584 (31.3)	5069 (34.7)
2.0 – 3.9	501 (3.4)	774 (5.3)	668 (4.6)	1132 (7.7)	244 (1.7)	855 (5.8)	1595 (10.9)	550 (3.8)	141 (1.0)	104 (0.7)	30 (0.2)	47 (0.3)	61 (0.4)	73 (0.5)	97 (0.7)	162 (1.1)	7034 (48.1)	12103 (82.7)
4.0 – 5.9	232 (1.6)	148 (1.0)	184 (1.3)	169 (1.2)	26 (0.2)	162 (1.1)	456 (3.1)	272 (1.9)	68 (0.5)	31 (0.2)	12 (0.1)	8 (0.1)	31 (0.2)	44 (0.3)	68 (0.5)	131 (0.9)	2042 (14.0)	14145 (96.7)
6.0 – 7.9	47 (0.3)	13 (0.1)	21 (0.1)	15 (0.1)	3 (0.0)	10 (0.1)	25 (0.2)	34 (0.2)	14 (0.1)	11 (0.1)	13 (0.1)	5 (0.0)	22 (0.2)	30 (0.2)	48 (0.3)	51 (0.3)	362 (2.5)	14507 (99.2)
8.0 – 9.9	11 (0.1)	2 (0.0)	2 (0.0)		1 (0.0)	1 (0.0)	3 (0.0)	2 (0.0)	5 (0.0)	5 (0.0)	2 (0.0)	3 (0.0)	7 (0.0)	15 (0.1)	10 (0.1)	14 (0.1)	83 (0.6)	14590 (99.8)
10.0 – 11.9	2 (0.0)						1 (0.0)	2 (0.0)	1 (0.0)			3 (0.0)	6 (0.0)		9 (0.1)	1 (0.0)	25 (0.2)	14615 (99.9)
12.0 – 13.9	1 (0.0)								1 (0.0)			4 (0.0)	1 (0.0)			4 (0.0)	11 (0.1)	14626 (100.0)
14.0 – 15.9																		14626 (100.0)
16.0 – 17.9																		14626 (100.0)
18.0 – 19.9																		14626 (100.0)
20.0 ≦																		14626 (100.0)
Sum	1038 (7.1)	1394 (9.5)	1394 (9.5)	1948 (13.3)	782 (5.3)	1849 (12.6)	2845 (19.5)	1161 (7.9)	368 (2.5)	265 (1.8)	147 (1.0)	141 (1.0)	223 (1.5)	261 (1.8)	328 (2.2)	482 (3.3)	14626 (100.0)	* *

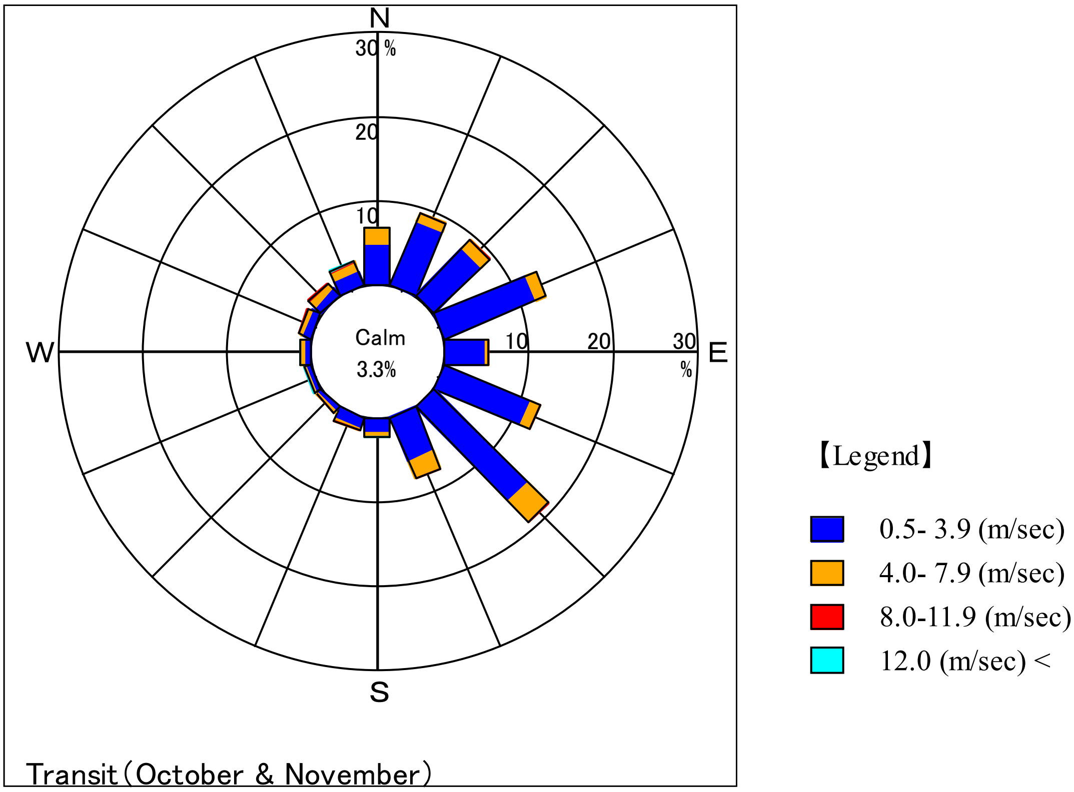


Figure 1.7 Wind Rose : Transit Season (October & November)

c) Strong Wind Speeds

Table 1.6 shows the monthly strongest wind speeds obtained wind data recorded at the SEAFRAME station during 1994 to 2009. Strong winds occur in December to March of the summer season, while comparatively weak winds in May to September of the winter season.

Table 1.6 Monthly Strongest Wind Speed (1994 - 2009)

Month	Strongest Wind Speed (m/sec)	Remarks
January	16.5	2007
February	16.2	2002
March	19.2	1997
April	15.4	2004
May	12.0	2005
June	13.6	2002
July	9.8	1998/2005
August	11.3	2006
September	9.5	1994
October	13.3	2002
November	13.8	2007
December	19.7	1994

Seeing the yearly occurrence frequency of strong wind speeds (refer to Table 1.7), it is specially noted that the strong winds blow in 1997 which is coincident with the El Niño event.

As a whole, the percentage occurrences of strong winds more than 10 m/sec and 14 m/sec were 0.7% and 0.06%, respectively.

Table 1.7 Yearly Occurrence Frequency of Strong Wind Speed

Year	Wind Speed (m/sec)					Sum (times)
	›18.0	17.9-16.0	15.9-14.0	13.9-12.0	11.9-10.0	
1994	1		7	13	50	71
1995			2	5	27	34
1996				2	15	17
1997	3	10	19	50	72	154
1998				3	42	45
1999					3	3
2000					17	17
2001		1	2	12	35	50
2002		1	9	32	43	85
2003			7	25	70	102
2004			4	20	124	148
2005	1		3	19	96	119
2006			1	4	28	33
2007		1	1	10	32	44
2008				3	15	18
2009		2	2	7	42	53
Total (times)	5	15	57	205	711	993

(Note) Total number of data : 137,853

d) Ranking of Strong Wind Speeds

The strongest wind speed is recorded to be 19.7 m/sec on December 14, 1994 followed by 19.2 m/sec March 15, 1997, when the Tropical Cyclone Hina passed nearby. Most of strong winds recorded during 1994 to 2009 were affected by the Tropical Cyclone Hina as shown in Table 1.8.

Hourly records of the strongest winds during observation period are shown in Table 1.9 in case of December 13 to 15, 1994 and in Table 1.10 in case of March 14 to 15, 1997.

Table 1.8 Strong Wind more than 15.0 m/sec during 1994 to 2009

Ranking	Wind Speed (m/sec)	Occurrence Date & Time	Remarks
1	19.7	Dec. 14, 1994 (16:00)	
2	19.2	March 15, 1997 (03:00)	T. Cyclone “Hina”
3	19.0	March 14, 1997 (23:00)	- ditto -
4	18.4	March 14, 1997 (18:00)	- ditto -
5	18.4	March 1, 2005 (00:00)	
6	17.8	March 15, 1997 (04:00)	T. Cyclone “Hina”
7	17.7	March 12, 1997 (13:00)	- ditto -
8	17.3	March 14, 1997 (16:00)	- ditto -
9	17.2	March 15, 1997 (09:00)	- ditto -
10	17.1	March 15, 1997 (06:00)	- ditto -
11	17.0	March 15, 1997 (02:00)	- ditto -
12	16.8	March 14, 1997 (20:00)	- ditto -
13	16.6	March 15, 1997 (01:00)	- ditto -
14	16.5	Jan. 26, 2007 (02:00)	
15	16.4	Dec. 21, 2001 (01:00)	
16	16.2	Feb. 19, 2002 (05:00)	
17	16.2	April 1, 2009 (15:00)	
18	16.1	March 14, 1997 (19:00)	T. Cyclone “Hina”
19	16.1	March 14, 1997 (22:00)	- ditto -
20	16.1	April 3, 2009 (00:00)	
21	15.9	Jan. 18, 2007 (05:00)	
22	15.7	March 21, 1994 (23:00)	
23	15.7	Jan. 8, 2004 (03:00)	
24	15.6	Dec, 14, 1994 (05:00)	
25	15.6	Jan. 28, 2003 (13:00)	
26	15.5	Jan. 12, 2003 (06:00)	
27	15.5	March 13, 1997 (08:00)	T. Cyclone “Hina”
28	15.5	March 14, 1997 (21:00)	- ditto -
29	15.5	March 15, 1997 (0:00)	- ditto -
30	15.4	Dec. 16, 1995 (19:00)	
31	15.4	March 15, 1997 (07:00)	T. Cyclone “Hina”
32	15.4	April 18, 2004 (04:00)	
33	15.2	March 12, 1997 (14:00)	T. Cyclone “Hina”
34	15.0	Feb. 17, 2002 (23:00)	
35	15.0	Feb. 18, 2002 (03:00)	
36	15.0	Feb. 18, 2002 (07:00)	
37	15.0	Jan. 10, 2004 (01:00)	

Table 1.9 Hourly Records of Strongest Winds during Observation Period (in case of December 1994)

Date & Time	Wind Speed (m/sec)	Wind Gust (m/sec)	Direction (degree)	Remarks
Dec. 13 22:00	8.6	13.8	356	
23:00	10.8	14.6	342	
Dec. 14 00:00	6.9	12.7	338	
01:00	10.2	14.1	339	(start)
02:00	10.5	15.7	335	
03:00	13.8	19.3	333	
04:00	13.9	18.5	331	
05:00	15.6	20.8	321	
06:00	14.8	21.3	315	
07:00	12.7	18.9	327	
08:00	14.1	17.8	325	
09:00	14.1	17.6	319	
10:00	11.9	21.8	300	
11:00	12.4	15.4	297	
12:00	12.6	15.0	304	
13:00	12.5	14.8	304	
14:00	13.1	17.3	302	
15:00	11.2	15.3	300	
16:00	19.7	24.6	285	Maximum
17:00	11.4	22.7	289	
18:00	11.1	13.5	293	
19:00	11.6	13.7	286	
20:00	11.4	14.6	306	
21:00	11.4	15.6	307	
22:00	13.7	16.2	296	
23:00	13.3	17.1	304	
Dec. 15 00:00	12.9	15.9	302	
01:00	12.0	15.1	291	
02:00	10.8	13.9	289	
03:00	11.8	14.1	291	
04:00	11.3	14.1	289	
05:00	11.0	13.9	296	
06:00	11.2	13.9	295	
07:00	11.1	12.7	291	(end)
08:00	8.3	11.9	284	31 hours
09:00	9.9	11.7	290	
10:00	9.5	12.1	289	

(Note) Direction of strong wind : 285 – 339 degree

Table 1.10 Hourly Records of Strongest Winds during Observation Period (in case of March 1997)

Date & Time	Wind Speed (m/sec)	Wind Gust (m/sec)	Direction (degree)	Remarks
Mar. 14 01:00	7.9	13.4	276	
02:00	11.3	14.4	310	(start)
03:00	11.9	16.0	317	
04:00	12.4	15.0	304	
05:00	13.0	20.0	285	
06:00	12.5	19.9	297	
07:00	13.6	16.2	295	
08:00	12.0	16.2	311	
09:00	12.3	15.5	311	
10:00	11.5	15.6	315	
11:00	13.6	16.1	314	
12:00	13.5	18.1	315	
13:00	14.7	18.0	322	
14:00	14.8	19.3	321	
15:00	13.5	22.9	301	
16:00	17.3	22.1	296	
17:00	12.8	23.1	303	
18:00	18.4	21.0	305	
19:00	16.1	22.2	302	
20:00	16.8	23.7	308	
21:00	15.5	20.8	316	
22:00	16.1	<u>24.1</u>	311	Max. Gust
23:00	19.0	24.0	311	
Mar. 15 00:00	15.5	22.1	310	
01:00	16.6	22.9	311	
02:00	17.0	20.7	307	
03:00	<u>19.2</u>	23.2	291	Max. Speed
04:00	17.8	23.7	300	
05:00	14.3	22.4	297	
06:00	17.1	21.3	294	
07:00	15.4	21.2	297	
08:00	14.1	20.4	306	
09:00	17.2	20.1	309	
10:00	-	-	-	
11:00	14.8	17.4	301	
12:00	12.9	18.6	305	
13:00	14.1	18.0	295	
14:00	12.9	17.0	290	
15:00	10.5	17.0	287	
16:00	12.5	14.3	286	
17:00	12.0	15.7	286	(end)
18:00	8.2	12.9	287	40 hours
19:00	7.9	10.8	294	

(Note) Direction of strong wind : 285 – 322 degree

(2) Precipitations

Tuvalu Meteorological Service (Station: J64800) at Funafuti observes the daily climatology such as rainfall, air temperature, atmospheric pressure (mean sea level), and wind speed and direction at 9:00 o'clock every day. Regarding to precipitation, the observation was started from January 1st, 1933.

The monthly precipitation data recorded are summarized in Table 1.11 and Figure 1.8. The precipitation at Funafuti shows a seasonal change in the monthly means, which is typically divided into two seasons, the rainy season from December to March and the dry season from April to November.

The annual mean precipitation over the duration of the recorded is 3,493.2 mm. The annual maximum and minimum precipitations was reached to 6,771.1 mm in 1940 and 2,226.0 in 1971, respectively.

Table 1.11 Monthly Precipitation (1933 – 2008)

Month	Precipitation (mm)			Remarks
	Maximum (year)	Mean	Minimum (year)	(Mean)
January	1,141.5 (1955)	399.7	163.7 (1978)	1945 - 2008
February	1,138.9 (1957)	347.3	93.4 (1979)	ditto
March	1,293.1 (1939)	347.7	81.8 (1941)	1945 - 2007
April	618.2 (1939)	265.7	58.8 (2006)	ditto
May	615.2 (1969)	249.6	46.0 (1971)	ditto
June	566.4 (1949)	226.3	67.6 (1955)	ditto
July	617.2 (1941)	259.0	72.2 (1999)	ditto
August	1,196.3 (1940)	265.3	40.9 (1950)	ditto
September	879.1 (1940)	209.5	47.0 (1950)	ditto
October	556.3 (1958)	263.2	55.1 (1999)	ditto
November	702.8 (1940)	268.3	56.3 (1976)	ditto
December	836.9 (1970)	391.7	129.8 (1933)	ditto
Annual	6,771.1 (1940)	3,493.2 mm	2,226.0 (1971)	

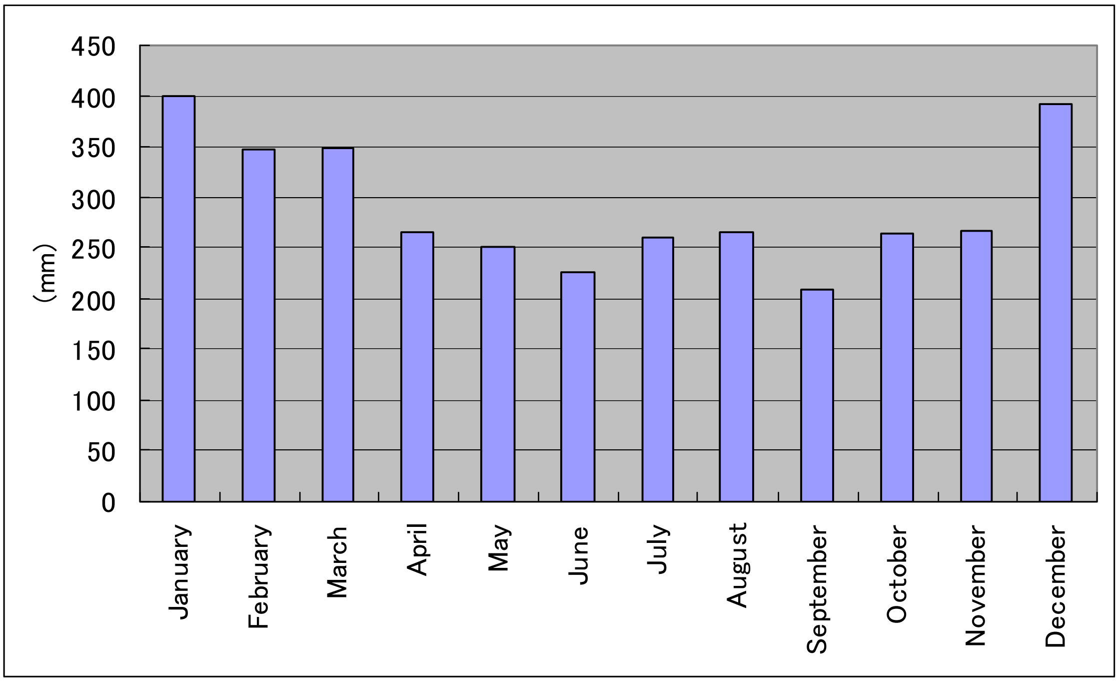


Figure 1.8 Monthly Mean Precipitation at Funafuti (1945 – 2008)

(3) Air and Water Temperatures

Monthly maximum and minimum recorded air temperatures and water temperatures from January 1994 to December 2009 at Funafuti are provided in "Data Book" attached to this report.

a) Air Temperatures

The air temperature data recorded from 1994 at Funafuti are summarized in Figure 1.9. The middle curve (red) represents the monthly mean temperature. The upper and lower curves show the highest and lowest values recorded each month.

The air temperature at Funafuti shows a slight downward trend in the monthly means from installation until 1999, followed by a slight upward trend. From 1999 – 2000, air temperature maxima were relatively low. Compared to high latitudes, air temperatures in the tropics vary little throughout the year. Funafuti recorded the lowest air temperature, 22.8℃, on 14th of January 1999 and the highest air temperature, 33.7℃, on 19th of November 2005. The mean air temperature over the duration of the recorded is 28.5℃.

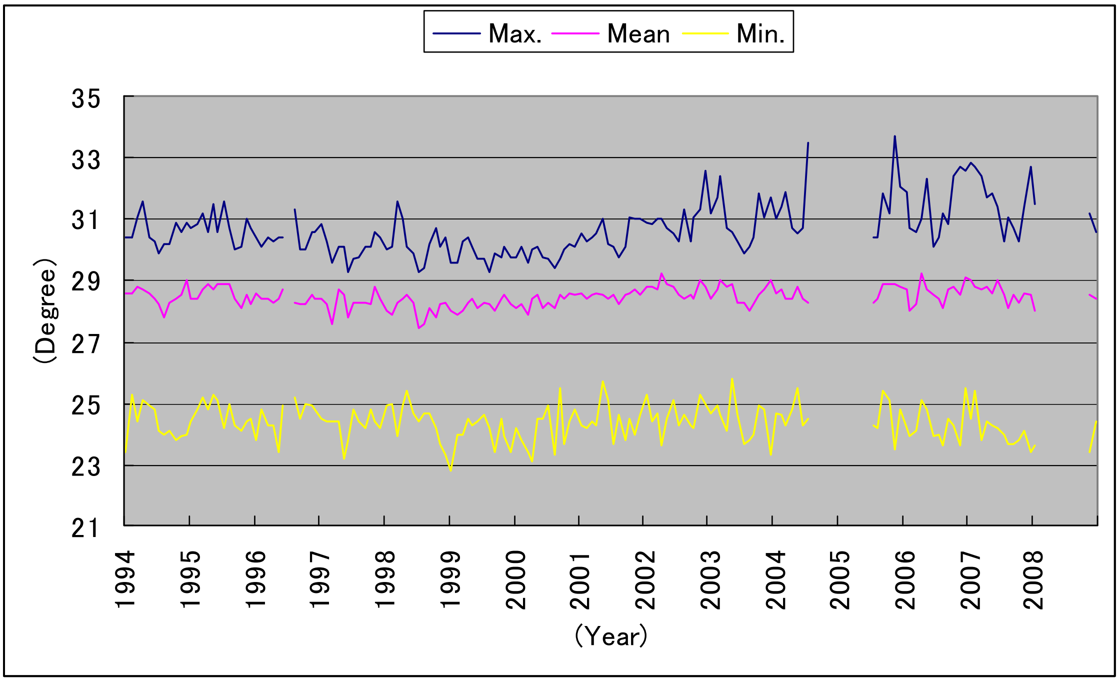
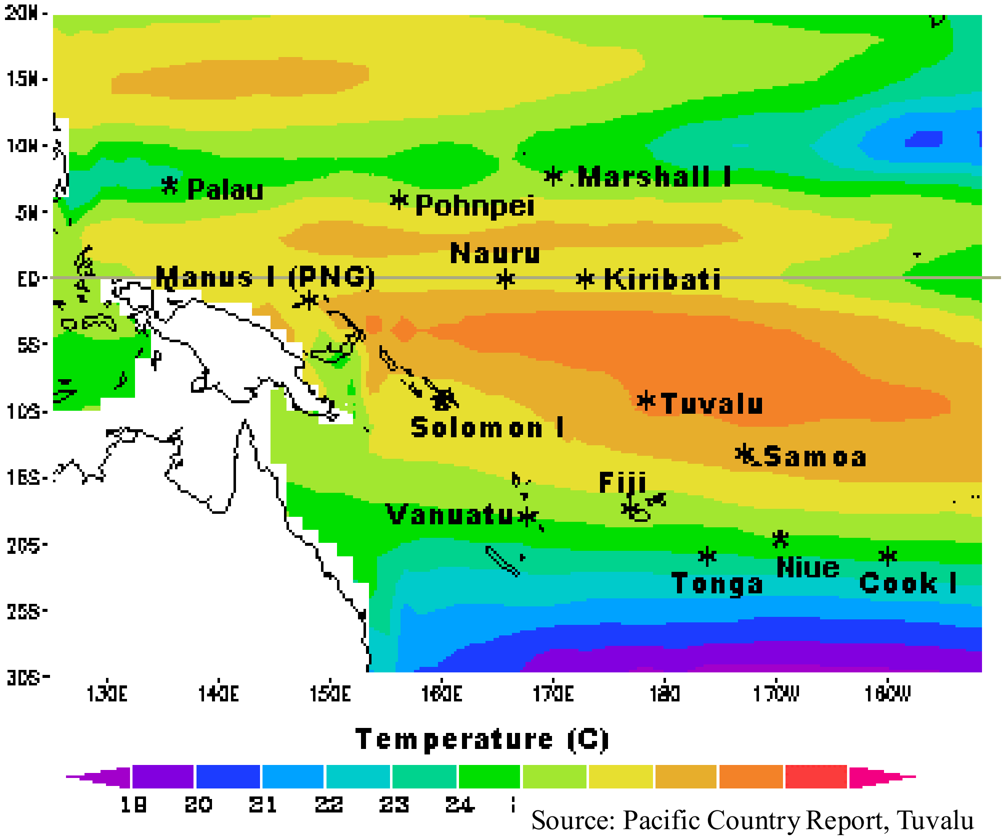


Figure 1.9 Monthly Air Temperature at Funafuti (1994 – 2008)

b) Water Temperatures

The convergence of the Trade Winds along SPCZ has the effect of deepening the warm upper layer on the ocean, which affects the sea surface water temperature. Tuvalu, which is in the heart of the SPCZ, is situated in the high water temperature zone (refer to Figure 1.10).



Source: Pacific Country Report, Tuvalu

Figure 1.10 Mean Surface Water Temperature

Since installation of the SEAFRAME in 1993 a decadal fluctuation in water temperature has been observed. The water temperature data recorded from 1994 are summarized in Figure 1.11. The middle curve (red) represents the monthly mean temperature. The upper and lower curves show the highest and lowest values recorded each month.

The annual maximum temperatures typically occur in November each year, although during El Niño the seasonal cycle of sea level and water temperature are interrupted. The mean water temperature over the duration of the recorded is 29.5℃. The maximum water temperature was 32.7℃ on 26th of November 2001, and a new minimum of 27.3℃ was recently recorded on

30th January 2008.

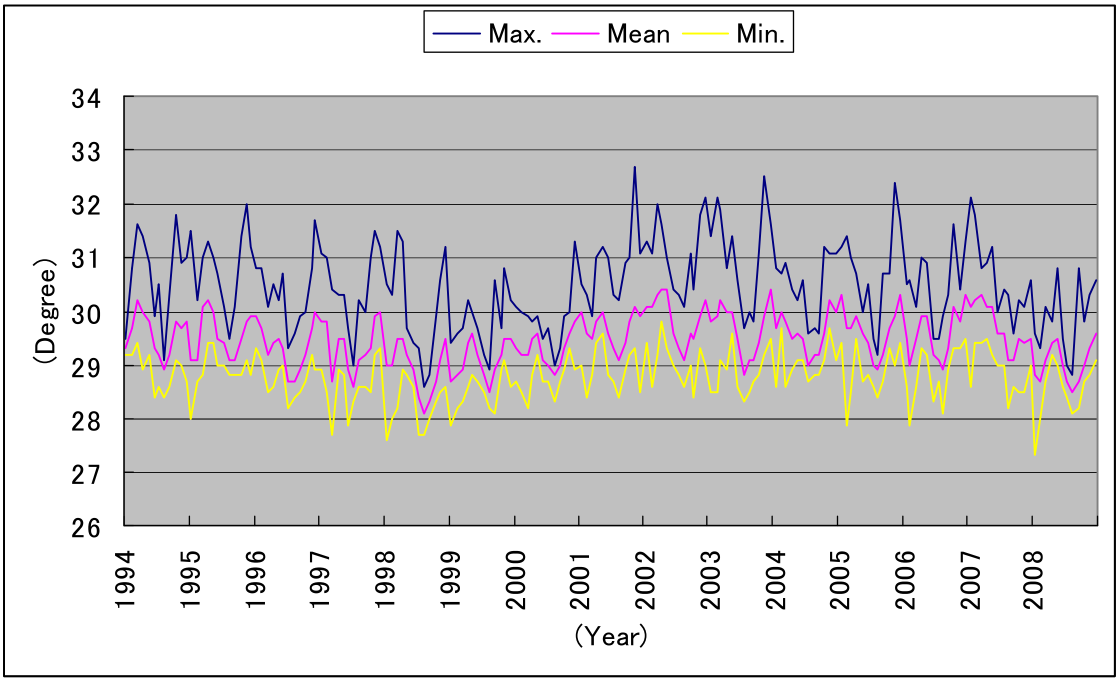


Figure 1.11 Monthly Water Temperature at Funafuti (1994 – 2008)

(4) Atmospheric Pressures

Atmospheric pressure is one of the parameters that can potentially influence relative sea level rise. Known as the inverted barometer effect, if a 1hPa fall in barometric pressure is sustained over a day or more, a 1 cm rise is produced in the local sea level within the area beneath the low pressure system. Trends in barometric pressure over a period of time will cause changes in relative sea level.

Monthly highest and lowest recorded barometric pressures from January 1994 to December 2009 at Funafuti are provided in “Data Book” attached to this report. The monthly barometric pressure data recorded from 1994 are summarized in Figure 1.12. The middle curve (red) represents the monthly mean pressure. The upper and lower curves show the highest and lowest values recorded each month.

Barometric pressures vary little throughout the year. The monthly atmospheric pressure at Funafuti shows a decline over the years after the El Niño of 1998. The mean barometric pressure over the duration on the recorded is 1008.5hPa. Funafuti recorded the highest barometric pressure, 1016.4hPa on 2nd of July 1998 and the lowest barometric pressure, 995.4hPa on 5th of March 1997, which coincides with the passage of Tropical Cyclone Gavin.

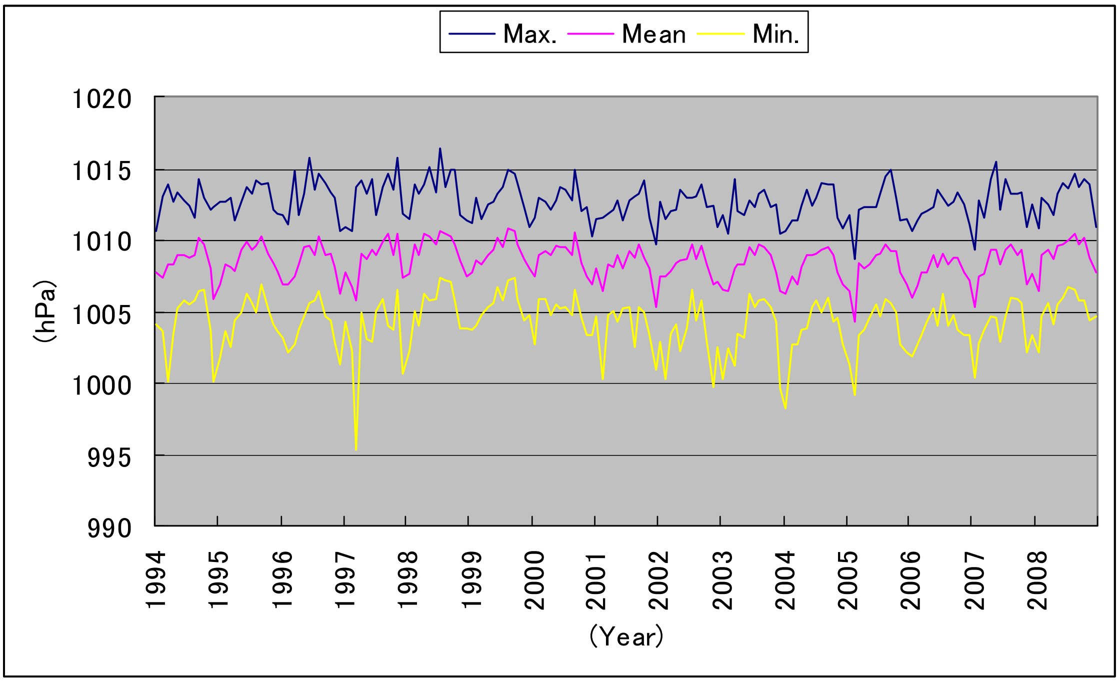


Figure 1.12 Monthly Atmospheric Pressure at Funafuti (1994 – 2008)

Table 1.12 Monthly Maximum and Minimum Air Temperature, Water Temperature and Atmospheric Pressure

(All Year: 1994 - 2009)

Month	Air Temperature (˚C)		Water Temperature (˚C)		Atmospheric Pressure (hPa)	
	Max.	Min.	Max.	Min.	Max.	Min.
January	32.8	22.8	32.1	27.3	1012.6	998.3
February	32.7	23.8	32.1	27.9	1013.9	999.2
March	32.4	23.4	32.0	27.7	1014.8	995.4
April	31.7	23.1	31.6	28.6	1014.2	1003.5
May	32.3	23.2	31.4	28.7	1015.5	1002.2
June	31.4	23.8	31.0	28.3	1015.7	1002.9
July	33.5	23.7	30.5	27.7	1016.4	1004.6
August	31.3	23.3	30.2	27.7	1014.9	1002.5
September	31.8	23.4	31.1	28.0	1015.0	1004.0
October	32.4	23.7	31.8	28.3	1014.3	1003.0
November	33.7	23.4	32.7	28.5	1015.7	999.8
December	32.7	23.3	32.1	28.5	1012.5	999.6
Max. & Min. (Date of Occur.)	33.7˚C Nov.19, 05	22.8˚C Jan.14, 99	32.7˚C Nov.26, 01	27.3˚C Jan.30, 08	1016.4 hPa July 2, 98	995.4 hPa Mar.5, 97

(5) Tropical Cyclones

Tropical cyclones, which are fueled by heat stored in the upper ocean, tend to occur in the hottest months. They do not occur within 5° of the equator due to the weakness of the "Corioli's Force", a rather subtle effect of the earth's rotation.

Tuvalu is situated in the southwest Pacific in an area that experiences tropical cyclones. The main Tropical Cyclones affected to Tuvalu are listed in Table 1.13.

Table 1.13 Records of Tropical Cyclone Effected to Tuvalu

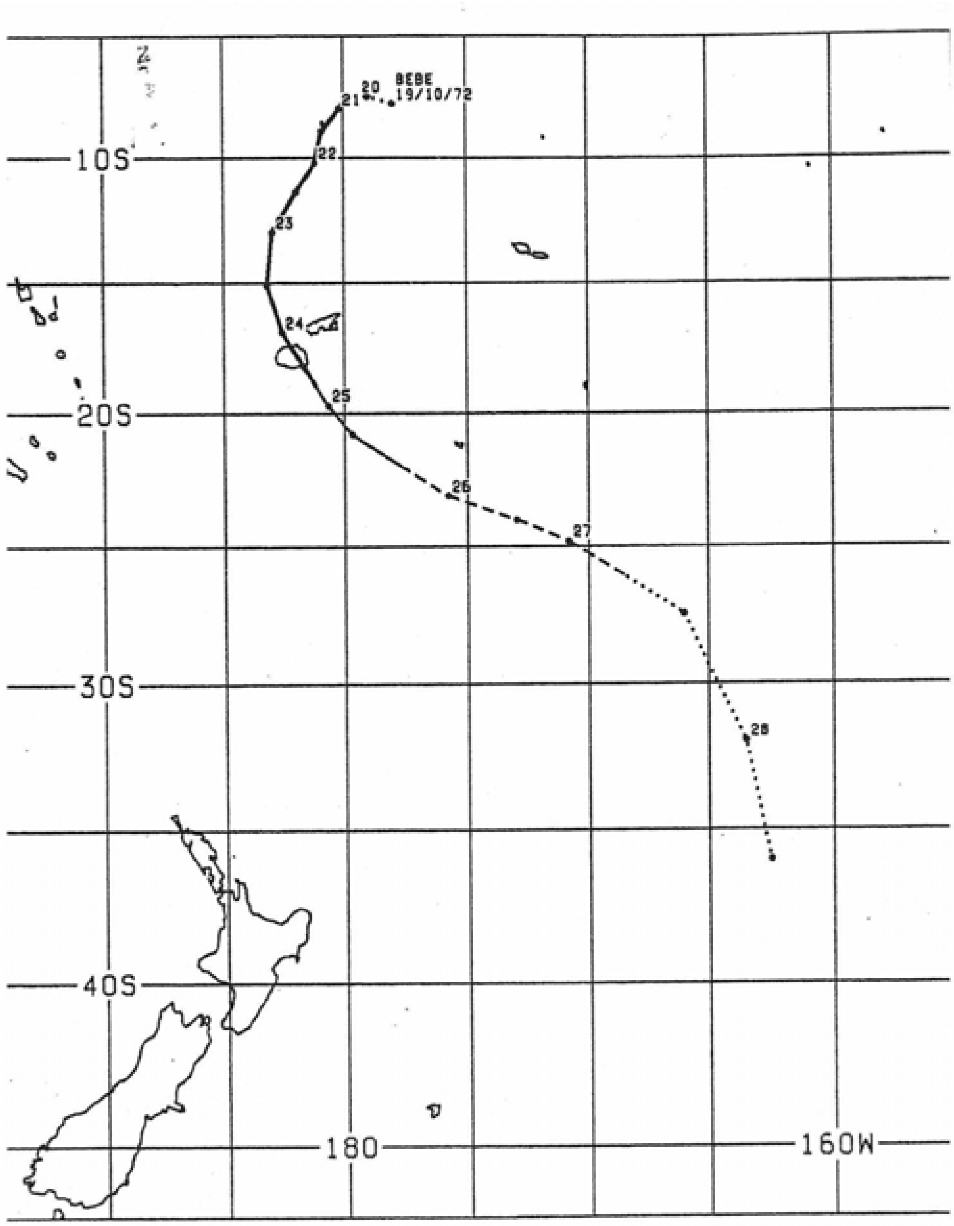
No.	Name of Cyclone	Date of Occurrence	Remarks
1	Unnamed	Feb. 18, 1891	
2	Unnamed	Jan. 02, 1958	
3	Bebe	Oct. 21, 1972	
4	Ofa	1990	
5	Sina	Nov. 1990	
6	Val	Dec. 1991	Dec. 4-5
7	Kina	1993	
8	Nina	1993	
9	Gavin	Mar. 1997	Mar. 5-7
10	Hina	Mar. 1997	Mar. 10-13
11	Keli	June 10, 1997	June 10-13
12	Ami	Jan. 11, 2003	Jan. 11-14
13	Heta	Jan. 02, 2004	Jan. 2-4

(Note) Date : UTC Time

In recorded history, there were three tropical cyclones which had a major impact on Tuvalu (formerly the Ellice Islands). They were unnamed and occurred on February 18, 1891 and January 2, 1958. Another was Cyclone Bebe occurred on October 21, 1972 (refer to Figure 1.13) with the lowest recorded mean sea level pressure 954 hPa at Funafuti and with a maximum 10-minute average wind speed of 80 knots and a maximum 3-second gust of about 110 knots. The storm surge was reported to be about 4 meters above the mean high level water mark.

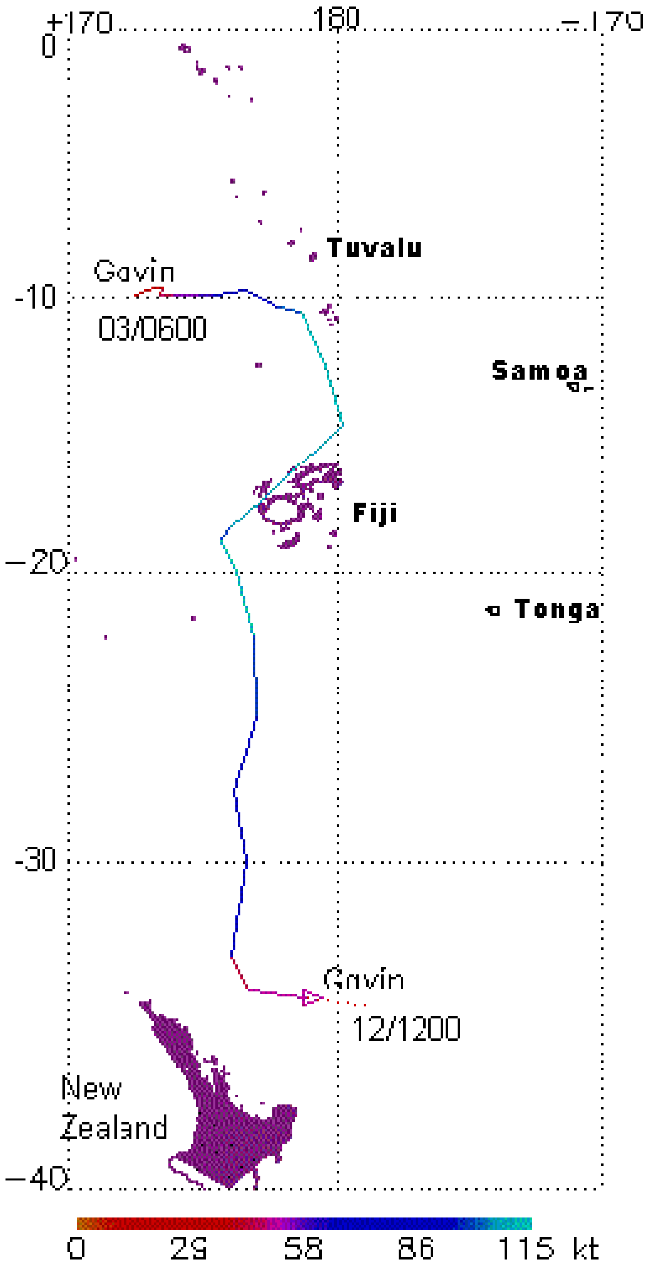
Only one tropical cyclone has passed close to the SEAFRAME at Funafuti since its installation in 1993. Tropical Cyclone Gavin originated close to the southwest of Funafuti on the 3rd March

1997 (see Figure 1.14). The storm surge, the non-tidal part of the recorded sea level, generated by Gavin reached a peak of 0.3 meters on the 5th of March, but since this was at a time of Neap tides it did not cause as much damage as it might have at Spring tides. Gavin did cause considerable erosion through wave action reaching into the lagoon.



Source: Tuvalu Government

Figure 1.13 Track of Tropical Cyclone (Bebe)



Source: SOPAC

Figure 1.14 Track of Tropical Cyclone (Gavin and Hina)

(6) El Niño- Southern Oscillation

The El Niño- Southern Oscillation (ENSO) refers to the periodic change in atmospheric and oceanic patterns in the tropical Pacific Ocean. The warm phase of the ENSO cycle is often simply referred to as El Niño, whilst the cool phase is termed La Niña. ENSO events have a return period of between four to seven years and typically last for around 12 to 18 months. They are a natural part of the climate system and have been affecting the Pacific Basin for thousands of years.

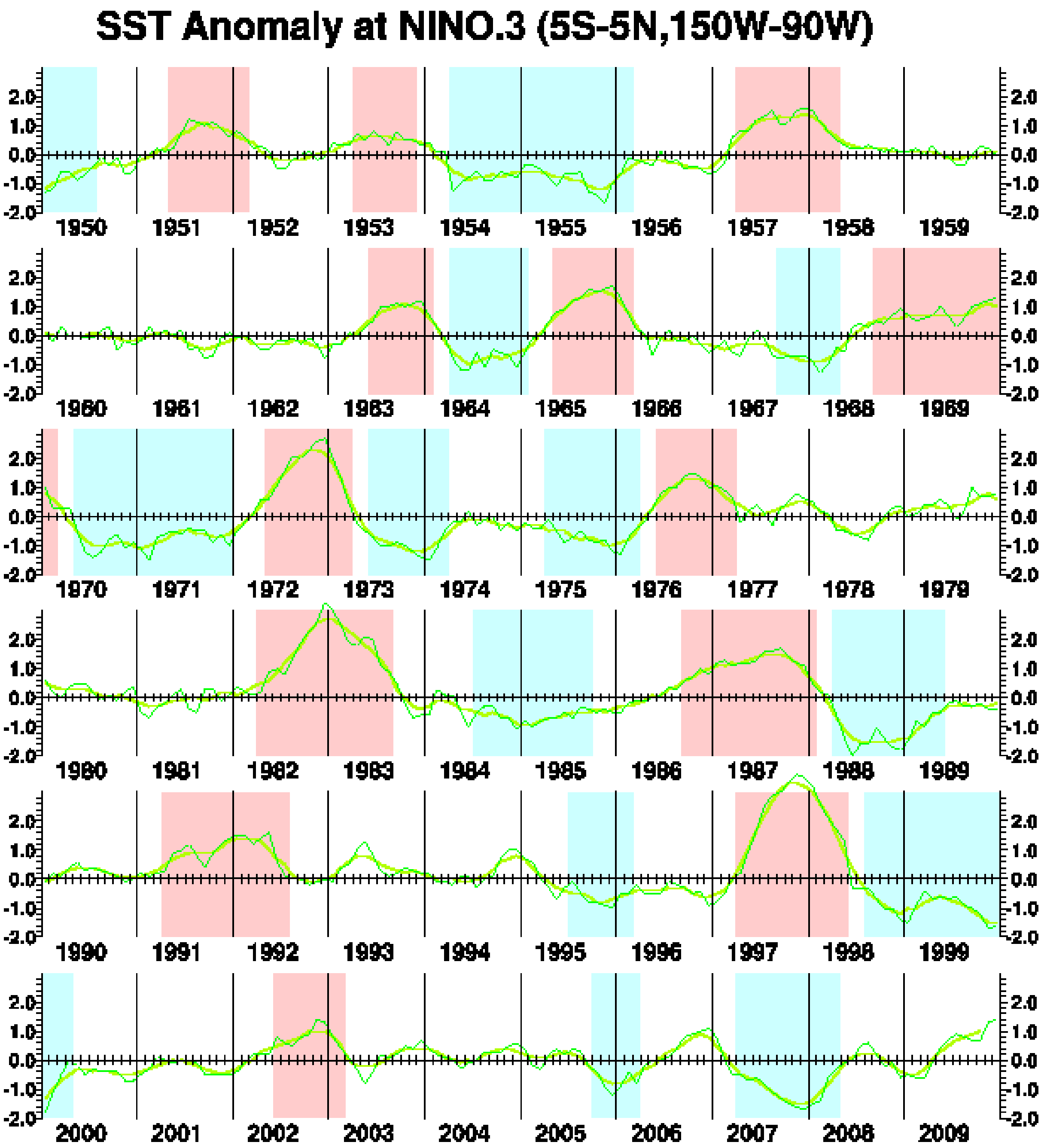
During neutral conditions (non- El Niño or La Niña phases), the easterly trade winds blow across the tropical Pacific. These winds pile up warm surface water in the west Pacific, so that the sea surface is about 50cm higher at Indonesia than at Ecuador. The sea surface temperature is about 8℃ higher in the west, with cool temperatures off South America, due to an upwelling of cold water from deeper levels. Rainfall is found in rising air over the warmer western waters and the east Pacific is relatively dry.

During El Niño events, the trade winds relax in the central and western Pacific. This reduction in the winds causes a reduction in the upwelling along the equator, leading to a depression of the ocean thermocline. The result is a rise in sea surface temperature and a drastic decline in primary productivity. Impacts of this shift eastwards in the circulation over the tropical Pacific may include increased cyclone activity in the central Pacific.

The opposite phase of El Niño is called La Niña. La Niña is characterized by unusually cold temperatures in the equatorial Pacific, as compared to El Niño, which is characterized by unusually warm ocean temperatures in the equatorial Pacific. Global climate anomalies associated with La Niña tend to be opposite those of El Niño.

Climate conditions during 1950- 2009 year at El Niño monitoring area NINO.3 (5°S-5°N, 150°W-90°W) were shown in Figure 1.15, in which the period of El Niño phenomena is shown with red and La Niña with blue in terms of the El Niño- Southern Oscillation..

In these 20 years, El Niño was observed three times in the Pacific climate, from March 1991 through to July 1992, from March 1997 to May 1998 and from May 2002 to February 2003. Whilst La Niña were observed four times from June 1995 through to February 1996, from July 1998 to May 1999, September 2005 to March 2006 and from March 2007 to April 2008.



Source: Japan Meteorological Agency

Figure 1.15 Occurrence Period of El Niño and La Niña Phenomena

1.2 Oceanographic Phenomena

The most striking oceanic and climatic fluctuations in the equatorial region are not the seasonal, but inter-annual changes associated with El Niño. These affect virtual every aspect of the system, including sea level, winds, precipitation, and air and water temperature.

(1) Sea Levels and Tides

a) Sea Levels

As part of the AusAid-sponsored South Pacific Sea Level and Climate Monitoring Project for the south pacific region, a SEAFRAME gauge was installed at Funafuti in March 1993. The time used for SEAFRAME is a Universal Time Coordinated (UTC). The SEAFRAME gauge records the sea level with high resolution since installation. Monthly highest and lowest sea levels from January 1994 to December 2009 at the SEAFRAME station in Funafuti are provided in "Data Book" together with monthly mean sea levels calculated from recorded data.

The sea levels in the Pacific Islands are controlled by many factors, some periodic like the tides, some brief but violent like cyclones, and some prolonged like El Niño. El Niño's impact on the sea level is mostly felt along the "South Pacific Convergence Zone (SPCZ)", because of changes in the strength and position of the Trade Winds, which have a direct bearing on sea level, and along the equator, due to related changes in ocean currents. The convergence of the Trade Winds along the SPCZ has the effect of deepening the warm upper layer of the ocean, which affects the seasonal sea level. Tuvalu, which is in the heart of the SPCZ, normally experiences higher-than-average sea levels early each year when this effect is at its peak.

The sea level data recorded since installation is summarized in Figure 1.16. The middle curve (red) represents the monthly mean sea level. The upper and lower curves show the highest and lowest values recorded each month. The most notable features of the monthly means are the annual peaks, which appear every year around February or March except in 1998, when a large drop in sea level was recorded during the 1997/1998 El Niño.

Although sea levels in the Tuvalu region normally fall in response to El Niño, the decrease that occurred during 1997/1998 El Niño can be considered extraordinary. Sea levels fell 35cm below average in February and March of 1998 due to the El Niño. By November 1998, sea level had completely recovered. Following the El Niño, the sea level resumed its normal seasonal cycle.

The mean sea level over the duration of the recorded is 2.01 m. The lowest sea level over the duration of the recorded is 0.53 m on 27th of February 1998 during the El Niño. Sea levels reached 3.30 m in March 1997 as a result of Tropical Cyclone Gavin, but the highest sea level recorded over the duration of the recorded is 3.42 m on 28th of February 2006. This was not caused by a tropical cyclone, but was due to the highest predicted astronomical tide 3.24m, which is the highest predicted level over the period 1990 to 2016, combined with a sea level anomaly of 0.18m due to the enhanced trade wind activity.

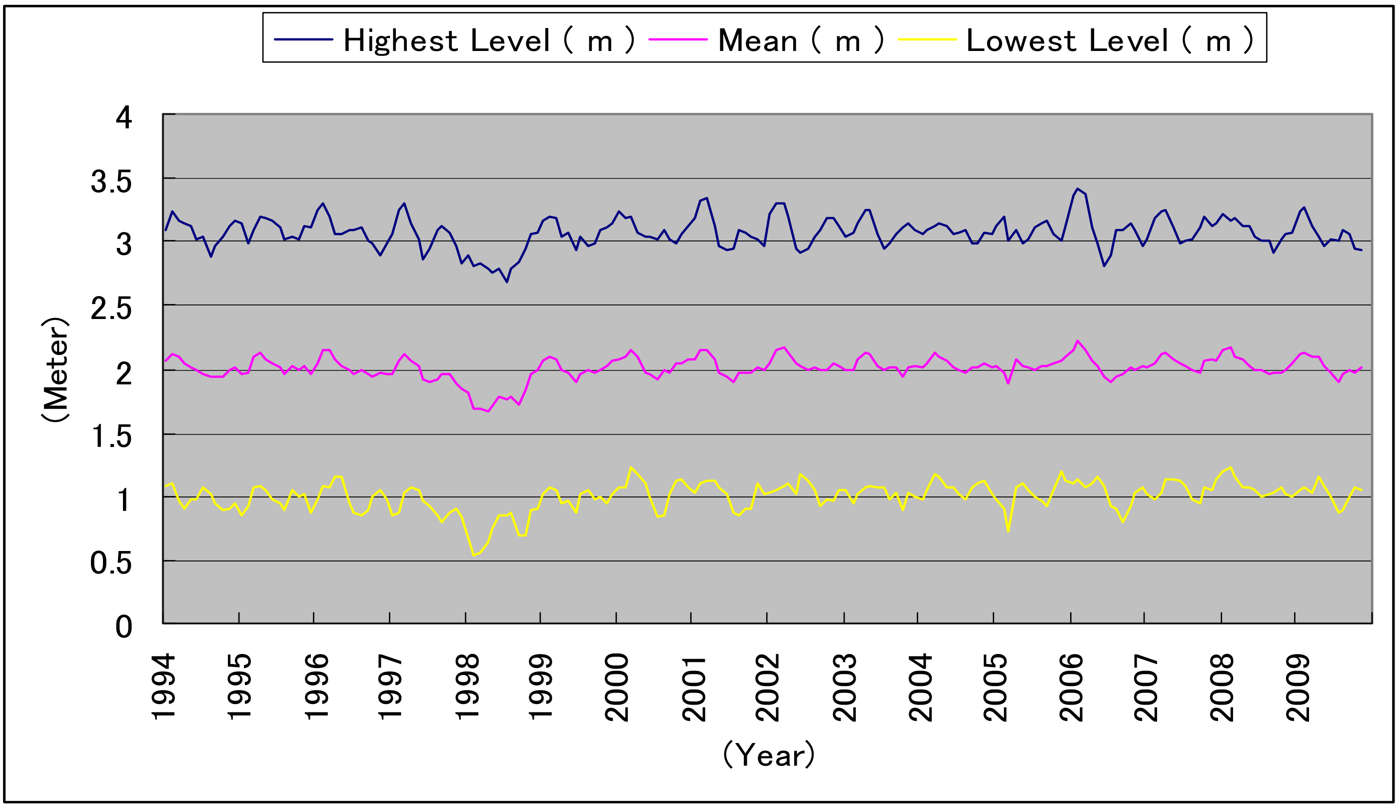


Figure 1.16 Monthly Sea Level at Funafuti

Table 1.14 summarizes the monthly highest sea level during 16 years from 1994 to 2009 at Funafuti and shows that the high sea level period is January to March and the low level period June to November.

Yearly occurrence of high sea levels more than 3.20m is shown in Table 1.15. Table 1.15 shows that high sea levels more than 3.20m were recorded 87 times during 16 years from 1994 to 2009 at Funafuti and most of them were recorded in summer season of January, February and March. The year 2006 is specially mentioned as recorded high sea levels and the highest sea level of 3.42 m was also recorded in this year.

Table 1.14 Monthly Highest Sea Level (All Year: 1994 - 2009)

Month	Highest Sea Level (m)	Remarks
January	3.358	2006
February	3.415	2006
March	3.370	2006
April	3.262	2007
May	3.246	2003
June	3.159	1995
July	3.115	2005
August	3.154	2005
September	3.163	2005
October	3.193	2007
November	3.151	2003
December	3.172	1994

Table 1.15 Yearly Occurrence Frequency of High Sea Level

Year	Sea Level (meter)					Sum (times)
	›3.40	3.39-3.35	3.34-3.30	3.29-3.25	3.24-3.20	
1994					2	2
1995						0
1996			2	5	6	13
1997			2	4	3	9
1998						0
1999					1	1
2000					2	2
2001			4	1	11	16
2002			2	4	6	12
2003				1	3	4
2004						0
2005						0
2006	1	4	2	5	5	17
2007				1	6	7
2008					1	1
2009				2	1	3
Total (times)	1	4	12	23	47	87

(Note) Total number of data : 130,618

b) Ranking of High Sea Levels

Every high sea levels more than 3.25 meters during 1994 to 2008 are summarized in Table 1.16. Total number of 40 high sea levels is recorded in this period and the most of these high levels belong to the following seven groups/periods;

Group- 1 : February 26 to March 1, 2006
Group- 2 : January 29 to January 31, 2006
Group- 3 : March 9 to March 10, 2001
Group- 4 : February 8 to February 9, 2001
Group- 5 : February 18 to February 20, 1996
Group- 6 : March 8 to March 9, 1997
Group- 7 : March 28 to March 29, 2002

Table 1.16 High Sea Level more than 3.25 meters during 1994 to 2009

Ranking	Sea Level (m)	Occurrence Date & Time	Remarks
1	3.415	Feb. 28, 2006 (5:00)	Group-1
2	3.384	Feb. 28, 2006 (6:00)	Group-1
3	3.370	March 1, 2006 (6:00)	Group-1
4	3.358	Jan. 30, 2006 (6:00)	Group-2
5	3.356	Feb. 27, 2006 (5:00)	Group-1
6	3.347	March 9, 2001 (5:00)	Group-3
7	3.322	Feb. 9, 2001 (6:00)	Group-4
8	3.317	Feb. 27, 2006 (4:00)	Group-1
9	3.312	Feb. 18, 1996 (5:00)	Group-5
10	3.310	March 10, 2001 (6:00)	Group-3
11	3.309	Feb. 28, 2002 (6:00)	
12	3.304	March 9, 1997 (5:00)	Group-6
13	3.304	Feb. 8, 2001 (5:00)	Group-4
14	3.303	March 28, 2002 (5:00)	Group-7
15	3.303	Jan. 31, 2006 (6:00)	Group-2
16	3.302	Feb. 19, 1996 (5:00)	Group-5
17	3.301	March 8, 1997 (5:00)	Group-6
18	3.294	Jan. 30, 2006 (5:00)	Group-2
19	3.291	Feb. 20, 1996 (6:00)	Group-5
20	3.288	Jan. 31, 2006 (7:00)	Group-2
21	3.286	Jan. 29, 2006 (5:00)	Group-2
22	3.284	Feb. 19, 1996 (6:00)	Group-5
23	3.279	March 9, 1997 (6:00)	Group-6
24	3.276	March 29, 2002 (6:00)	Group-7
25	3.271	Feb. 10, 2009 (6:00)	
26	3.270	Feb. 9, 2009 (5:00)	
27	3.269	March 29, 2002 (5:00)	Group-7
28	3.267	Feb. 18, 1996 (4:00)	Group-5
29	3.264	March 29, 2002 (18:00)	Group-7
30	3.263	March 10, 2001 (5:00)	Group-3
31	3.262	April 17, 2007 (17:00)	
32	3.258	March 8, 1997 (4:00)	Group-6
33	3.258	March 28, 2002 (17:00)	Group-7
34	3.258	Feb. 26, 2006 (4:00)	Group-1
35	3.257	March 1, 2006 (7:00)	Group-1
36	3.255	Jan. 21, 1996 (6:00)	
37	3.255	Feb. 8, 1997 (6:00)	
38	3.254	Jan. 20, 1996 (5:00)	
39	3.253	April 16, 2003 (17:00)	
40	3.250	Feb. 7, 1997 (5:00)	

c) Sea Level Rise due to Climate Change

As discussed in detail by the Intergovernmental Panel on Climate Change (IPCC) in its Fourth Assessment Report (IPCC AR4, 2007), sea level change is an important consequence of climate change, both for communities and environment.

IPCC AR4, 2007 estimates that global average eustatic sea level rise over the last century was 1.7±0.5 mm/year. From 1961 to 2003, the average rate of sea level rise is estimated as 1.8± 0.5 mm/year. IPCC AR4, 2007 also recognizes that sea level records contain a considerable amount of inter-annual and decadal variability. For instance, the average rate of sea level rise for the decadal period 1993- 2003 based on satellite altimetry is 3.1±0.7 mm/year. Studies have shown that comparably large rates of average sea level rise have been observed in previous decades.

Using these ten years' mean sea level data during 1999 to 2008, we calculated the sea level rise at a SEAFRAME station in Funafuti as shown in Figure 1.17. The average rate of sea level rise was obtained to be 2.3 mm/year, which is in the range of IPCC (AR4) estimation 3.1±0.7 mm/year for the decadal period 1993- 2003.

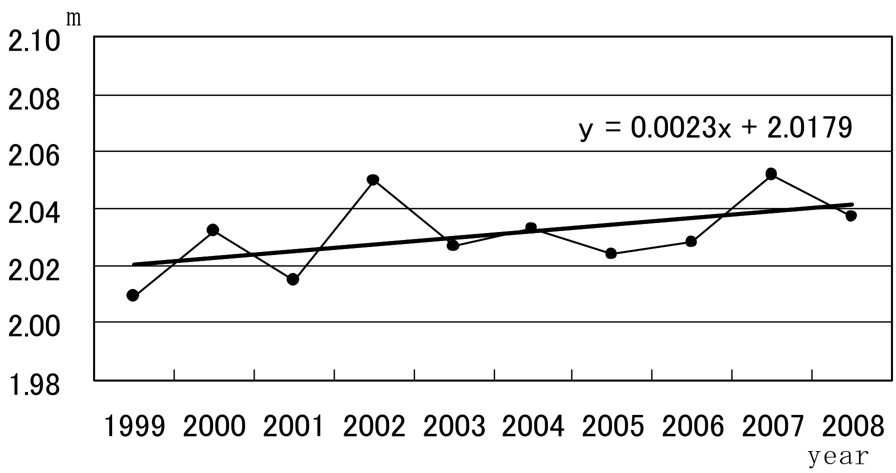


Figure 1.17 Yearly Mean Sea Levels during 1999 to 2008 at Funafuti

d) Tidal Diagram

When carrying out a survey, the surveyor must refer measured heights and depths to datum levels. These need not to be the same provided the difference in level between them is known; indeed, for convenience they are normally different. A datum level may be chosen arbitrarily, but it should always be referred to a defined physical reference mark or bench mark, with this available, later surveyors will be able to connect their work to the original survey.

Some of the more important water levels, datum and the relation among Bench Marks (BM-22 etc.) for vertical control are shown in Figure 1.18 as "Tidal Diagram" considering existing tidal information at Funafuti, and the reason why the levels were chosen and/or some explanations for the levels are described below.

Chart Datum Level / Zero of SEAFRAME Gauge

Chart Datum Level (CDL) is the level to which soundings on a published chart are reduced, and above which tidal predictions and tidal levels are given in the tidal tables. Chart Datum Level in Fongafale is determined 4.0123 meters below Deep Bench Mark: BM-22 at present as shown in Figure 3.18. This Chart Datum Level was originally chosen by the Hydrographic Office of the Royal New Zealand Navy, using RNZN Bench Mark on the Deep Sea Wharf. The zero of SEAFRAME tide gauge was also set to be the same as the Chart Datum Level by National Tidal Centre, Australian Bureau of Meteorology.

Chart Datum Level (CDL) = Deep Bench Mark: BM-22 − 4.0123 meters
Zero of Tide Gauge = Chart Datum Level (CDL) ± 0.000 meter

Seeing the Chart Datum historically, "Zero of University of Hawaii Tide Staff" was used as the Datum in 1990 and UH-1 (University of Hawaii Tide Staff Bench Mark) at the Vaiaku Wharf had been held fixed at a Reduced Level of 3.0072 meters.

Mean Sea Level

As its name implies, Mean Sea Level (MSL) is the average level taken up by the sea. Although this sounds very simple, it is not easy to obtain an accurate value for Mean Sea Level, since the actual level of the sea is continually altering. Seasonal changes in Mean Sea Level occur when winds blow regularly in the same direction over definite periods of a year, or when large amounts of fresh water are released after heavy seasonal rains. The reliability of a value for Mean Sea Level will depend on the length of the period of observation taken to determine it.

On this report, Mean Sea Level was newly calculated using observed data over 15 years period from 1994 to 2008 at the SEAFRAME station (1993 year was omitted from the calculation because of many lack of data). This value calculated is 2.1cm higher than the existing Mean Sea Level (CDL + 1.985 meters) for the period of 1993 to 1994.

Mean Sea Level (MSL) = Chart Datum Level (CDL) + 2.0067 meters

Highest High Water and Lowest Low Water

The heights of Highest High Water (HHW) and Lowest Low Water (LLW) are defined as the maximum and minimum heights recorded at the site through tidal observation for a long period.

Highest High Water was recorded as 3.415 meters on February 28, 2006, while Lowest Low Water was recorded as 0.531 meters on February 27, 1998 since installation at Funafuti. As a reference, predicted values of highest and lowest heights in the year of 2009 in Tide Table at Funafuti by Australian Bureau of Meteorology are 3.20 meters and 0.88 meters, respectively.

Highest High Water (HHW) = Chart Datum Level (CDL) + 3.415 meters
Lowest Low Water (LLW) = Chart Datum Level (CDL) + 0.531 meters

Mean High and Low Water Springs

The height of Mean High Water Springs (MHWS) is the average, throughout a year when the average maximum declination of the moon is 23.5 degrees, of the heights of the two successive high waters during those periods of 24 hours (approximately once a fortnight) when the range of the tide is greatest. The height of Mean Low Water Springs (MLWS) is the average height obtained from the two successive low waters during the same periods.

Mean High Water Springs and Mean Low Water Springs of this report are estimated using Mean Tidal Range 1.6 meters in Springs and, which are described in USA Nautical Chart No.83094.

Mean High Water Springs (MHWS) = Mean Sea Level (MSL) + 0.8 meters
Mean Low Water Springs (MLWS) = Mean Sea Level (MSL) − 0.8 meters

Mean High and Low Water Neaps

The height of Mean High Water Neaps (MHWN) is the average, throughout a year as defined in above, of the heights of the two successive high waters during those periods (approximately once a fortnight) when the range of the tide is least. The height of Mean Low Water Neaps (MLWN) is the average height obtained from the two successive low waters during the same periods.

Mean High Water Neaps and Mean Low Water Neaps of this report are estimated using Mean Tidal Range 0.6 meters in Neaps, which are described in USA Nautical Chart No.83094.

Mean High Water Neaps (MHWN) = Mean Sea Level (MSL) + 0.3 meters
Mean Low Water Neaps (MLWN) = Mean Sea Level (MSL) − 0.3 meters

Highest and Lowest Astronomical Tide

The Highest Astronomical Tide (HAT.) and Lowest Astronomical Tide (LAT.) are defined to be the highest and lowest levels which can be predicted to occur under average meteorological conditions and under any combination of astronomical conditions. It can only be obtained properly by studying tidal predictions covering several years (ideally 18.4 years), as the level of HAT and LAT will not be reached every year. It should be noted that the water may rise above the level of HAT and fall below the level of LAT if abnormal meteorological conditions are experienced.

Regarding the levels of HAT and LAT at Funafuti, "Pacific Country Report–Sea Level & Climate: Their Present State (Tuvalu)" gives the values of +3.24 meters and +0.7859 meters above Chart Datum Level, respectively. The highest predicted level (3.24m) is reported to be over the period 1990 to 2016.

Highest Astronomical Tide (HAT) = Chart Datum Level (CDL) + 3.24 meters
Lowest Astronomical Tide (LAT.) = Chart Datum Level (CDL) + 0.7859 meters

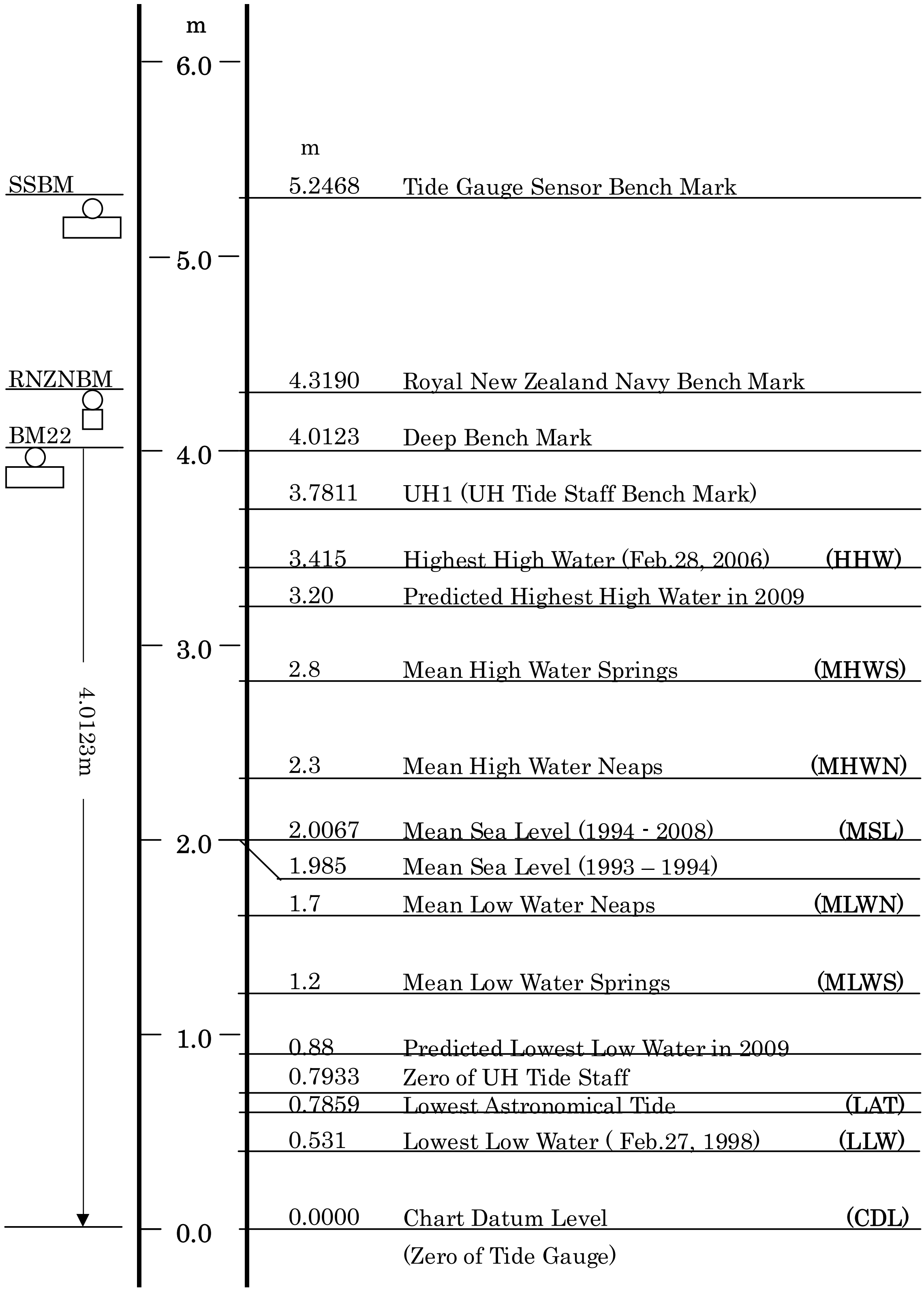


Figure 1.18 Tidal Diagram at Funafuti

e) Tides

Tidal curve during February 27 to March 1, 2006, when the highest high water 3.415 meters since installation was recorded, at SEAFRAME station in Funafuti is shown in Figure 1.19.

This graph clearly shows that the type of tides in this area is a semi-diurnal tide, which has two high waters and two low waters in a day, and the each heights of successive high waters and low waters are almost equal.

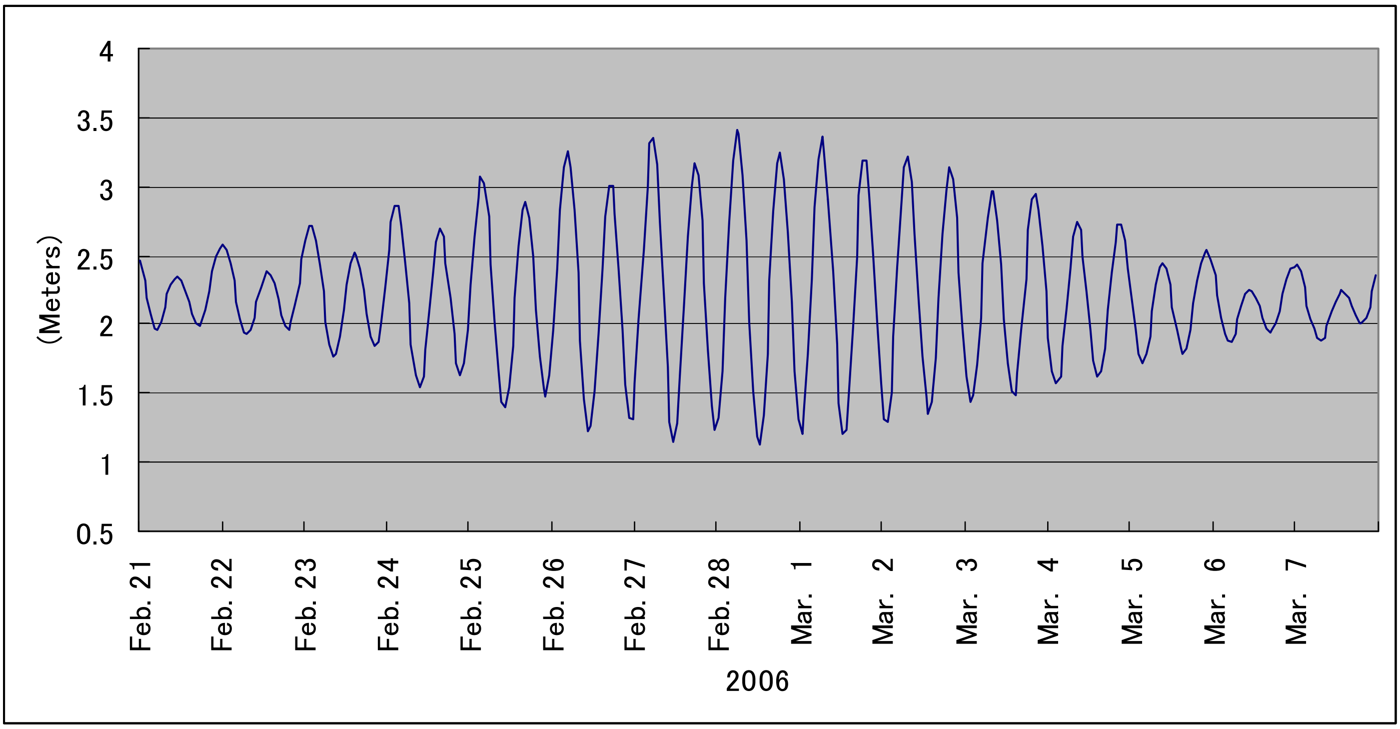
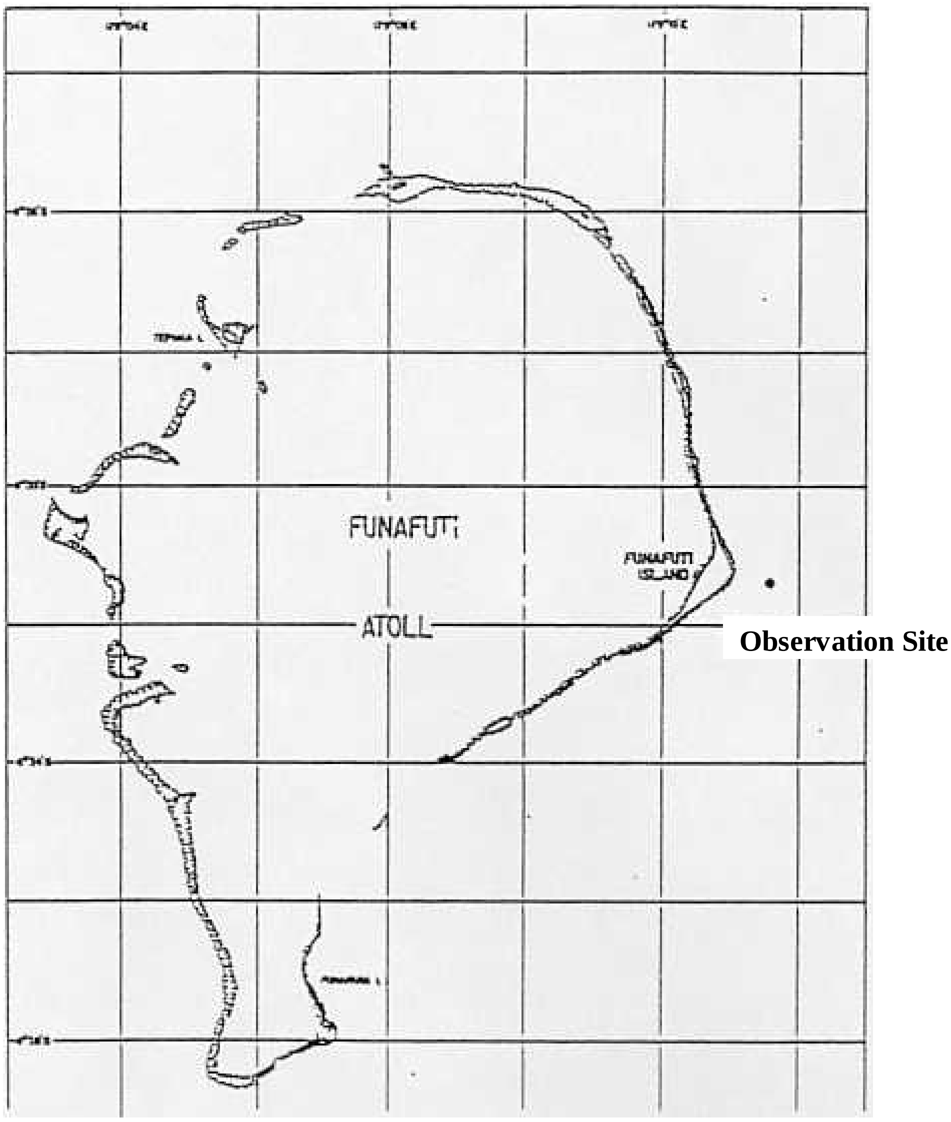


Figure 1.19 Tidal Curve during February 21 to March 7, 2006 at Funafuti

(2) Waves

Wave measurements with a Waverider Buoy were carried out off the eastern coast of Funafuti Atoll between May 8th, 1990 and April 7th, 1992 with sampling interval of every 3 hours by Oceanographic Company of Norway AS (OCEANOR) as part of the Wave Measurement Program funded by the Norwegian Government Agency. Figure 1.20 shows the measurement location (Position: 08°31.5'S, 179°12.9'E. Water depth: 585 m).



Source: SOPAC TR 186

Figure 1.20 Location Map of Wave Observation (OCEANOR-Wave Buoy)

The monthly data recovery and average significant wave heights (H1/3), wave period (Tm) recorded for 1990 to 1992 are shown in Table 1.17. Monthly maximum wave heights with periods from May 1990 to April 1992 are summarized in Table 1.18.

The significant wave heights (H1/3) is remarkably constant throughout the year with an average of 1.8 m. The average wave period is 9.2 sec, in the main dominated by local wind seas. Although the wave climate is steady offshore, it is not necessarily the case on the coast due to a strong seasonality in wind direction in this region.

The highest measured sea state occurred in November 1990 when the H1/3 reached 3.4 m with a peak period (Tp) of 16.7 sec, partly as a result of swell arriving from Tropical Cyclone Sina to the south. Due to the fact that tropical cyclones tend to be in their early stages in the area of Tuvalu, high winds and waves are uncommon.

Table 1.17 Monthly Data Recovery and Average Values of Wave Records for 1990 to 1992

Month	Data Recovery		Mean Values	
	No. of Records	Percentage(%)	H1/3 (m)	Tm (sec)
January	496	100	1.7	10.0
February	455	100	1.7	10.0
March	493	100	1.8	10.2
April	283	59	1.8	9.7
May	429	90	1.8	9.1
June	472	98	1.8	8.1
July	336	68	1.8	8.1
August	246	50	2.1	8.2
September	231	48	1.7	8.2
October	493	100	1.6	8.8
November	479	100	1.7	9.6
December	496	100	1.9	9.8
Annual	4,911	84 %	1.8 m	9.2 sec

Source: SOPAC TR 186

Table 1.18 Monthly Maximum Wave Heights and Periods from May 1990 to April 1992

Year/ Month	H1/3 (m)	Tm (sec)	Year/ Month	H1/3 (m)	Tm (sec)
1990/ May	2.61	12.1	1991/ May	2.41	14.2
June	2.23	10.0	June	2.66	10.5
July	2.37	10.3	July	2.56	10.5
August	N/A	N/A	August	3.34	11.1
September	1.85	9.5	September	3.04	10.5
October	2.41	10.0	October	2.82	11.8
November	3.40	13.8	November	1.97	12.9
December	2.56	11.8	December	3.10	12.9
1991/ January	2.66	13.3	1992/ January	2.8	13.3
February	2.37	12.5	February	2.3	13.3
March	2.32	12.1	March	2.5	13.8
April	2.51	11.1	April	2.1	11.1
Maximum Wave Height (H1/3)			3.40 m		
Peak Wave Period (Tp)			16.7 sec		

Source: SOPAC TR 186

"Joint frequency of occurrence of significant wave height and mean wave periods for all years" is summarized in Table 1.19 by using data recorded.

Significant wave height (H1/3) between 1.5m and 1.9m is predominant as 57.2% and H1/3 less than 2.0m occurred with high frequency of 80.0%. While wave period (Tm) is predominant in period of 7.0sec to 10.9sec as 87.4%.

We refer the following comments. Although average wave heights are remarkably steady in Tuvalu, the directional character of the waves is extremely variable through the year. Swell are relatively common from the north during summer, whilst swells from south occur all year but tend to be more frequent in winter.

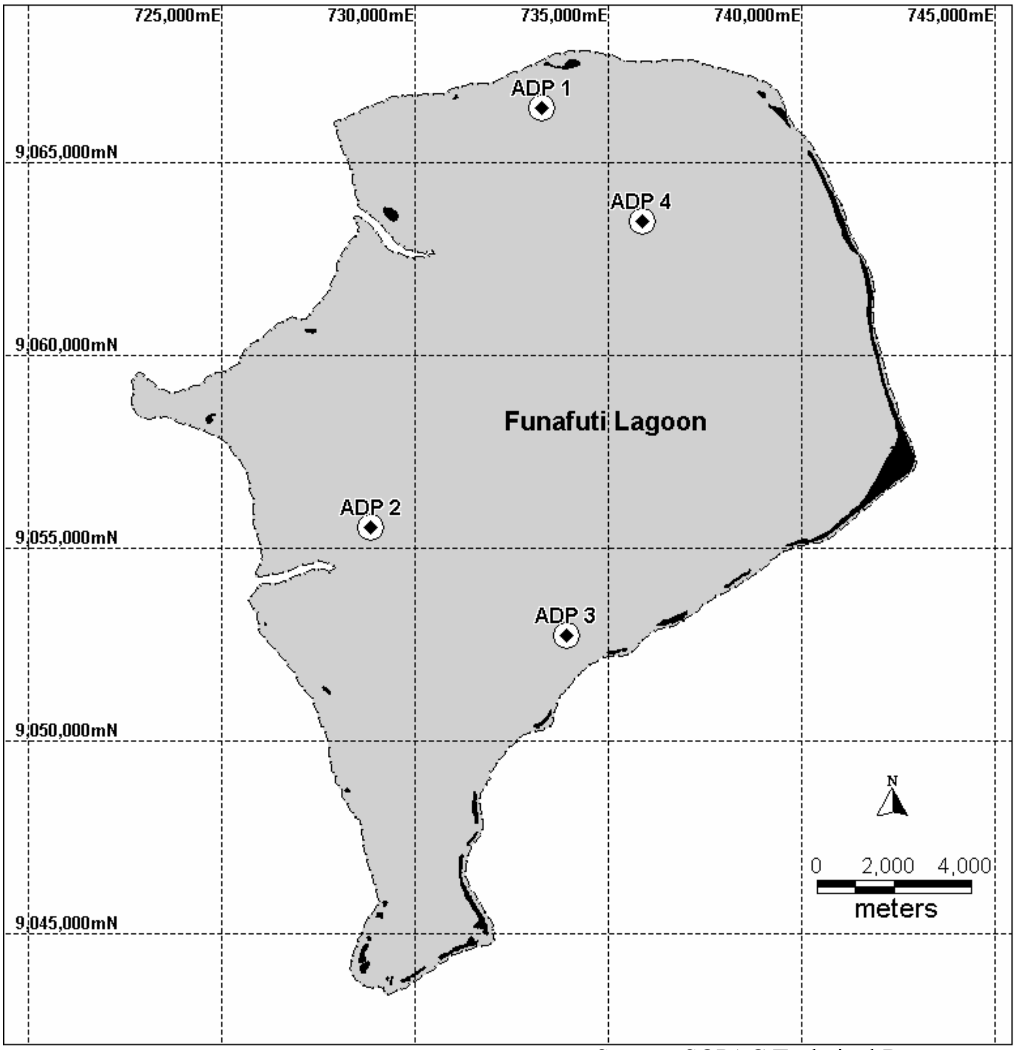
Table 1.19 Joint Frequency of Occurrence of Significant Wave Height and Mean Wave Periods for All Years

Wave Period	Significant Wave Height : H1/3 (m)							Sum
Tm (sec)	0.0-0.9	1.0-1.4	1.5-1.9	2.0-2.4	2.5-2.9	3.0-3.4	›3.5	(%)
0.0 - 4.9								0 (0.0)
5.0 - 5.9		1	2					3 (0.1)
6.0 - 6.9		7	55	24	1			87 (1.8)
7.0 - 7.9		169	459	172	42	1		843 (17.2)
8.0 - 8.9		371	724	153	27	8		1,283 (26.1)
9.0 – 9.9		302	640	136	11			1,089 (22.2)
10.0 - 10.9		215	649	200	10			1,074 (21.9)
11.0 – 11.9		45	209	107	19	1		381 (7.8)
12.0 - 12.9		6	69	46	13			134 (2.7)
13.0 – 13.9			2	8	2	2		14 (0.3)
14.0 - 14.9			1					1 (0.0)
› 15.0								0 (0.0)
Sum (%)	0 (0.0)	1,116 (22.7)	2,810 (57.2)	846 (17.2)	125 (2.5)	12 (0.2)	0 (0.0)	4,909 (100 %)
Accum. Sum (%)	0 (0.0)	1,116 (22.7)	3,926 (80.0)	4,772 (97.2)	4,897 (99.7)	4,909 (100.0)	4,909 (100.0)	

Source: SOPAC TR 186

(3) Currents

Current observations in the Funafuti Lagoon were recently carried out using Sontek Acoustic Doppler Profilers (ADP), which were settled at 0.63 m above seabed, at four points shown in Figure 1.21. ADPs are capable to measure horizontal and vertical currents throughout the water column from near bottom to near surface as well as water pressure. The detailed deployment of current observation are summarized in Table 1.20.



Source: SOPAC Technical Report

Figure 1.21 Location Map of Current Observation

Table 1.20 Deployment of Acoustic Doppler Profiler (September to October, 2004)

Station No.	Location	Water Depth	Observation Period	Duration
ADP-1	Pa'ava	30 m	Sep.18 (15:00) to Oct.22 (07:00), 2004	33 days
ADP-2	Te Ava Fuagea	27 m	Sep.18 (15:00) to Oct.04 (11:20), 2004	15 days
ADP-3	Payne Rock	24 m	Sep.18 (15:00) to Oct.22 (10:40), 2004	32 days
ADP-4	Te Atau Loa	31 m	Oct.04 (13:30) to Oct.22 (09:50), 2004	17 days

Results of this current observation are shown in Figure 1.22 as "Histogram of Current Speed and Current Direction" and in Figure 1.23 as "Current Rose Diagram". Maximum current speeds, mean speeds and main current directions recorded at each observation station are summarized in Table 1.21.

At Station No.1 (ADP-1), the maximum speed was 20cm/sec and direction was prevailed around 300° which means "going to outer ocean from lagoon" through the channel between Paava islet and Te Afualiku islet. At Station No.2 (ADP-2), the maximum speed was 27cm/sec and direction was prevailed around 340° which means "going to north-northwest".

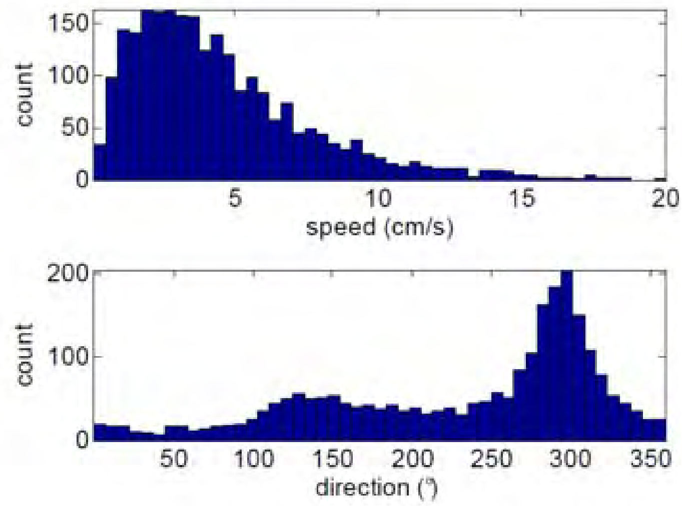
The maximum speed of 44cm/sec during the observation was recorded at Station No.3 (ADP-3) with direction of 220° which means "going to outer ocean from lagoon" through the channel between Funamanu islet and Falefatu islet. Whilst an alternative motion to direction of 80°-260° was observed at Station No.4 (ADP-4) with weak current speeds.

Table 1.21 Results of Current Observation by ADPs (Statistics for Depth Averaged Velocity)

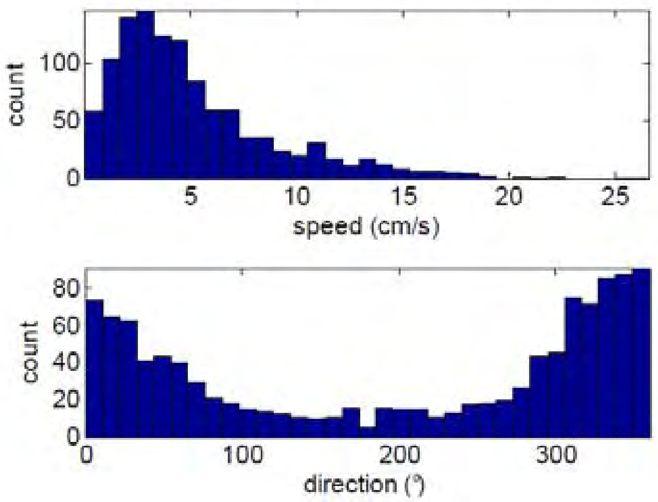
Station No.	Max. Speed	Mean Speed	Mean Dir.	Main Dir.	Remarks
ADP-1	20 cm/sec	5 cm/sec	232°	300°	going to ocean
ADP-2	27 cm/sec	5 cm/sec	200°	340°	going to north
ADP-3	44 cm/sec	14 cm/sec	200°	220°	going to ocean
ADP-4	7 cm/sec	2 cm/sec	179°	80°- 260°	alternative motion

(Note) Directions are given in "going to".

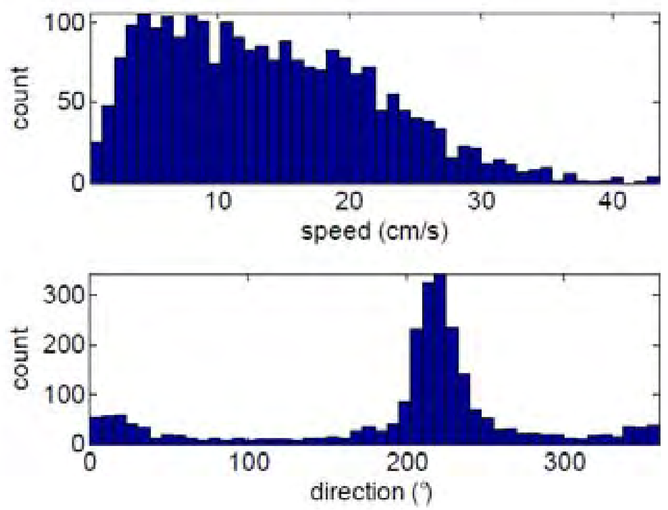
ADP-1



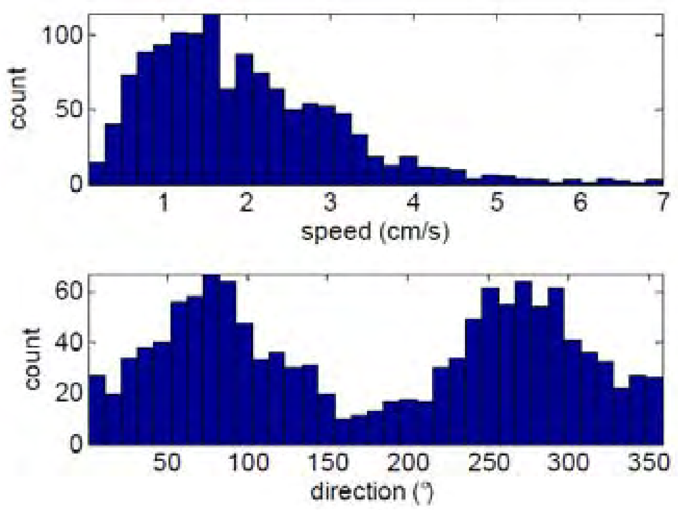
ADP-2



ADP-3

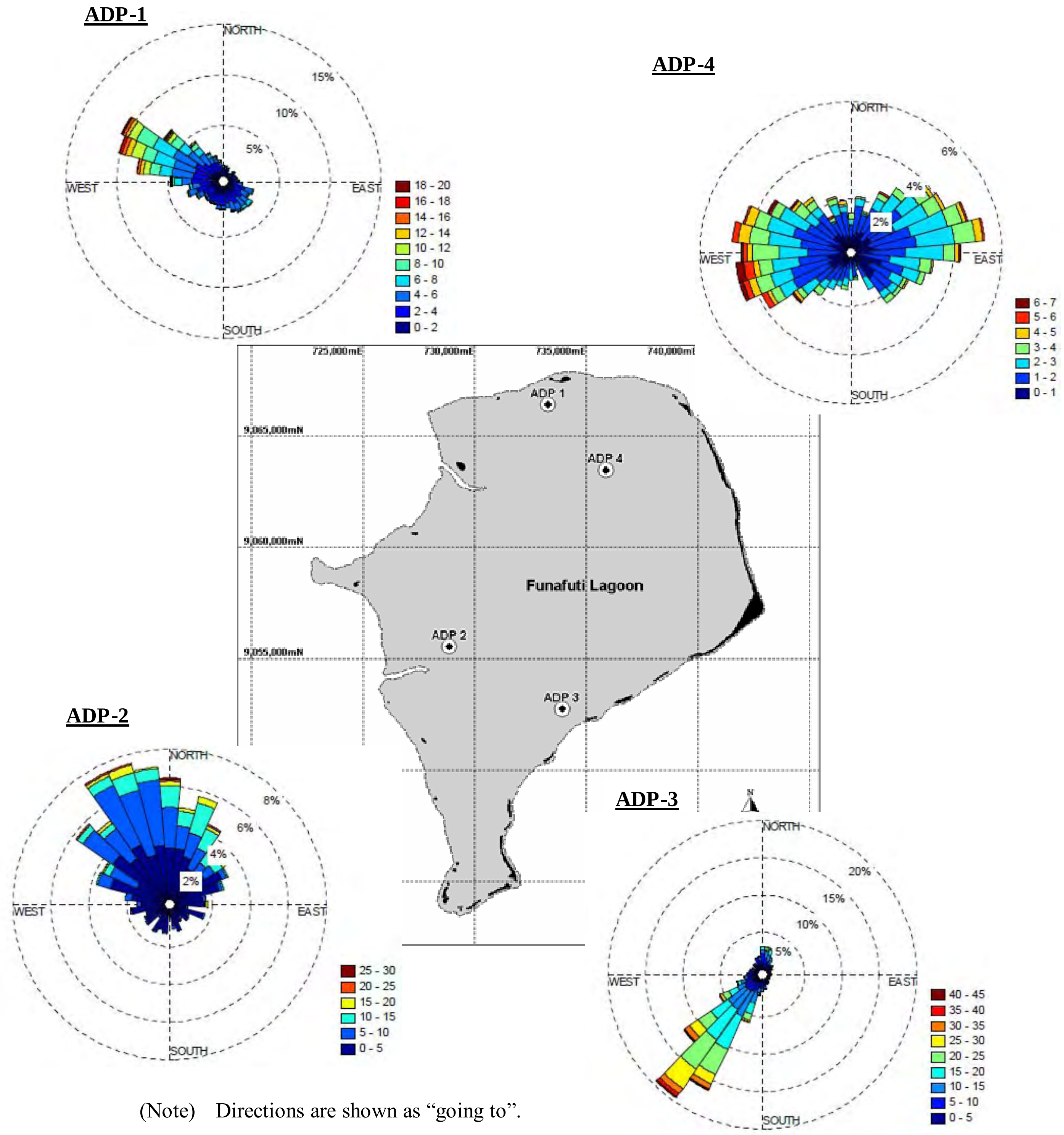


ADP-4



(Note) Directions are shown as "gong to".

Figure 1.22 Histogram of Current Speed and Current Direction



(Note) Directions are shown as “going to”.

Figure 1.23 Current Rose Diagram

A few other current observations had been performed in the coastal area of the lagoon. In February 1986, currents were measured at interval of 20 minutes using an Aanderaa Current Meter at the end of main wharf (water depth: 8m) during the period of February 11 (9:48) to February 13 (00:28), 1986 . The result shows weak currents of maximum speed 2.2 cm/sec at the surface and main direction of 350° - 180° (SOPAC Technical Report No.58).

The other current observation was carried out, as a part of pilot dredging project, in November 1993 at the pilot dredging site (water depth: 15m) offshore of the Vaiaku Wharf, using an Aanderra Current Meter (RCM-7) with 10 minutes' interval. The report says that a weak southeast flowing current prevailed, consisting with the wind data (SOPAC Technical Report No.216).

1.3 Topographic and Geological Characteristics

Funafuti atoll consists of about thirty islets. Fongafale located on the eastern side of the atoll is the main islet of Funafuti atoll. It is 1.42 km^2 in area and has functions of a capital city of Tuvalu with an international airport and seaport.

(1) Land Topography

Fongafale islet is a long and narrow strip of extremely low elevation with a broad "V" shaped outline. Rabbles of dead coral are piled up at ocean-side fringe of the islet up to 4 m above sea level, making the highest points of the islet. Other areas are below 2 m above sea level in large portion of the islet which provided residential area for long time inhabitants, namely, Alapi and Senala villages (see Figure 1.24).

Fongafale islet can be divided into three geographical areas, namely ①the south part (or arm) extending southwestward approximately 2.5 km from the south end of the runway, ②the central area from the south end of the runway north approximately 2 km to Teuaea road and ③ the north part (arm) extending northeastward approximately 4.5 km from Teuaea road.

When the US forces arrived in Funafuti in October 1942 during the Second World War (WWⅡ), there was a lake with surrounding mangroves in the north part of the central area of Fongafale. In order to build a long runway, a large volume of gravel had to be dug from the land area to fill in the lake and mangroves. Sand dug from the lagoon was used for paving the runway, and area 2 km long and 25-40 meters wide was reclaimed along the lagoon shore to provide an access road (SOPAC TR 221).

As the results of the airport construction, ten borrow pits in the islet including one in Tengako islet exist at present. There are persistent sea water intrusions in every day basis; and the water levels of the borrow pits fluctuate according to the tidal movement.

During spring tides called King Tide, both sides of the airstrip are inundated by sea water coming through coral rabbles.

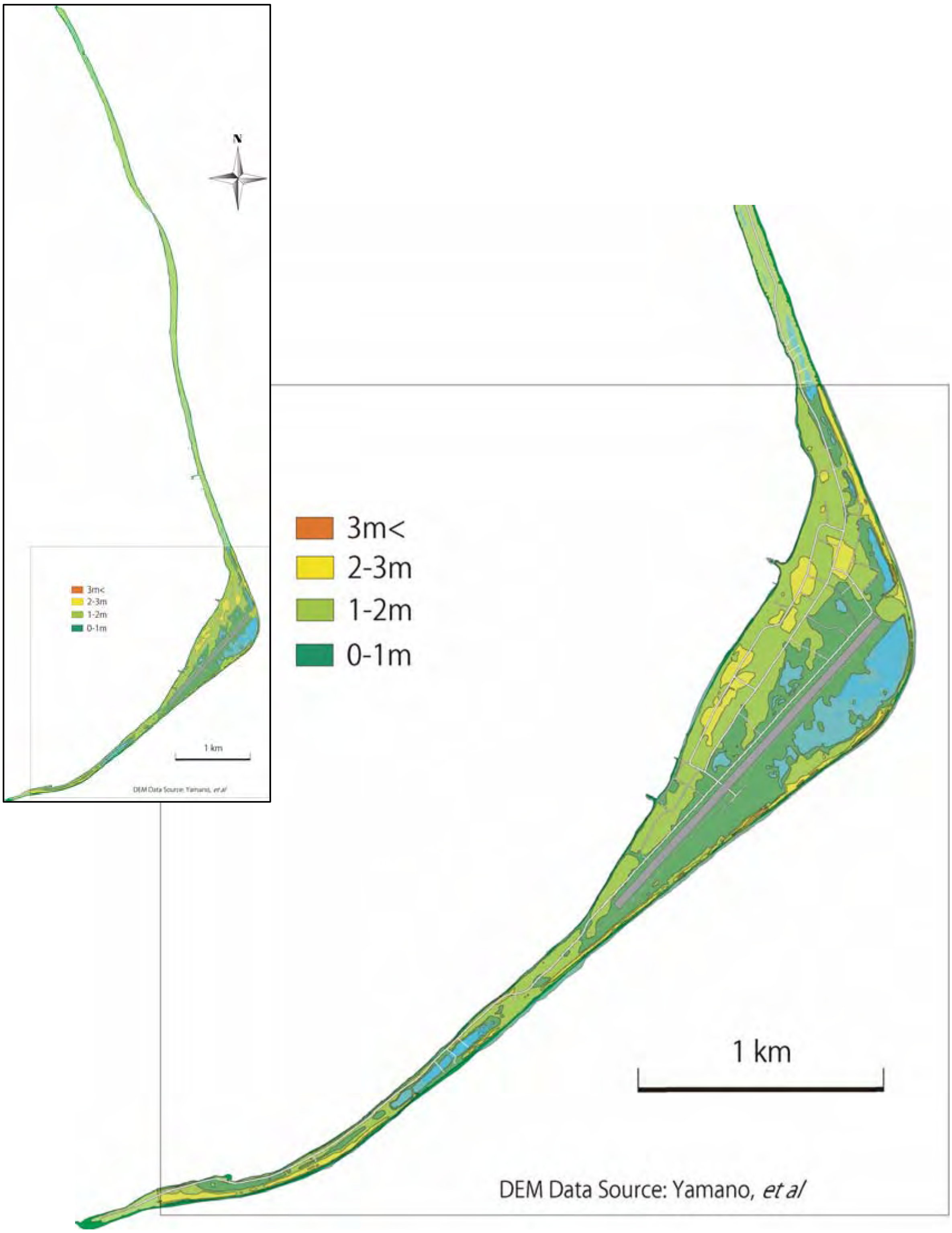


Figure 1 .24 Topographic Map

(2) Coastal Line

On Fongafale islet with a broad “V” shaped outline, the direction angle of the coastal line in the north arm is N155°E and that of the coastal line in the south arm is N230°E, characterized by a 75-degree change in the direction angle of the coastal line at the maximum protrusion to the east (see Figure 1.25).

Senior residents remember that there was a long, low-gradient, sandy beach prior to the WWII. Modifications of the lagoon side of Fongafale islet during WWII include a 2.3 km long piece of reclamation with coral rock seawall, a long borrow pit (often called channel) beside the seawall, and other channels normal or parallel to the seashore.

The Catalina Ramp was the seaplane base and there was a borrow pit beside and in front of the ramp. A shore-normal channel 35 m wide was dredged 450 m southwest of the south end of the present runway for a petrol torpedo (P.T.) boat base. In the north area, two other channels normal to the shore and one 125 m long channel parallel to the shore near the present Tuvalu Co-operative Wholesale Society were also dug.

These developments changed the shoreline and sedimentation patterns. The seawall was placed at about the former low tide line and suffered erosion after it was built. The borrow pits (or channels) have been filled with sand transported by wave and long-shore currents and with sand and/or gravel eroded from the reclaimed land. The natural trend is to fill the borrow pits and erode the reclaimed land, as nature attempts to recover the natural beach gradient (SOPAC TR 221).

Observing the present state of the coastline along lagoon side in the central area of Fongafale islet, most of the beach is covered by beach rocks and the sandy beach extends with only 500 m length from the north of Vaiaku Lagi Hotel to the south of Catalina Ramp.

Detailed conditions of the coasts in the study area are described in Supporting Report 2 “Field Reconnaissance Survey”.

Figure 1.25 Satellite Image Showing Coastal Line and Marine Borrow Pits

(3) Bathymetric Feature

Figure 1.26 and Figure 1.27 show the coastal geology of Funafuti and the bathymetry in the Funafuti lagoon by SOPAC, respectively.

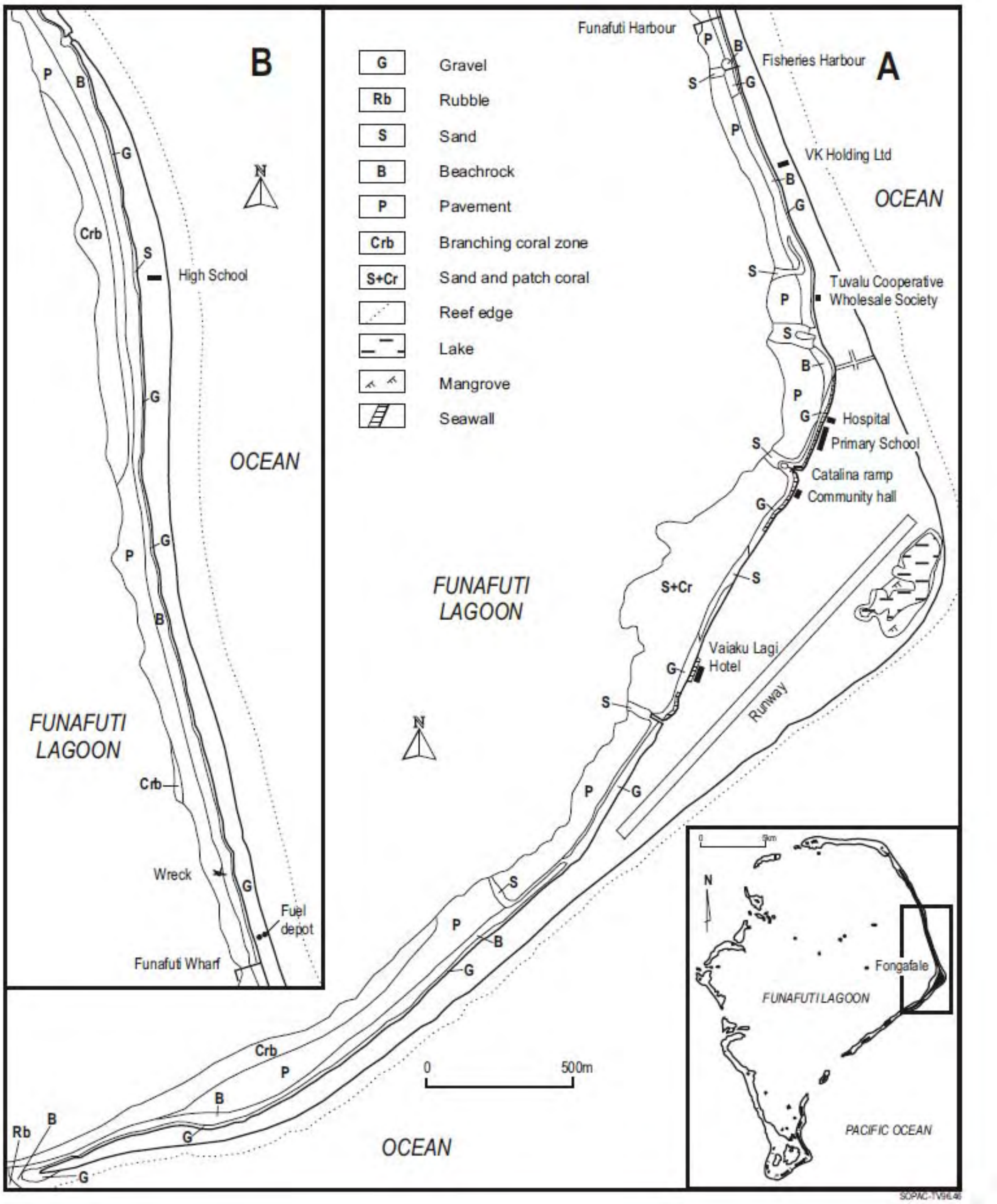
The reef flat on the ocean side is about 100 m wide in front of storm ridge. Outside of reef edge increases rapidly depth and is over 1,000 m depth.

The lagoon side reef flat is 55 – 350 m wide including a 15 – 25 m wide beach. Chungting Xue (1995) divided the reef flat in the lagoon into three provinces of the south province southward from Vaiaku Wharf, the central province from Vaiaku Wharf to Catalina, and the north province northward from Catalina Ramp. He also classified the coral flat into two types, such as Type 1: coral reef pavement with beachrock and/or loose sediments, and Type 2: sand and patch coral with sandy beach.

Type 1 coral flat occurs in the south and north provinces. The coral reef flat pavement is composed of coral reef in the outer western part (lagoonward) and beachrock partly covered with sediments or loose sediments in the inner part. Type 2 coral flat occurs in the central province. It consists of sand and patch coral reef in the outside of the beach.

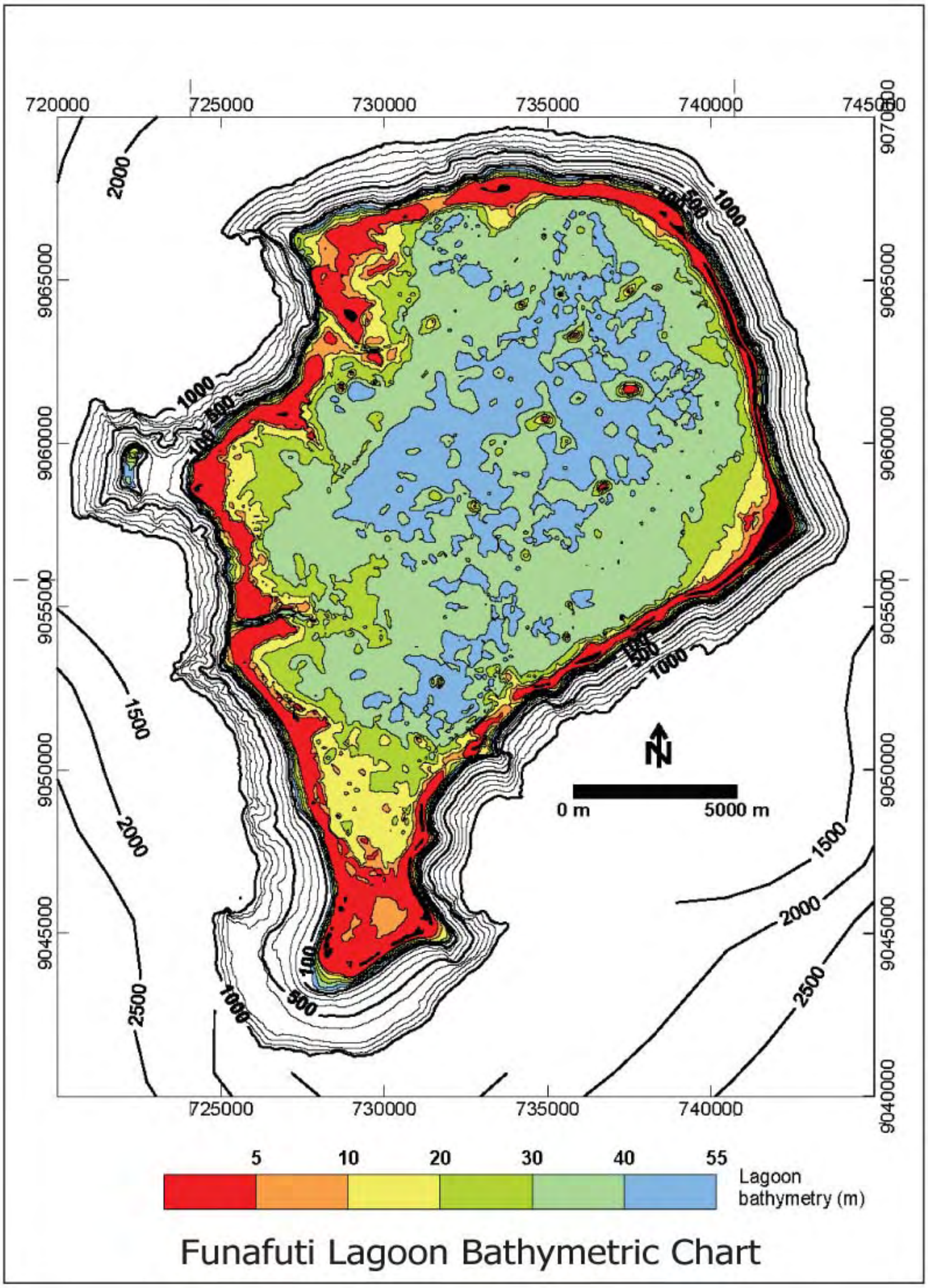
Inside of lagoon, shallow place (Te Akaue) such as Te Akaue Fasua Kaupa. Loa, Pukeu, Tuluaga, Pusa, Fasua and Asano is scattered about. The water depth in the central part of lagoon is range from 40 to 50 meters and the maximum depth can be read as 49 meters on the existing chart (Funafuti Atoll, Chart No.83094).

On the other hand, main channels (Te Ava) from the ocean side into the lagoon are Te Ava I Te Lape in the north part of the atoll; Te Ava Tepuka, Tepuka Vili Vili. Kumkum and Fuagea in the west part of the atoll; and Te Ava Puapua and Mateika in the southeast part of the atoll.



Source : SOPAC CM 06 (1995)

Figure 1.26 Coastal Geology of Fongafale



Sources: 1983 Royal Australian Navy digitised fair sheets (lagoon),

2004 SOPAC/EU multibeam survey (lagoon & ocean side),

1997 Smith and Sandwell predicted bathymetry (offshore)

Figure 1.27 Bathymetric Map of Funafuti Lagoon

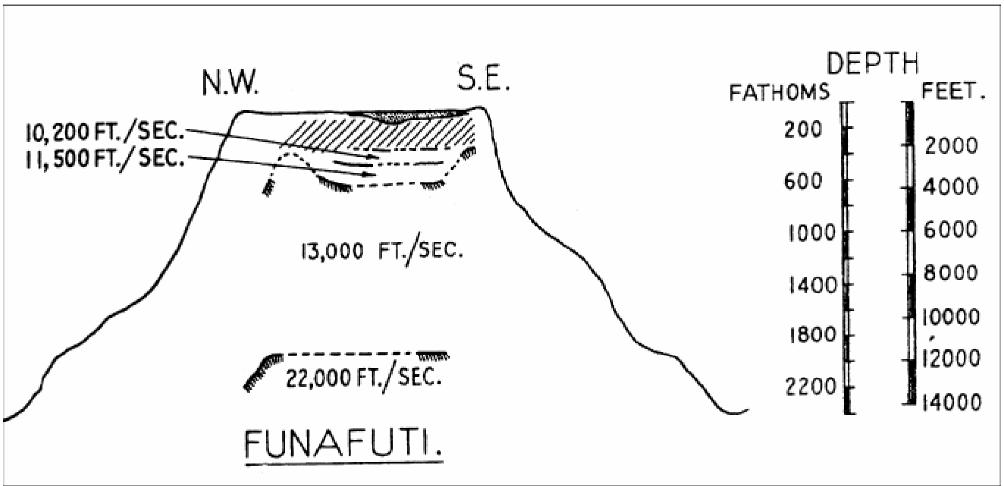
(4) Submarine Geology

a) Literature Review

Early geological investigations of the Tuvalu were driven by the debate over concepts relating to the long-term development of mid-ocean coral atolls and Dawin's subsidence theory (Darwin, 1842). Drilling exploration at Funafuti from 1896 to 1898 resulted in 340 m long cores comprising shallow-water carbonates without encountering basement volcanic (David & Sweet, 1904).

Additional studies on the deep structure of Funafuti comprised a magnetic survey (Creak, 1904) and a single seismic refraction survey inside the lagoon (Gaskell & Swallow, 1953). These two data sets are interpreted to show a minimum of 500 meters of limestone below the lagoon floor, with presumed underlying volcanic (Locke, 1991).

No volcanic basement was reached during the drilling campaign in Funafuti in the late 19th century, and the boundary depth was estimated at approximately 1,000 meters from data provided by seismic experiments shown in Figure 1.28 (Gaskell & Swallow, 1953).



(Source: Gaskell & Swallow, 1953)

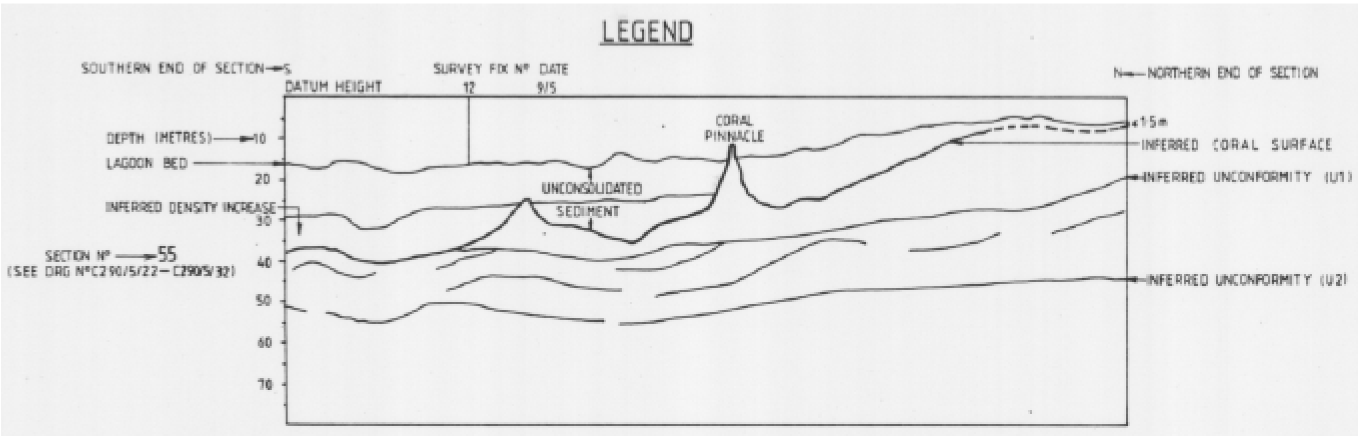
Note : This figure shows profile and inferred depth to volcanic bedrock at appr. 1,000 m

Figure 1.28 Interpreted Refraction Line through Funafuti Lagoon

b) Tuvalu Lagoon Bed Resources Survey

The “Tuvalu Lagoon Bed Resources Survey” was carried out by Gibb Australia in May 1983 in order to determine sources and quantities of the engineering and reclamation materials in Funafuti Lagoon. The specific objectives of the geophysical survey were to estimate the thickness of unconsolidated sediments beneath the lagoon bed and map the spatial distribution of lagoon bed materials (Gibb, 1985).

The geophysical survey composed from 57 line numbers and a total of 67 cross sections /interpreted seismic sections. A general view and legend of a section is shown in Figure 1.29.



Gibb (1985) interpreted the following features from the seismic reflection profiles that comprise unconsolidated sediments:

1. *Surface Sediments*

   Comprising an acoustically soft material with a structure-less, non-bedded character.

   Generally to depth of 5 – 10 m below bed level.

2. *Density Increase*

   Apparent change from structure-less to well-bedded.

   This is a boundary of poor contrast in acoustic impedance, and may represent a density increase due to compaction and/or reduction in particle size.

3. *Coral Surface*

   This marker horizon represents the base of the unconsolidated sediments.

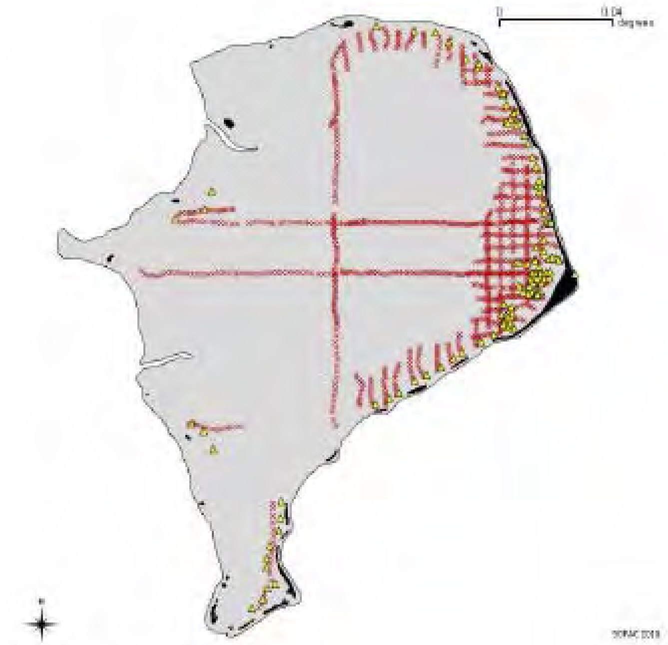
   Distinct character in seismic record showing small-scale diffractions, an irregular surface and rapid reduction in seismic energy transmission.

Figure 1.29 General View and Legend for Longitudinal Section

The results of the "Tuvalu Lagoon Bed Resources Survey" are compiled as maps shown in Figure 1.30 to Figure 1.32 (Gibb, 1985). Figure 1.30 is an overall view of the information, showing the survey lines and the location of all digitized fix numbers of the seismic survey (red crosses) as well as the location of sediment samples taken during the survey (yellow triangles).

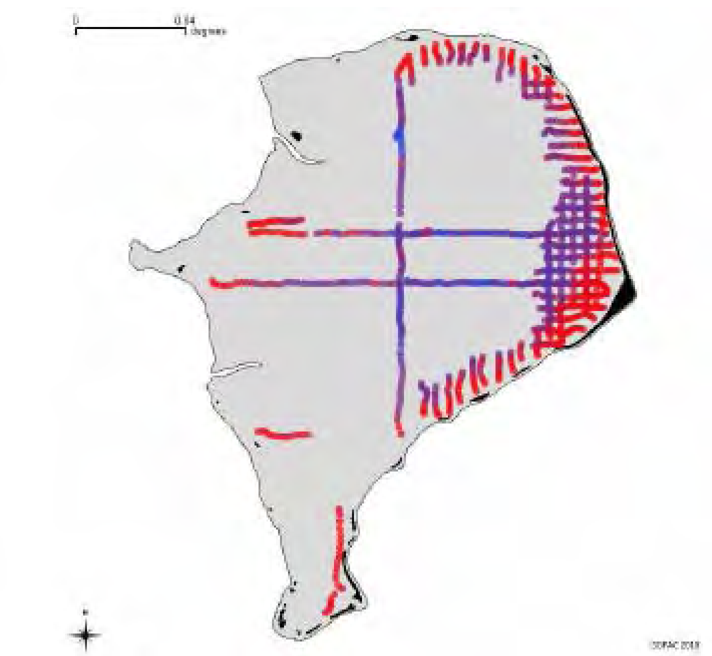
Figure 1.31 shows the thickness of unconsolidated sediments (or depth to coral surface) at each fix point throughout the lagoon as a thematic map using the colours red to blue as an indication of thin to thick layers of sediment over the inferred coral surface.

More details of the seismic survey is shown in Figure 1.32, which shows an isopach map of the depth to the inferred coral surface, in other wards, an isopach map of the thickness of unconsolidated sediments. Isopachs are labeled every 4 meters and 10, 20, 30 meters. Seeing the map, the maximum thickness of unconsolidated sediments is around 25 meters at offshore area approximately 3 km long from Viaku area.



(Note) seismic survey: red crosses, sediment sampling points: yellow triangles

Figure 1.30 Location Map of Seismic Survey and Sediment Sampling Points



bb, 1985)

(Note) colours red to blue as an indication of thin to thick layer of sediment over the inferred coral surface

Figure 1.31 Thickness of Unconsolidated Sediments

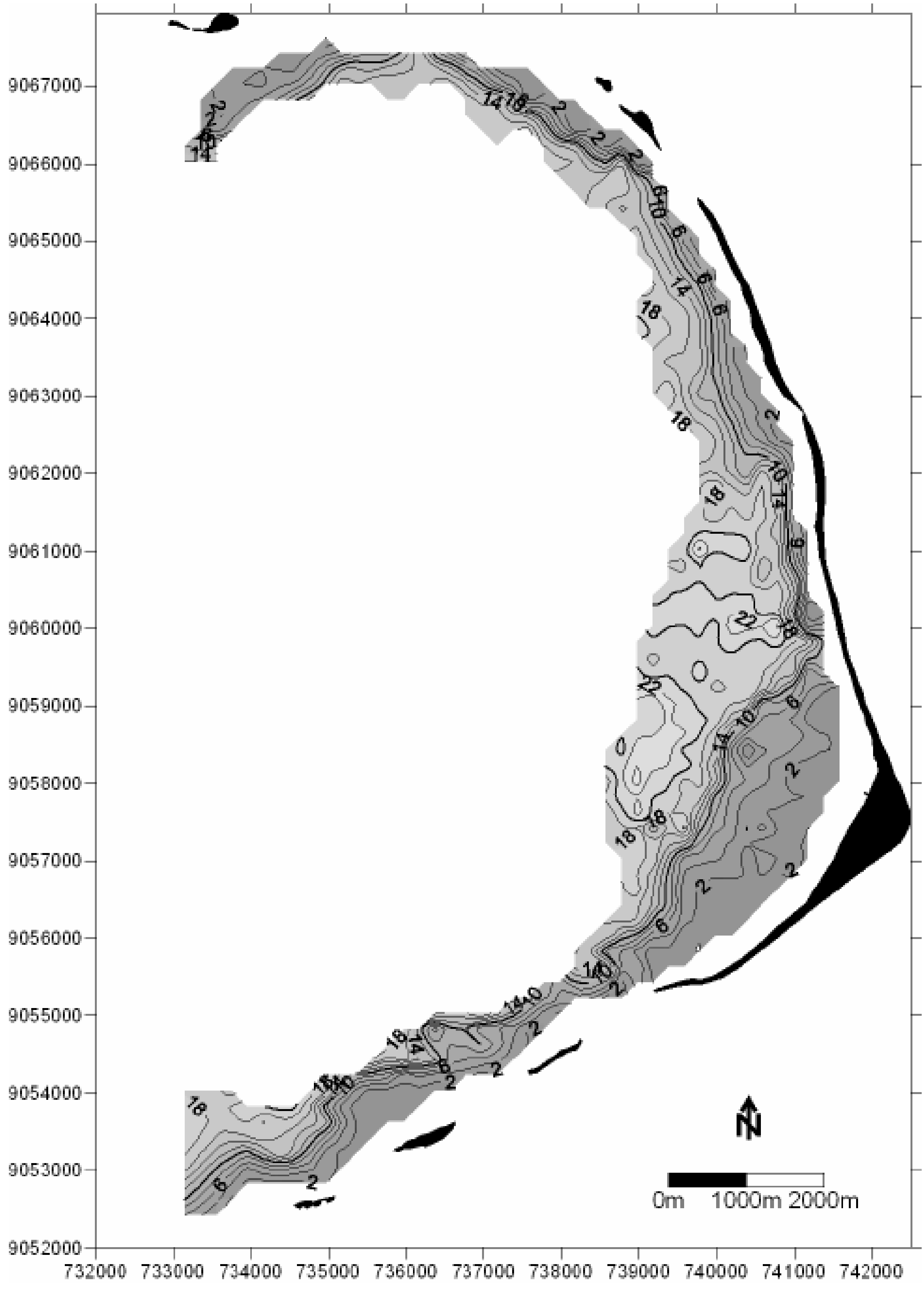


Figure 1.32 Isopach Map for Thickness of Unconsolidated Sediments

2. Environmental Conditions

2. Environmental Conditions

2.1 Water Quality and Sediment Analysis

(1) Water Quality

a) Overview

On Funafuti, the domestic sewage (fecal and non-fecal wastewater) of about 5,000 people is seeping into the ground, either untreated or only after simple treatment. Many of the families keep swine, reportedly 4.2 pigs per household on average. Sewage from pigsties flows out mostly untreated into borrow pits and ponds and onto ground surface and seeps into the ground. At waste disposal sites, garbage is dumped mostly untreated and unsegregated. In Tuvalu where there are no large plants or farms, principal sources of water contamination are considered to be domestic sewage, animal sewage (pigsties), and sewage from the waste disposal site.

Thus, inappropriate sewage and waste disposal in the land area is considered to be affecting groundwater and coastal seawater. However, no water quality surveys have been conducted on groundwater, water in ponds, or coastal seawater. Only simple water analyses of conductivity are carried out in specific areas.

The waste disposal project supported by AusAID is conducting water quality surveys for E coli., nitrites, nitrates and phosphates on groundwater, coastal seawater on lagoon side, and water in rainwater storage tanks in June 2005 (Economics of Liquid Waste Management in Funafuti, Tuvalu; 2006). The result of this study suggests that the ground water is highly contaminated with faecal matter as shown in Table 1.22. However, this survey using a simplified water analysis kit has produced analysis results with low accuracy and hardly identified the water quality conditions of groundwater or coastal seawater.

Table 1.22 Water Quality Assessment in June 2005

Water Source	Bacterial Count	Nitrites	Nitrates	Phosphates
Ground water (North of Luck set)	>130	0	0	< 10
Lagoon water (old jetty)	> 62	0	0	< 10
Rainwater tank (Control) (Tausoa Lima, southern tank)	< 50	5	0	< 10

Source: Water Quality Report, June 2005, Waste Management Unit, Funafuti.

b) Quality of Groundwater

Conductivity measurements in Tuvalu were carried out by Arthur Webb between January and April 2006 in order to monitoring increased salinity of groundwater in pits used to cultivate swamp taro (or pulaka). This study attempts to determine, through accurate conductivity measurement, the present condition of groundwater quality (salinity) within the pits throughout Tuvalu.

A conductivity meter, Hanna Instrument–HI9033, Multi-range Conductivity Meter, was used to record conductivity (salinity) of the freestanding water within each pit at the approximate center or deeper basins. Measurements were taken at the surface (-5cm), midway (-15cm) and bottom (-30cm) through the water column and recorded as μ S cm^{-1} (microsiemens per cm; ppt – parts per thousand).

The sampling points in Fongafale islet are shown in Figure 1.33 and the results of conductivity measurements are shown in Table 1.23. Rainfall conditions during are though to reflect average conditions for this time over the year and as such the conductivity data collected should be a representative of ambient groundwater conditions. Because, rainfall is extremely important with respect to groundwater recharge and salinity conditions of groundwater lens and could also greatly influence the results gained at the sampling time. The results show too high salinity concentration (>5.000 μ S cm^{-1}) for successful swamp taro growth. This means that the swamp taro production is unlikely to succeed anywhere on Fongafale islet (SOPAC ER-75).

Table 1.24 shows the "Comparative conductivity value guidelines developed by Falkland (1999) for coral atoll groundwater lenses" as a reference.

Table 1.24 Comparative Conductivity Value Guidelines developed by Falkland (1999) for Coral Atoll Groundwater Lenses

Type of Water	Typical conductivity range (μS cm^{-1})	Approximate salinity equivalent (ppt)
Rainwater	40 – 120	< 1
Very fresh groundwater	250 – 500	< 1
Fresh groundwater	500 – 1 500	< 1
Limit of freshwater	1 500 – 2 500	< 1
Mildly brackish water	3 000 – 5 000	2 – 3*
Brackish water	5 000 –10 000	3 – 5*
Very brackish water	10 000 – 25 000	5 – 15
Highly brackish water	25 000 – 50 000	15 – 33
Seawater	50 000 – 55 000	33 – 37

*An approximate, intuitive guide to salinity concentrations is human ability to detect (taste) salt in water.
This usually this starts around 3.0 to 4.0 ppt, however there is considerable variation in ability between individuals.

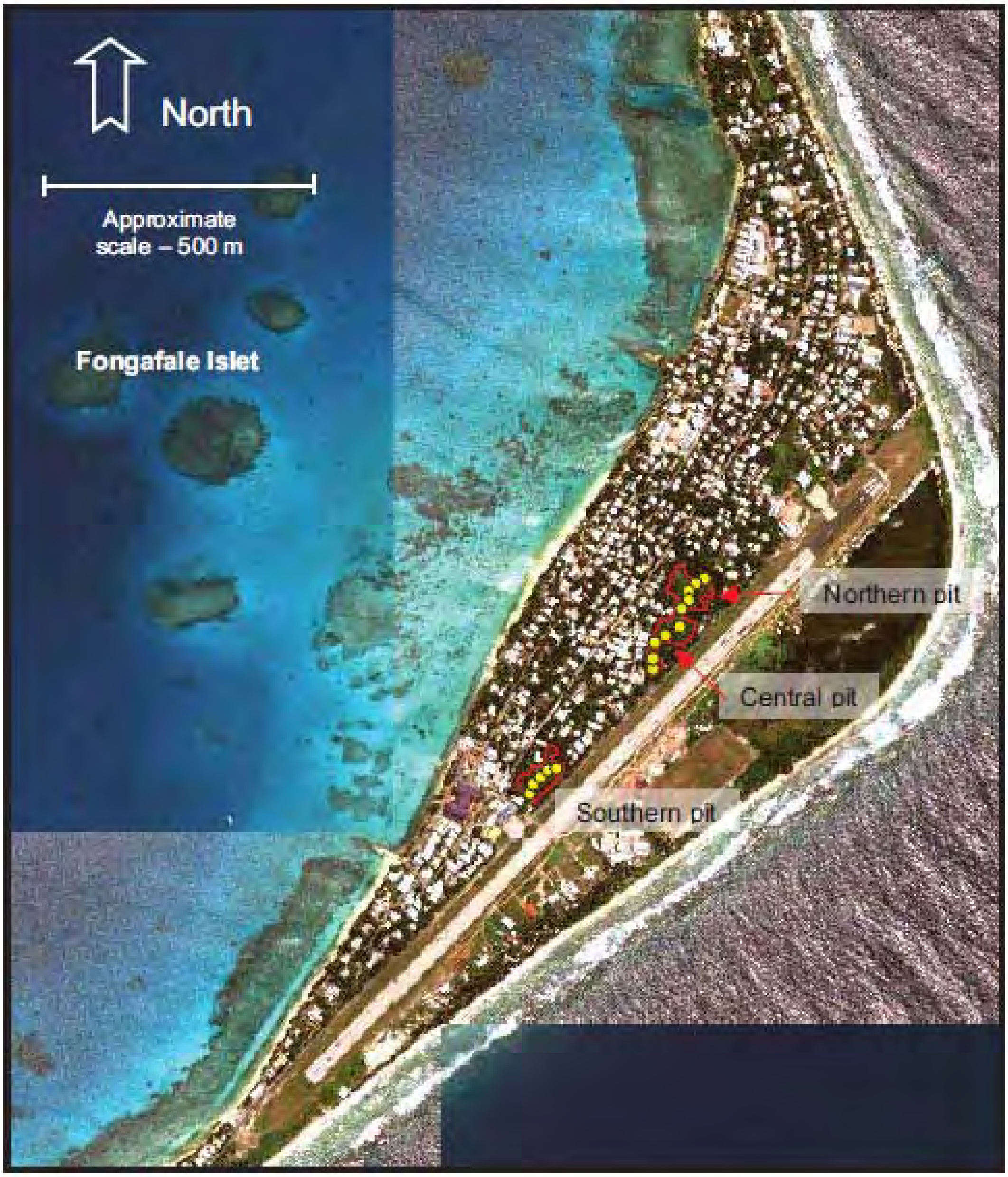


Figure 1.33 Location Map of Groundwater Samples

Table 1.23 Results of Conductivity Measurements of Groundwater

Funafuti – conductivity profiles 20/03/06

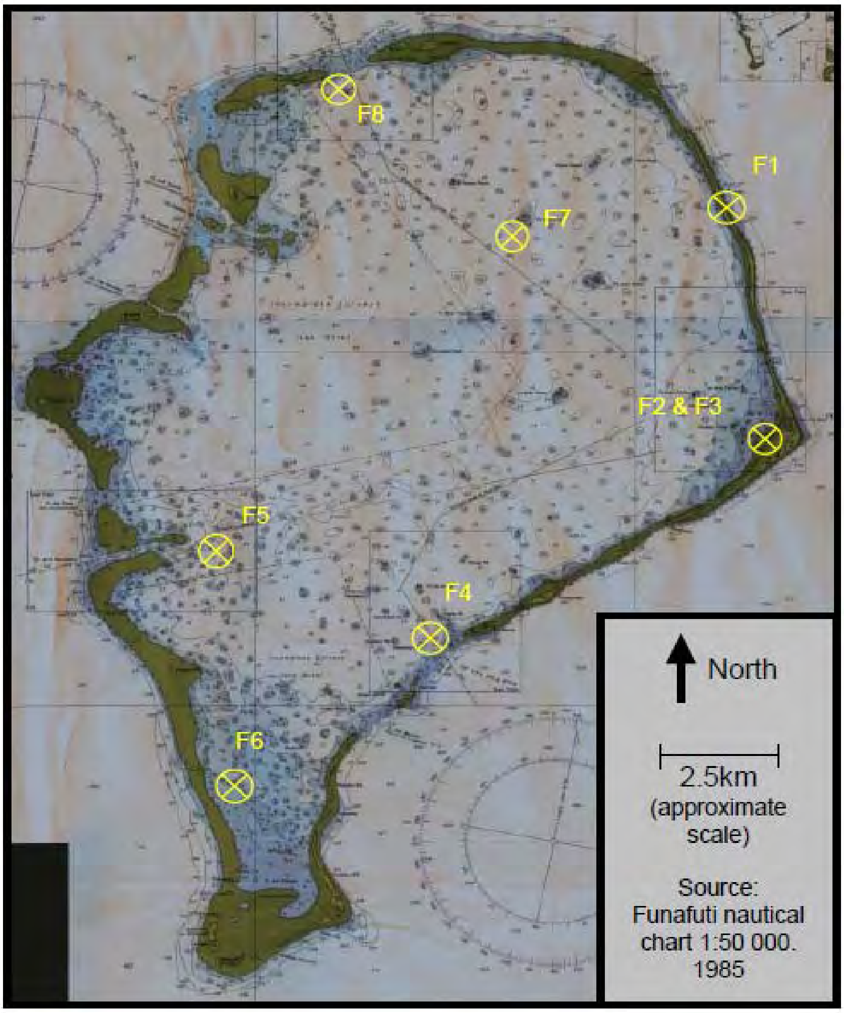
Date / Time	Weather	Island / islet	Pit name (if known)	Conductivity µS / cm					Pit Area Mean		Notes / Observations
				Surface	Mid.	Bottom	Mean	Std. Dev.	Mean	Std. Dev.	
20/3/06 3.30pm	Fine	Funafuti-Fongafale	Pulaka pit Vaiaku (Southern)	4650	5200	5640	**5163**	496			Pit partially in use, planted with dalo, pulaka and bananas - banana look poor
"	Fine	"	"	4800	5020	6120	**5313**	707			- many areas overgrown with weeds only small patches near shallow edges well cultivated.
"	Fine	"	"	2270	2270	4690	**3077**	1397			- growers indicated that plants died off during recent very high tides and heavy rainfall to the bank of the pit
"	Fine	"	"	3990	3990	5280	**4420**	745	4493	1203	Planted dalo and pulaka are of average health
20/03/06 3.55 pm	Fine	"	Central Pulaka pit	5290	5290	6320	**5633**	595			Partially in use, planted with dalo, pulaka, bananas, sugar cane & breadfruit
"	Fine	"	"	4200	4670	4960	**4610**	384			- most area overgrown with weeds and unused, only a few patches of cultivated pulaka
"	Fine	"	"	6570	6570	7760	**6967**	687			Planted dalo and pulaka are of average health - some with yellowish leaves
"	Fine	"	"	4910	5510	5700	**5373**	412	5646	998	
20/03/06 4.10 pm	Fine	"	Northern Pulaka Pit (Fakaifou)	2330	2470	2500	**2433**	91			Overall, this pit seems better than the above two pits with pulaka in ok health
"	Fine	"	"	1450	2680	2800	**2310**	747			- not all of the pit area is properly cultivated and pulaka is growing wild
"	Fine	"	"	1050	1300	2060	**1470**	526	2071	646	Pulaka, dalo, banana and some sugarcane are growing in this pit
			mean	**3774**	**4088**	**4894**	**4252**				
			Standard deviation	1750	1666	1769	1741				
			%CV	46	41	36	41				

Sources: SOPAC ER-75

(2) Sediment Analysis

a) Funafuti Lagoon

The study for the composition and grain-size analysis of sediment samples in Funafuti lagoon and Vaitupu were carried out by Arthur Webb between September and October 2004. Eight sand samples in Funafuti lagoon and three samples in Vaitupu were collected using scoop by hand from the upper 15 cm. The sampling points and sample collection information in Funafuti are shown in shown in Figure 1.34 and Table 1.25.



(Source: SOPAC ER-36)

Figure 1.34 Location Map of Sediment Samples in Funafuti Lagoon

Table 1.25 Sediment Sample Collection Information in Funafuti Lagoon

Location description *Funafuti*	*Date*	*Position*	*Sample #*	*Notes*
Funafuti Nth. Tengako terrestrial deposit	16/09/04	179 11 31.308 8 27 53.532	F1	0.5 m deep homogenous sand deposit – undisturbed horizon / midpoint through island – sand mine
Funafuti Subtidal near-shore deposit Vaiaku Langi Hotel	15/09/04	179 11 40.992 8 31 21.468	F2	2 m depth sand flats Halimeda meadows close by
Funafuti Beach deposit Vaiaku Langi Hotel	15/09/04	179 11 41.64 8 31 21.468	F3	Mean sea level beach deposit
Funafuti Doppler position 3 Funamanu Islet / Te Ava Puapua Passage	19/09/04	179 07 30.6506 08 33 49.8054	F4	Approximate depth 25 m
Funafuti Doppler Position 2 Vasafua Islet / Te Ava Fuagea Passage	18/09/04	179 04 45.4076 08 32 18.9435	F5	Approximate depth 25 m
Funafuti Southern lagoon / West off Luamotu	05/10/04	179 09 49.11 8 60 94.80	F6	Approximate depth 6 m
Funafuti Northern lagoon / North off Te Akau Loa reef	04/10/04	179 14 24.14 8 46 66.06	F7	Approximate depth 10 m
Funafuti Northern lagoon / South off Te Afuaaliku reef	23/10/04	179 11 40.17 8 43 19.95	F8	Approximate depth 16 m

(Source: SOPAC ER-36)

The result of the sediment sample composition analysis shows a predominance of Foraminiferal tests (40–60 %) in shallow lagoon and terrestrial sediment from Funafuti. Otherwise, Halimeda greatly dominated the composition of deeper lagoon samples (Figure 1.35).

On the other hand, the result of the grain-size analysis shows that F1 sample from land and F3 sample from beach deposit have comparatively low percentages of Halimeda and at least 60 % of these sands are composed of granules between 0.25 and 1.4 mm ϕ (Figure 1.36).

Deeper channel deposits F4 and F5 samples contained a large Halimeda component (>35 %) and also contained a greater percentages of coarse material (2 - 4 mm ϕ ;>35 %). F6 sands from the southern lagoon area contained a comparatively large percentages of fines (<0.125 mm ϕ ; >60 %) and were almost entirely Halimeda-derived.

The remaining samples F2, F7 and F8 are comparable to beach and land deposits in grain size (approximately 60 % lying between 0.25 and 1.4 mm ϕ) but had higher percentages of Halimeda (20–25 %) (SOPAC ER-36).

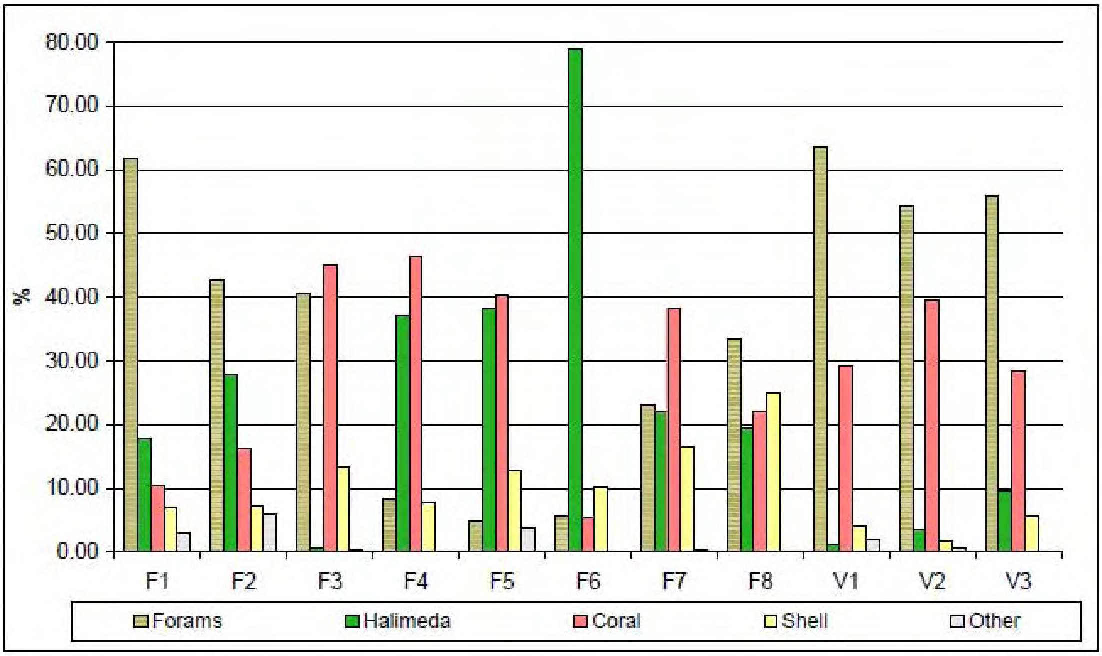
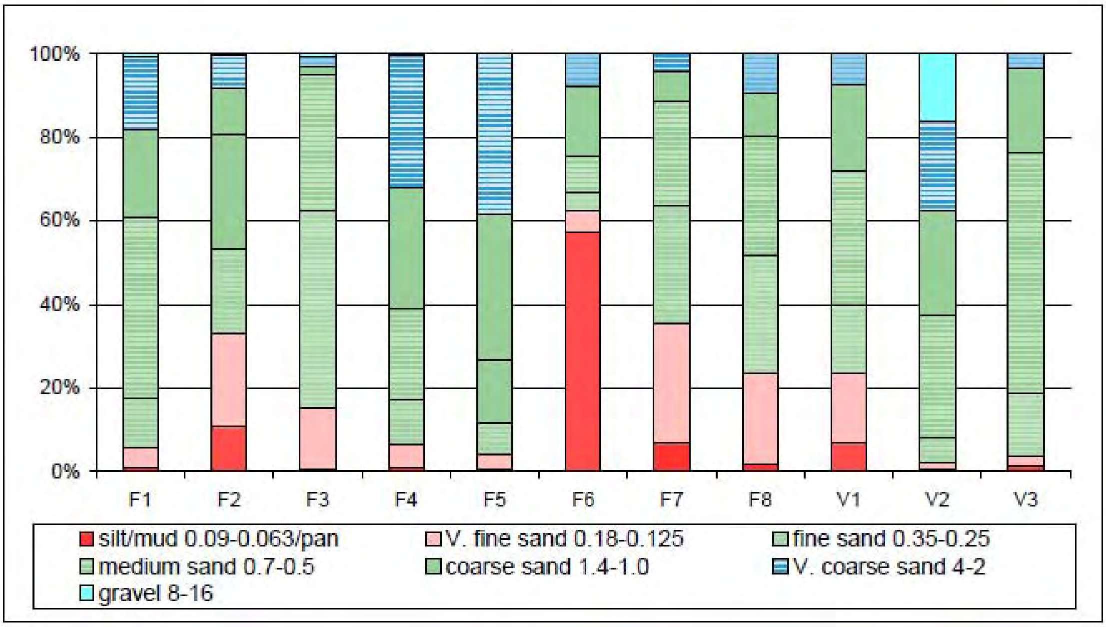


Figure 1.35 Comparative Composition of Sediment Samples

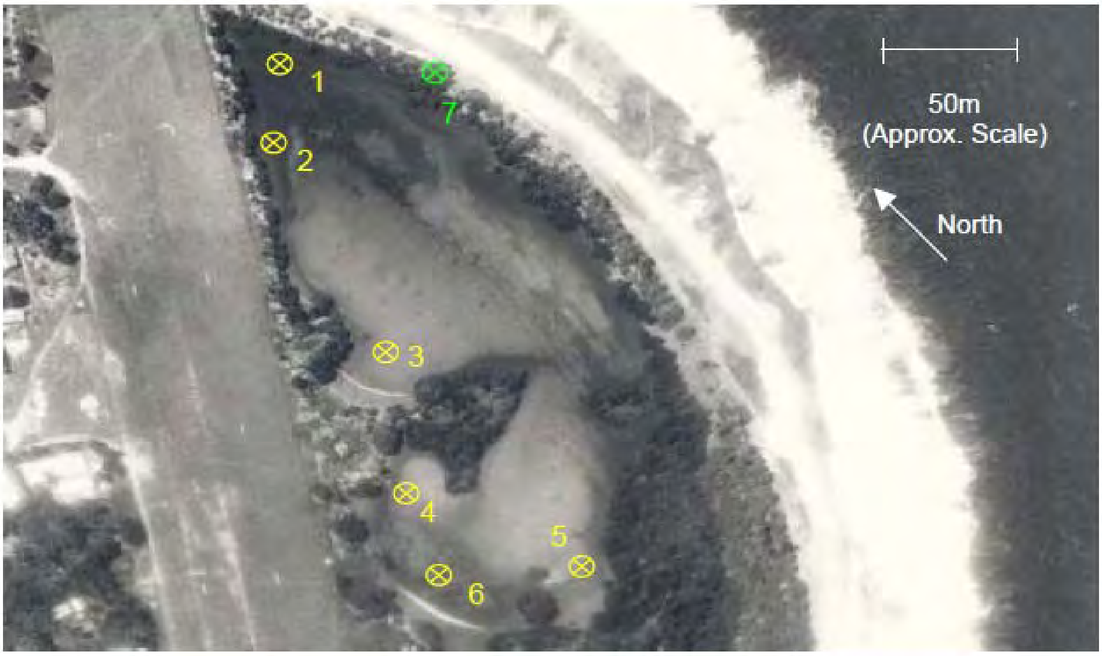


(Source: SOPAC ER-36)

Figure 1.36 Grain-size Analysis of Sediment Samples

b) Tafua Pond

The study for the analysis of nitrogen, lead and copper for sediment samples in Tafua pond was carried out by SOPAC in cooperation with TANGO and IWP (International Water Project) in September 2004. Seven sediment samples were taken from the western side. The 7th sediment sample was collected and analyzed as a control, which was collected from a comparatively undisturbed area on the leeside of the fore-dune between the pond and the ocean (site No.7 on Figure 1.37).



(Source: SOPAC ER-36)

Figure 1.37 Location Map of Sediment Samples in Tafua Pond

The results of the chemical analyses are shown in Table 1.26 and Figure 1.38. Groundwater is no longer used for human consumption on Fongafale as it is often brackish but also because of the known risks of bacterial, metal and nutrient contamination. The IWP indicated that concentrations of both copper (Cu) and lead (Pb) have been found to be of concern in ground water samples elsewhere on Fongafale and the Tafua samples were analyzed for the presence of both metals (elevated concentration of Cu and Pb is presumably related to ordinance haphazardly dumped and buried by the US forces in the early 1940's).

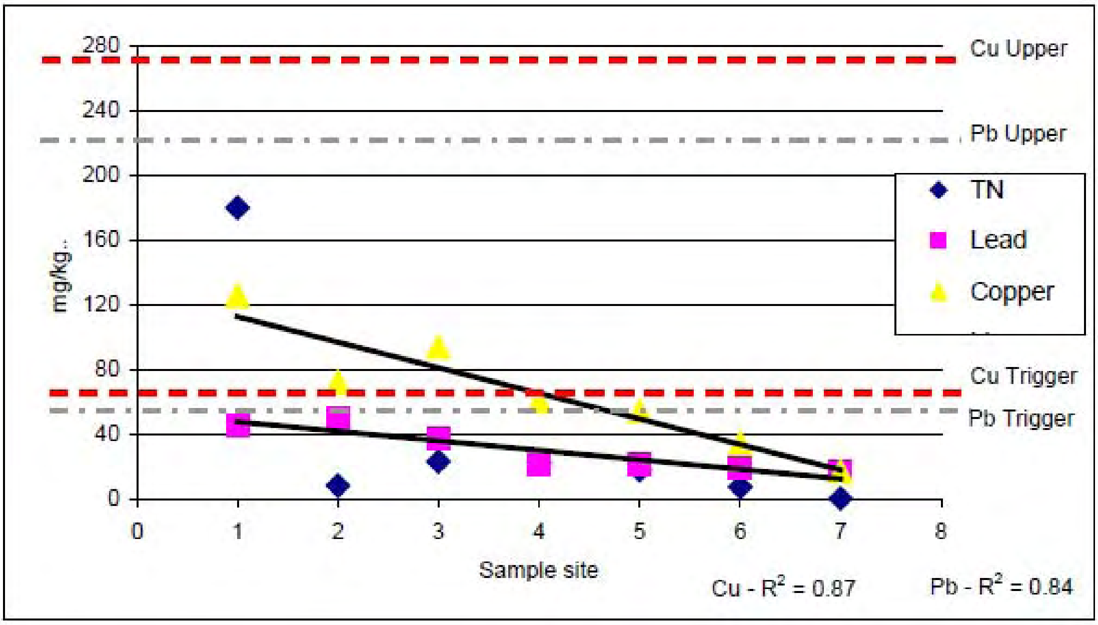
It is important to consider the level of contamination of Tafua as it is possible that persistent metals may transfer up the food chain due to bioaccumulation in food species (milkfish) and become a human health issue. This is also an important consideration if tilapia are to be used as a pig food as a similar accumulation could occur.

Total nitrogen was also analyzed, as in brackish and marine systems the availability or nitrogen usually limits primary production (algal growth). Sediment-nutrient concentrations in turn can give an indication of the level of nitrogen enrichment in shallow systems as much of the organic matter produced and added to the system settles in the sediments. Once this material enters the sediment environment, redox (anoxic/oxic) reactions act to recycle and return the nitrogen to the water column for subsequent use by primary producers, or nitrogen may also be removed from the system by sedimentary processes.

Due to these processes and other factors (tide, rainfall, loading, weather, etc.) water column nitrogen concentrations may vary considerably in such a sall water body over short time intervals and the storage of nitrogen in the sediments gives an overall indication of enrichment particularly when compared with the control sediments (SOPAC ER-36).

Table 1.26 Results of Total Nitrogen, Lead and Copper

Site	Unit	1	2	3	4	5	6	7(Ctrl)
T - N	mg/kg	180.0	8.3	23.2	22.7	17.9	7.6	0.5
Pb	mg/kg	45.7	50.0	37.3	21.2	21.6	19.0	16.7
Cu	mg/kg	125.7	72.2	94.1	60.6	54.4	34.4	16.8



Note: Dashed lines indicate the ANZECC (2000) "trigger" and "high" concentration limit recommendation of Cu and Pb in sediments.

(Source: SOPAC ER-36)

Figure 1.38 Total Nitrogen, Lead and Copper Concentration of Tafua Pond

PART I: COLLECTION AND ANALYSIS OF EXISTING DATA

Section 2 in Part I: Data Book

1. Wind Data

1.1 Monthly Joint Frequency of Occurrence of Wind Speed and Wind Direction (1999 - 2008)

Site	Funafuti	Regulation	7440	
Term	1999/ 1/ 1/ 0:00- 2008/ 12/ 31/ 23:00(January)	Observation	7433 (99.9)
		Error	7 (0.1)

(m/sec)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum	Accum. Sum
	Wind Speed																	
0.0 ～ 0.4	7	14	13	9	11	15	20	18	9	11	7	14	9	5	9	7	178	178
	(0.1)	(0.2)	(0.2)	(0.1)	(0.1)	(0.2)	(0.3)	(0.2)	(0.1)	(0.1)	(0.1)	(0.2)	(0.1)	(0.1)	(0.1)	(0.1)	(2.4)	(2.4)
0.5 ～ 1.9	103	185	198	193	158	227	171	77	43	38	39	38	42	54	53	57	1676	1854
	(1.4)	(2.5)	(2.7)	(2.6)	(2.1)	(3.1)	(2.3)	(1.0)	(0.6)	(0.5)	(0.5)	(0.5)	(0.6)	(0.7)	(0.7)	(0.8)	(22.5)	(24.9)
2.0 ～ 3.9	413	343	386	367	105	121	214	94	58	48	33	55	100	91	98	131	2657	4511
	(5.6)	(4.6)	(5.2)	(4.9)	(1.4)	(1.6)	(2.9)	(1.3)	(0.8)	(0.6)	(0.4)	(0.7)	(1.3)	(1.2)	(1.3)	(1.8)	(35.7)	(60.7)
4.0 ～ 5.9	344	120	233	131	18	10	16	16	16	22	22	45	83	97	134	146	1453	5964
	(4.6)	(1.6)	(3.1)	(1.8)	(0.2)	(0.1)	(0.2)	(0.2)	(0.2)	(0.3)	(0.3)	(0.6)	(1.1)	(1.3)	(1.8)	(2.0)	(19.5)	(80.2)
6.0 ～ 7.9	199	5	41	20	3	2		4	5	5	37	37	78	116	156	137	845	6809
	(2.7)	(0.1)	(0.6)	(0.3)	(0.0)	(0.0)		(0.1)	(0.1)	(0.1)	(0.5)	(0.5)	(1.0)	(1.6)	(2.1)	(1.8)	(11.4)	(91.6)
8.0 ～ 9.9	39		1	3	1				3	5	21	36	30	55	114	83	391	7200
	(0.5)		(0.0)	(0.0)	(0.0)				(0.0)	(0.1)	(0.3)	(0.5)	(0.4)	(0.7)	(1.5)	(1.1)	(5.3)	(96.9)
10.0 ～ 11.9	2								1		11	34	30	27	47	28	180	7380
	(0.0)								(0.0)		(0.1)	(0.5)	(0.4)	(0.4)	(0.6)	(0.4)	(2.4)	(99.3)
12.0 ～ 13.9											1	2	6	10	22	2	43	7423
											(0.0)	(0.0)	(0.1)	(0.1)	(0.3)	(0.0)	(0.6)	(99.9)
14.0 ～ 15.9												1		7	1		9	7432
												(0.0)		(0.1)	(0.0)		(0.1)	(100.0)
16.0 ～ 17.9														1			1	7433
														(0.0)			(0.0)	(100.0)
18.0 ～ 19.9																		7433
																		(100.0)
20.0 ≦																		7433
																		(100.0)
Sum	1107	667	872	723	296	375	421	209	135	129	171	262	378	463	634	591	7433	*
	(14.9)	(9.0)	(11.7)	(9.7)	(4.0)	(5.0)	(5.7)	(2.8)	(1.8)	(1.7)	(2.3)	(3.5)	(5.1)	(6.2)	(8.5)	(8.0)	(100.0)	*

Site	Funafuti	Regulation	6792
Term	1999/ 1/ 1/ 0:00- 2008/ 12/ 31/ 23:00(February)	Observation	6788 (99.9)
		Error	4 (0.1)

(m/sec)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum	Accum. Sum
	Wind Speed																	
0.0 ～ 0.4	7	8	11	18	13	15	14	7	12	4	7	2	14	7	2	6	147	147
	(0.1)	(0.1)	(0.2)	(0.3)	(0.2)	(0.2)	(0.2)	(0.1)	(0.2)	(0.1)	(0.1)	(0.0)	(0.2)	(0.1)	(0.0)	(0.1)	(2.2)	(2.2)
0.5 ～ 1.9	106	206	218	189	115	152	142	79	32	28	17	29	39	34	52	53	1491	1638
	(1.6)	(3.0)	(3.2)	(2.8)	(1.7)	(2.2)	(2.1)	(1.2)	(0.5)	(0.4)	(0.3)	(0.4)	(0.6)	(0.5)	(0.8)	(0.8)	(22.0)	(24.1)
2.0 ～ 3.9	309	576	364	462	76	106	165	75	18	16	22	54	56	64	94	99	2556	4194
	(4.6)	(8.5)	(5.4)	(6.8)	(1.1)	(1.6)	(2.4)	(1.1)	(0.3)	(0.2)	(0.3)	(0.8)	(0.8)	(0.9)	(1.4)	(1.5)	(37.7)	(61.8)
4.0 ～ 5.9	287	133	250	212	11	15	14	17	11	10	15	48	91	71	92	129	1406	5600
	(4.2)	(2.0)	(3.7)	(3.1)	(0.2)	(0.2)	(0.2)	(0.3)	(0.2)	(0.1)	(0.2)	(0.7)	(1.3)	(1.0)	(1.4)	(1.9)	(20.7)	(82.5)
6.0 ～ 7.9	166	19	41	10		1		1	5	5	25	56	134	80	70	145	758	6358
	(2.4)	(0.3)	(0.6)	(0.1)		(0.0)		(0.0)	(0.1)	(0.1)	(0.4)	(0.8)	(2.0)	(1.2)	(1.0)	(2.1)	(11.2)	(93.7)
8.0 ～ 9.9	25	1	3					2	3	6	8	31	64	64	34	58	299	6657
	(0.4)	(0.0)	(0.0)					(0.0)	(0.0)	(0.1)	(0.1)	(0.5)	(0.9)	(0.9)	(0.5)	(0.9)	(4.4)	(98.1)
10.0 ～ 11.9	2							1		4	1	4	11	31	25	9	88	6745
	(0.0)							(0.0)		(0.1)	(0.0)	(0.1)	(0.2)	(0.5)	(0.4)	(0.1)	(1.3)	(99.4)
12.0 ～ 13.9									1			2	6	6	12	3	30	6775
									(0.0)			(0.0)	(0.1)	(0.1)	(0.2)	(0.0)	(0.4)	(99.8)
14.0 ～ 15.9												1		1	10		12	6787
												(0.0)		(0.0)	(0.1)		(0.2)	(100.0)
16.0 ～ 17.9															1		1	6788
															(0.0)		(0.0)	(100.0)
18.0 ～ 19.9																		6788
																		(100.0)
20.0 ≦																		6788
																		(100.0)
Sum	902	943	887	891	215	289	335	182	82	73	95	227	415	358	392	502	6788	*
	(13.3)	(13.9)	(13.1)	(13.1)	(3.2)	(4.3)	(4.9)	(2.7)	(1.2)	(1.1)	(1.4)	(3.3)	(6.1)	(5.3)	(5.8)	(7.4)	(100.0)	*

Site	Funafuti	Regulation	7440
Term	1999/ 1/ 1/ 0:00- 2008/ 12/ 31/ 23:00(March)	Observation	7420 (99.7)
		Error	20 (0.3)

(m/sec)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum	Accum. Sum
	Wind Speed																	
0.0 ～ 0.4	18	13	8	13	19	18	20	19	17	5	9	13	10	11	13	14	220	220
	(0.2)	(0.2)	(0.1)	(0.2)	(0.3)	(0.2)	(0.3)	(0.3)	(0.2)	(0.1)	(0.1)	(0.2)	(0.1)	(0.1)	(0.2)	(0.2)	(3.0)	(3.0)
0.5 ～ 1.9	180	216	251	321	251	511	350	118	33	46	23	37	37	30	64	57	2525	2745
	(2.4)	(2.9)	(3.4)	(4.3)	(3.4)	(6.9)	(4.7)	(1.6)	(0.4)	(0.6)	(0.3)	(0.5)	(0.5)	(0.4)	(0.9)	(0.8)	(34.0)	(37.0)
2.0 ～ 3.9	364	452	363	584	143	391	465	109	25	20	9	19	40	62	118	99	3263	6008
	(4.9)	(6.1)	(4.9)	(7.9)	(1.9)	(5.3)	(6.3)	(1.5)	(0.3)	(0.3)	(0.1)	(0.3)	(0.5)	(0.8)	(1.6)	(1.3)	(44.0)	(81.0)
4.0 ～ 5.9	202	67	116	143	24	28	68	20	6	7	6	14	13	33	68	91	906	6914
	(2.7)	(0.9)	(1.6)	(1.9)	(0.3)	(0.4)	(0.9)	(0.3)	(0.1)	(0.1)	(0.1)	(0.2)	(0.2)	(0.4)	(0.9)	(1.2)	(12.2)	(93.2)
6.0 ～ 7.9	57	3	29	11			2	2	2	1	1	1	9	26	68	60	272	7186
	(0.8)	(0.0)	(0.4)	(0.1)			(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(0.4)	(0.9)	(0.8)	(3.7)	(96.8)
8.0 ～ 9.9	11		3	2						2	1	4	10	36	34	43	146	7332
	(0.1)		(0.0)	(0.0)						(0.0)	(0.0)	(0.1)	(0.1)	(0.5)	(0.5)	(0.6)	(2.0)	(98.8)
10.0 ～ 11.9	2												3	24	24	12	65	7397
	(0.0)												(0.0)	(0.3)	(0.3)	(0.2)	(0.9)	(99.7)
12.0 ～ 13.9													3	6	5	5	19	7416
													(0.0)	(0.1)	(0.1)	(0.1)	(0.3)	(99.9)
14.0 ～ 15.9											1			2			3	7419
											(0.0)			(0.0)			(0.0)	(100.0)
16.0 ～ 17.9																		7419
																		(100.0)
18.0 ～ 19.9													1				1	7420
													(0.0)				(0.0)	(100.0)
20.0 ≦																		7420
																		(100.0)
Sum	834	751	770	1074	437	948	905	268	83	81	50	88	126	230	394	381	7420	*
	(11.2)	(10.1)	(10.4)	(14.5)	(5.9)	(12.8)	(12.2)	(3.6)	(1.1)	(1.1)	(0.7)	(1.2)	(1.7)	(3.1)	(5.3)	(5.1)	(100.0)	*

Site	Funafuti	Regulation	7200
Term	1999/ 1/ 1/ 0:00- 2008/ 12/ 31/ 23:00(April)	Observation	7180 (99.7)
		Error	20 (0.3)

(m/sec)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum	Accum. Sum
0.0 ～ 0.4	7	15	8	18	19	25	14	23	18	11	7	7	5	4	8	8	197	197
	(0.1)	(0.2)	(0.1)	(0.3)	(0.3)	(0.3)	(0.2)	(0.3)	(0.3)	(0.2)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(2.7)	(2.7)
0.5 ～ 1.9	122	207	236	390	309	524	487	101	40	28	10	21	49	32	41	70	2667	2864
	(1.7)	(2.9)	(3.3)	(5.4)	(4.3)	(7.3)	(6.8)	(1.4)	(0.6)	(0.4)	(0.1)	(0.3)	(0.7)	(0.4)	(0.6)	(1.0)	(37.1)	(39.9)
2.0 ～ 3.9	247	224	298	567	147	467	748	123	29	20	12	24	57	45	68	107	3183	6047
	(3.4)	(3.1)	(4.2)	(7.9)	(2.0)	(6.5)	(10.4)	(1.7)	(0.4)	(0.3)	(0.2)	(0.3)	(0.8)	(0.6)	(0.9)	(1.5)	(44.3)	(84.2)
4.0 ～ 5.9	154	19	59	81	30	48	137	30	4	3	4	4	36	42	80	70	801	6848
	(2.1)	(0.3)	(0.8)	(1.1)	(0.4)	(0.7)	(1.9)	(0.4)	(0.1)	(0.0)	(0.1)	(0.1)	(0.5)	(0.6)	(1.1)	(1.0)	(11.2)	(95.4)
6.0 ～ 7.9	23	2	6	10	1	6	4	3	3		5	2	17	29	45	45	201	7049
	(0.3)	(0.0)	(0.1)	(0.1)	(0.0)	(0.1)	(0.1)	(0.0)	(0.0)		(0.1)	(0.0)	(0.2)	(0.4)	(0.6)	(0.6)	(2.8)	(98.2)
8.0 ～ 9.9	1		1	2						1		1	7	12	26	26	77	7126
	(0.0)		(0.0)	(0.0)						(0.0)		(0.0)	(0.1)	(0.2)	(0.4)	(0.4)	(1.1)	(99.2)
10.0 ～ 11.9	1								1		1	3	6	7	23	4	46	7172
	(0.0)								(0.0)		(0.0)	(0.0)	(0.1)	(0.1)	(0.3)	(0.1)	(0.6)	(99.9)
12.0 ～ 13.9													2	1	3		6	7178
													(0.0)	(0.0)	(0.0)		(0.1)	(100.0)
14.0 ～ 15.9													1	1			2	7180
													(0.0)	(0.0)			(0.0)	(100.0)
16.0 ～ 17.9																		7180
																		(100.0)
18.0 ～ 19.9																		7180
																		(100.0)
20.0 ≦																		7180
																		(100.0)
Sum	555	467	608	1068	506	1070	1390	280	95	63	39	62	180	173	294	330	7180	*
	(7.7)	(6.5)	(8.5)	(14.9)	(7.0)	(14.9)	(19.4)	(3.9)	(1.3)	(0.9)	(0.5)	(0.9)	(2.5)	(2.4)	(4.1)	(4.6)	(100.0)	*

Site	Funafuti	Regulation	7440
Term	1999/ 1/ 1/ 0:00- 2008/ 12/ 31/ 23:00(May)	Observation	7429 (99.9)
		Error	11 (0.1)

(m/sec)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum	Accum. Sum
0.0 ～ 0.4	24	18	17	17	23	25	25	14	10	4	7	8	9	11	14	13	239	239
	(0.3)	(0.2)	(0.2)	(0.2)	(0.3)	(0.3)	(0.3)	(0.2)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.2)	(0.2)	(3.2)	(3.2)
0.5 ～ 1.9	117	225	316	431	344	680	477	177	56	38	24	22	27	37	37	57	3065	3304
	(1.6)	(3.0)	(4.3)	(5.8)	(4.6)	(9.2)	(6.4)	(2.4)	(0.8)	(0.5)	(0.3)	(0.3)	(0.4)	(0.5)	(0.5)	(0.8)	(41.3)	(44.5)
2.0 ～ 3.9	125	171	212	494	159	625	913	278	82	35	30	15	26	36	55	54	3310	6614
	(1.7)	(2.3)	(2.9)	(6.6)	(2.1)	(8.4)	(12.3)	(3.7)	(1.1)	(0.5)	(0.4)	(0.2)	(0.3)	(0.5)	(0.7)	(0.7)	(44.6)	(89.0)
4.0 ～ 5.9	36	14	25	46	15	77	222	86	34	10	8	7	12	15	31	50	688	7302
	(0.5)	(0.2)	(0.3)	(0.6)	(0.2)	(1.0)	(3.0)	(1.2)	(0.5)	(0.1)	(0.1)	(0.1)	(0.2)	(0.2)	(0.4)	(0.7)	(9.3)	(98.3)
6.0 ～ 7.9	8	2	3	5	4	1	11	21	6	7	7	3	1	6	6	16	107	7409
	(0.1)	(0.0)	(0.0)	(0.1)	(0.1)	(0.0)	(0.1)	(0.3)	(0.1)	(0.1)	(0.1)	(0.0)	(0.0)	(0.1)	(0.1)	(0.2)	(1.4)	(99.7)
8.0 ～ 9.9	1							1	2	1	1		3			4	13	7422
	(0.0)							(0.0)	(0.0)	(0.0)	(0.0)		(0.0)			(0.1)	(0.2)	(99.9)
10.0 ～ 11.9									3	1					2		6	7428
									(0.0)	(0.0)					(0.0)		(0.1)	(100.0)
12.0 ～ 13.9										1							1	7429
										(0.0)							(0.0)	(100.0)
14.0 ～ 15.9																		7429
																		(100.0)
16.0 ～ 17.9																		7429
																		(100.0)
18.0 ～ 19.9																		7429
																		(100.0)
20.0 ≦																		7429
																		(100.0)
Sum	311	430	573	993	545	1408	1648	577	193	97	77	55	78	105	145	194	7429	*
	(4.2)	(5.8)	(7.7)	(13.4)	(7.3)	(19.0)	(22.2)	(7.8)	(2.6)	(1.3)	(1.0)	(0.7)	(1.0)	(1.4)	(2.0)	(2.6)	(100.0)	*

Site	Funafuti	Regulation	7200
Term	1999/ 1/ 1/ 0:00- 2008/ 12/ 31/ 23:00(June)	Observation	7193 (99.9)
		Error	7 (0.1)

(m/sec)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum	Accum. Sum
0.0 ～ 0.4	5	10	7	8	14	19	15	13	3	7	7	3	7	1	7	5	131	131
	(0.1)	(0.1)	(0.1)	(0.1)	(0.2)	(0.3)	(0.2)	(0.2)	(0.0)	(0.1)	(0.1)	(0.0)	(0.1)	(0.0)	(0.1)	(0.1)	(1.8)	(1.8)
0.5 ～ 1.9	63	106	162	234	258	549	313	101	26	12	12	14	18	26	21	16	1931	2062
	(0.9)	(1.5)	(2.3)	(3.3)	(3.6)	(7.6)	(4.4)	(1.4)	(0.4)	(0.2)	(0.2)	(0.2)	(0.3)	(0.4)	(0.3)	(0.2)	(26.8)	(28.7)
2.0 ～ 3.9	83	121	175	513	208	990	1143	239	45	14	5	5	7	22	19	36	3625	5687
	(1.2)	(1.7)	(2.4)	(7.1)	(2.9)	(13.8)	(15.9)	(3.3)	(0.6)	(0.2)	(0.1)	(0.1)	(0.1)	(0.3)	(0.3)	(0.5)	(50.4)	(79.1)
4.0 ～ 5.9	38	15	36	123	24	375	516	119	26	9	1			5	6	16	1309	6996
	(0.5)	(0.2)	(0.5)	(1.7)	(0.3)	(5.2)	(7.2)	(1.7)	(0.4)	(0.1)	(0.0)			(0.1)	(0.1)	(0.2)	(18.2)	(97.3)
6.0 ～ 7.9	5	2	6	8	6	30	53	41	10	3	4			1	2	4	175	7171
	(0.1)	(0.0)	(0.1)	(0.1)	(0.1)	(0.4)	(0.7)	(0.6)	(0.1)	(0.0)	(0.1)			(0.0)	(0.0)	(0.1)	(2.4)	(99.7)
8.0 ～ 9.9	1					2	5	8	3							1	20	7191
	(0.0)					(0.0)	(0.1)	(0.1)	(0.0)							(0.0)	(0.3)	(100.0)
10.0 ～ 11.9				1													1	7192
				(0.0)													(0.0)	(100.0)
12.0 ～ 13.9			1														1	7193
			(0.0)														(0.0)	(100.0)
14.0 ～ 15.9																		7193
																		(100.0)
16.0 ～ 17.9																		7193
																		(100.0)
18.0 ～ 19.9																		7193
																		(100.0)
20.0 ≦																		7193
																		(100.0)
Sum	195	254	387	887	510	1965	2045	521	113	45	29	22	32	55	55	78	7193	*
	(2.7)	(3.5)	(5.4)	(12.3)	(7.1)	(27.3)	(28.4)	(7.2)	(1.6)	(0.6)	(0.4)	(0.3)	(0.4)	(0.8)	(0.8)	(1.1)	(100.0)	*

Regulation	7440	
Observation	7410	(99.6)
Error	30	(0.4)

Site: Funafuti
Term: 1999/ 1/ 1/ 0:00- 2008/ 12/ 31/ 23:00(July)

(m/sec)	Wind Speed																Sum	Accum. Sum
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW		
0.0 ～ 0.4	6	7	2	8	9	11	10	3	2	4	4	4	6	4	4	4	88	88
	(0.1)	(0.1)	(0.0)	(0.1)	(0.1)	(0.1)	(0.1)	(0.0)	(0.0)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(1.2)	(1.2)
0.5 ～ 1.9	53	86	103	197	273	583	434	83	27	22	21	19	21	33	23	24	2002	2090
	(0.7)	(1.2)	(1.4)	(2.7)	(3.7)	(7.9)	(5.9)	(1.1)	(0.4)	(0.3)	(0.3)	(0.3)	(0.3)	(0.4)	(0.3)	(0.3)	(27.0)	(28.2)
2.0 ～ 3.9	82	76	172	534	152	983	1323	217	42	22	5	4	13	9	28	27	3689	5779
	(1.1)	(1.0)	(2.3)	(7.2)	(2.1)	(13.3)	(17.9)	(2.9)	(0.6)	(0.3)	(0.1)	(0.1)	(0.2)	(0.1)	(0.4)	(0.4)	(49.8)	(78.0)
4.0 ～ 5.9	18	16	54	150	18	345	618	167	17	8	3	3	4	5	9	20	1455	7234
	(0.2)	(0.2)	(0.7)	(2.0)	(0.2)	(4.7)	(8.3)	(2.3)	(0.2)	(0.1)	(0.0)	(0.0)	(0.1)	(0.1)	(0.1)	(0.3)	(19.6)	(97.6)
6.0 ～ 7.9	5		2	10	6	20	68	42	4		2	1	1	2	1	2	166	7400
	(0.1)		(0.0)	(0.1)	(0.1)	(0.3)	(0.9)	(0.6)	(0.1)		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(2.2)	(99.9)
8.0 ～ 9.9				1			2	4					1		2		10	7410
				(0.0)			(0.0)	(0.1)					(0.0)		(0.0)		(0.1)	(100.0)
10.0 ～ 11.9																		7410
																		(100.0)
12.0 ～ 13.9																		7410
																		(100.0)
14.0 ～ 15.9																		7410
																		(100.0)
16.0 ～ 17.9																		7410
																		(100.0)
18.0 ～ 19.9																		7410
																		(100.0)
20.0 ≦																		7410
																		(100.0)
Sum	164	185	333	900	458	1942	2455	516	92	56	35	31	46	53	67	77	7410	*
	(2.2)	(2.5)	(4.5)	(12.1)	(6.2)	(26.2)	(33.1)	(7.0)	(1.2)	(0.8)	(0.5)	(0.4)	(0.6)	(0.7)	(0.9)	(1.0)	(100.0)	*

Regulation	7440	
Observation	7415	(99.7)
Error	25	(0.3)

Site: Funafuti
Term: 1999/ 1/ 1/ 0:00- 2008/ 12/ 31/ 23:00(August)

(m/sec)	Wind Speed																Sum	Accum. Sum
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW		
0.0 ～ 0.4	3	6	9	8	9	11	8	10	5	4	2	5	8	7	4	3	102	102
	(0.0)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.0)	(0.1)	(0.1)	(0.1)	(0.1)	(0.0)	(1.4)	(1.4)
0.5 ～ 1.9	51	103	131	211	239	491	341	111	36	21	13	10	11	6	16	16	1807	1909
	(0.7)	(1.4)	(1.8)	(2.8)	(3.2)	(6.6)	(4.6)	(1.5)	(0.5)	(0.3)	(0.2)	(0.1)	(0.1)	(0.1)	(0.2)	(0.2)	(24.4)	(25.7)
2.0 ～ 3.9	85	124	210	577	187	880	1165	290	78	31	18	11	10	11	11	25	3713	5622
	(1.1)	(1.7)	(2.8)	(7.8)	(2.5)	(11.9)	(15.7)	(3.9)	(1.1)	(0.4)	(0.2)	(0.1)	(0.1)	(0.1)	(0.1)	(0.3)	(50.1)	(75.8)
4.0 ～ 5.9	24	18	69	159	22	340	616	216	35	11	8	4	4	4	18	13	1561	7183
	(0.3)	(0.2)	(0.9)	(2.1)	(0.3)	(4.6)	(8.3)	(2.9)	(0.5)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.2)	(0.2)	(21.1)	(96.9)
6.0 ～ 7.9	7	3	5	20	1	22	70	47	18		1	4			11	5	214	7397
	(0.1)	(0.0)	(0.1)	(0.3)	(0.0)	(0.3)	(0.9)	(0.6)	(0.2)		(0.0)	(0.1)			(0.1)	(0.1)	(2.9)	(99.8)
8.0 ～ 9.9			3			1	4	1	1	1					2	2	15	7412
			(0.0)			(0.0)	(0.1)	(0.0)	(0.0)	(0.0)					(0.0)	(0.0)	(0.2)	(100.0)
10.0 ～ 11.9									2	1							3	7415
									(0.0)	(0.0)							(0.0)	(100.0)
12.0 ～ 13.9																		7415
																		(100.0)
14.0 ～ 15.9																		7415
																		(100.0)
16.0 ～ 17.9																		7415
																		(100.0)
18.0 ～ 19.9																		7415
																		(100.0)
20.0 ≦																		7415
																		(100.0)
Sum	170	254	427	975	458	1745	2204	675	175	69	42	34	33	28	62	64	7415	*
	(2.3)	(3.4)	(5.8)	(13.1)	(6.2)	(23.5)	(29.7)	(9.1)	(2.4)	(0.9)	(0.6)	(0.5)	(0.4)	(0.4)	(0.8)	(0.9)	(100.0)	*

Regulation	7200	
Observation	7107	(98.7)
Error	93	(1.3)

Site: Funafuti
Term: 1999/ 1/ 1/ 0:00- 2008/ 12/ 31/ 23:00(September)

(m/sec)	Wind Speed																Sum	Accum. Sum
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW		
0.0 ～ 0.4	3	4	10	6	13	20	8	12	6	7	6	4	9	2	4	7	121	121
	(0.0)	(0.1)	(0.1)	(0.1)	(0.2)	(0.3)	(0.1)	(0.2)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.0)	(0.1)	(0.1)	(1.7)	(1.7)
0.5 ～ 1.9	37	87	146	267	265	501	438	62	27	21	17	20	24	25	11	15	1963	2084
	(0.5)	(1.2)	(2.1)	(3.8)	(3.7)	(7.0)	(6.2)	(0.9)	(0.4)	(0.3)	(0.2)	(0.3)	(0.3)	(0.4)	(0.2)	(0.2)	(27.6)	(29.3)
2.0 ～ 3.9	67	150	230	677	233	676	1253	268	41	34	21	21	14	27	21	17	3750	5834
	(0.9)	(2.1)	(3.2)	(9.5)	(3.3)	(9.5)	(17.6)	(3.8)	(0.6)	(0.5)	(0.3)	(0.3)	(0.2)	(0.4)	(0.3)	(0.2)	(52.8)	(82.1)
4.0 ～ 5.9	15	27	56	137	27	138	482	155	29	5	6	4	6	12	12	13	1124	6958
	(0.2)	(0.4)	(0.8)	(1.9)	(0.4)	(1.9)	(6.8)	(2.2)	(0.4)	(0.1)	(0.1)	(0.1)	(0.1)	(0.2)	(0.2)	(0.2)	(15.8)	(97.9)
6.0 ～ 7.9	3		6	8	2	3	54	40	1			3	6	2	5	5	138	7096
	(0.0)		(0.1)	(0.1)	(0.0)	(0.0)	(0.8)	(0.6)	(0.0)			(0.0)	(0.1)	(0.0)	(0.1)	(0.1)	(1.9)	(99.8)
8.0 ～ 9.9				4		1		3							1	2	11	7107
				(0.1)		(0.0)		(0.0)							(0.0)	(0.0)	(0.2)	(100.0)
10.0 ～ 11.9																		7107
																		(100.0)
12.0 ～ 13.9																		7107
																		(100.0)
14.0 ～ 15.9																		7107
																		(100.0)
16.0 ～ 17.9																		7107
																		(100.0)
18.0 ～ 19.9																		7107
																		(100.0)
20.0 ≦																		7107
																		(100.0)
Sum	125	268	448	1099	540	1339	2235	540	104	67	50	52	59	68	54	59	7107	*
	(1.8)	(3.8)	(6.3)	(15.5)	(7.6)	(18.8)	(31.4)	(7.6)	(1.5)	(0.9)	(0.7)	(0.7)	(0.8)	(1.0)	(0.8)	(0.8)	(100.0)	*

Regulation	7440	
Observation	7427	(99.8)
Error	13	(0.2)

Site: Funafuti

Term: 1999/ 1/ 1/ 0:00- 2008/ 12/ 31/ 23:00(October)

(m/sec)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum	Accum. Sum
0.0 ～ 0.4	9 (0.1)	14 (0.2)	19 (0.3)	13 (0.2)	11 (0.1)	21 (0.3)	25 (0.3)	10 (0.1)	11 (0.1)	9 (0.1)	9 (0.1)	5 (0.1)	11 (0.1)	6 (0.1)	7 (0.1)	9 (0.1)	189 (2.5)	189 (2.5)
0.5 ～ 1.9	97 (1.3)	197 (2.7)	239 (3.2)	276 (3.7)	253 (3.4)	423 (5.7)	386 (5.2)	138 (1.9)	40 (0.5)	44 (0.6)	20 (0.3)	18 (0.2)	28 (0.4)	27 (0.4)	31 (0.4)	35 (0.5)	2252 (30.3)	2441 (32.9)
2.0 ～ 3.9	185 (2.5)	349 (4.7)	331 (4.5)	589 (7.9)	150 (2.0)	518 (7.0)	970 (13.1)	330 (4.4)	70 (0.9)	61 (0.8)	18 (0.2)	19 (0.3)	26 (0.4)	29 (0.4)	55 (0.7)	57 (0.8)	3757 (50.6)	6198 (83.5)
4.0 ～ 5.9	51 (0.7)	42 (0.6)	78 (1.1)	92 (1.2)	15 (0.2)	117 (1.6)	316 (4.3)	141 (1.9)	40 (0.5)	24 (0.3)	5 (0.1)	3 (0.0)	11 (0.1)	12 (0.2)	33 (0.4)	59 (0.8)	1039 (14.0)	7237 (97.4)
6.0 ～ 7.9	11 (0.1)	3 (0.0)	6 (0.1)	10 (0.1)	2 (0.0)	7 (0.1)	18 (0.2)	21 (0.3)	9 (0.1)	8 (0.1)	7 (0.1)	3 (0.0)	4 (0.1)	7 (0.1)	15 (0.2)	20 (0.3)	151 (2.0)	7388 (99.5)
8.0 ～ 9.9	2 (0.0)	1 (0.0)				1 (0.0)	3 (0.0)	2 (0.0)	4 (0.1)	2 (0.0)	2 (0.0)		1 (0.0)	1 (0.0)	2 (0.0)	4 (0.1)	25 (0.3)	7413 (99.8)
10.0 ～ 11.9								2 (0.0)	1 (0.0)			2 (0.0)	1 (0.0)		3 (0.0)		9 (0.1)	7422 (99.9)
12.0 ～ 13.9									1 (0.0)			4 (0.1)					5 (0.1)	7427 (100.0)
14.0 ～ 15.9																		7427 (100.0)
16.0 ～ 17.9																		7427 (100.0)
18.0 ～ 19.9																		7427 (100.0)
20.0 ≦																		7427 (100.0)
Sum	355 (4.8)	606 (8.2)	673 (9.1)	980 (13.2)	431 (5.8)	1087 (14.6)	1718 (23.1)	644 (8.7)	176 (2.4)	148 (2.0)	61 (0.8)	54 (0.7)	82 (1.1)	82 (1.1)	146 (2.0)	184 (2.5)	7427 (100.0)	* *

Regulation	7200	
Observation	7199	(100.0)
Error	1	(0.0)

Site: Funafuti

Term: 1999/ 1/ 1/ 0:00- 2008/ 12/ 31/ 23:00(November)

(m/sec)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum	Accum. Sum
0.0 ～ 0.4	18 (0.3)	25 (0.3)	10 (0.1)	15 (0.2)	17 (0.2)	30 (0.4)	36 (0.5)	25 (0.3)	19 (0.3)	16 (0.2)	17 (0.2)	12 (0.2)	10 (0.1)	13 (0.2)	14 (0.2)	19 (0.3)	296 (4.1)	296 (4.1)
0.5 ～ 1.9	120 (1.7)	221 (3.1)	251 (3.5)	328 (4.6)	227 (3.2)	347 (4.8)	318 (4.4)	128 (1.8)	68 (0.9)	45 (0.6)	44 (0.6)	36 (0.5)	46 (0.6)	53 (0.7)	44 (0.6)	56 (0.8)	2332 (32.4)	2628 (36.5)
2.0 ～ 3.9	316 (4.4)	425 (5.9)	337 (4.7)	543 (7.5)	94 (1.3)	337 (4.7)	625 (8.7)	220 (3.1)	71 (1.0)	43 (0.6)	12 (0.2)	28 (0.4)	35 (0.5)	44 (0.6)	42 (0.6)	105 (1.5)	3277 (45.5)	5905 (82.0)
4.0 ～ 5.9	181 (2.5)	106 (1.5)	106 (1.5)	77 (1.1)	11 (0.2)	45 (0.6)	140 (1.9)	131 (1.8)	28 (0.4)	7 (0.1)	7 (0.1)	5 (0.1)	20 (0.3)	32 (0.4)	35 (0.5)	72 (1.0)	1003 (13.9)	6908 (96.0)
6.0 ～ 7.9	36 (0.5)	10 (0.1)	15 (0.2)	5 (0.1)	1 (0.0)	3 (0.0)	7 (0.1)	13 (0.2)	5 (0.1)	3 (0.0)	6 (0.1)	2 (0.0)	18 (0.3)	23 (0.3)	33 (0.5)	31 (0.4)	211 (2.9)	7119 (98.9)
8.0 ～ 9.9	9 (0.1)	1 (0.0)	2 (0.0)		1 (0.0)				1 (0.0)	3 (0.0)		3 (0.0)	6 (0.1)	14 (0.2)	8 (0.1)	10 (0.1)	58 (0.8)	7177 (99.7)
10.0 ～ 11.9	2 (0.0)						1 (0.0)					1 (0.0)	5 (0.1)		6 (0.1)	1 (0.0)	16 (0.2)	7193 (99.9)
12.0 ～ 13.9	1 (0.0)												1 (0.0)			4 (0.1)	6 (0.1)	7199 (100.0)
14.0 ～ 15.9																		7199 (100.0)
16.0 ～ 17.9																		7199 (100.0)
18.0 ～ 19.9																		7199 (100.0)
20.0 ≦																		7199 (100.0)
Sum	683 (9.5)	788 (10.9)	721 (10.0)	968 (13.4)	351 (4.9)	762 (10.6)	1127 (15.7)	517 (7.2)	192 (2.7)	117 (1.6)	86 (1.2)	87 (1.2)	141 (2.0)	179 (2.5)	182 (2.5)	298 (4.1)	7199 (100.0)	* *

Regulation	7440	
Observation	7427	(99.8)
Error	13	(0.2)

Site: Funafuti

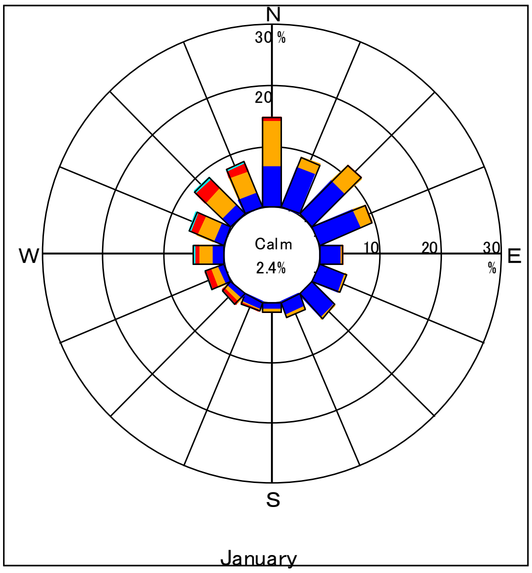
Term: 1999/ 1/ 1/ 0:00- 2008/ 12/ 31/ 23:00(December)

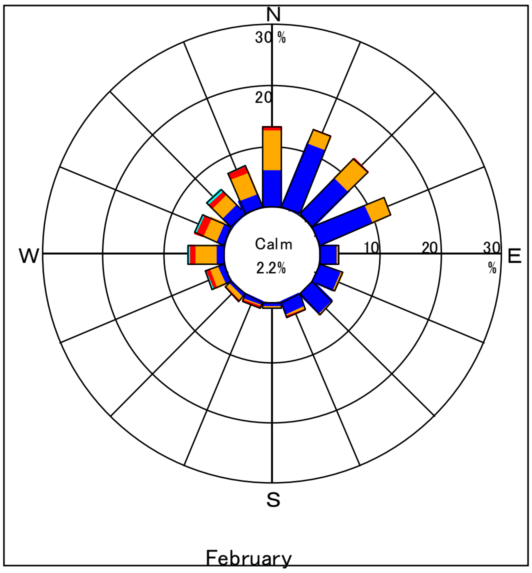
(m/sec)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum	Accum. Sum
0.0 ～ 0.4	14 (0.2)	20 (0.3)	10 (0.1)	10 (0.1)	12 (0.2)	23 (0.3)	19 (0.3)	26 (0.4)	17 (0.2)	16 (0.2)	8 (0.1)	10 (0.1)	9 (0.1)	16 (0.2)	14 (0.2)	15 (0.2)	239 (3.2)	239 (3.2)
0.5 ～ 1.9	161 (2.2)	255 (3.4)	210 (2.8)	207 (2.8)	163 (2.2)	235 (3.2)	230 (3.1)	116 (1.6)	57 (0.8)	65 (0.9)	46 (0.6)	64 (0.9)	70 (0.9)	79 (1.1)	66 (0.9)	90 (1.2)	2114 (28.5)	2353 (31.7)
2.0 ～ 3.9	424 (5.7)	348 (4.7)	265 (3.6)	297 (4.0)	149 (2.0)	146 (2.0)	267 (3.6)	165 (2.2)	71 (1.0)	42 (0.6)	32 (0.4)	46 (0.6)	95 (1.3)	133 (1.8)	165 (2.2)	151 (2.0)	2796 (37.6)	5149 (69.3)
4.0 ～ 5.9	232 (3.1)	125 (1.7)	137 (1.8)	63 (0.8)	40 (0.5)	23 (0.3)	29 (0.4)	41 (0.6)	27 (0.4)	12 (0.2)	23 (0.3)	44 (0.6)	87 (1.2)	97 (1.3)	161 (2.2)	180 (2.4)	1321 (17.8)	6470 (87.1)
6.0 ～ 7.9	42 (0.6)	10 (0.1)	16 (0.2)	7 (0.1)	1 (0.0)	1 (0.0)	2 (0.0)	5 (0.1)	9 (0.1)	6 (0.1)	14 (0.2)	46 (0.6)	102 (1.4)	98 (1.3)	166 (2.2)	118 (1.6)	643 (8.7)	7113 (95.8)
8.0 ～ 9.9	4 (0.1)	1 (0.0)	1 (0.0)		1 (0.0)				1 (0.0)	3 (0.0)	8 (0.1)	23 (0.3)	34 (0.5)	47 (0.6)	72 (1.0)	24 (0.3)	219 (2.9)	7332 (98.7)
10.0 ～ 11.9			1 (0.0)							1 (0.0)	2 (0.0)	4 (0.1)	13 (0.2)	16 (0.2)	29 (0.4)	8 (0.1)	74 (1.0)	7406 (99.7)
12.0 ～ 13.9											1 (0.0)		2 (0.0)	8 (0.1)	7 (0.1)	1 (0.0)	19 (0.3)	7425 (100.0)
14.0 ～ 15.9															1 (0.0)		1 (0.0)	7426 (100.0)
16.0 ～ 17.9															1 (0.0)		1 (0.0)	7427 (100.0)
18.0 ～ 19.9																		7427 (100.0)
20.0 ≦																		7427 (100.0)
Sum	877 (11.8)	759 (10.2)	640 (8.6)	584 (7.9)	366 (4.9)	428 (5.8)	547 (7.4)	353 (4.8)	182 (2.5)	145 (2.0)	134 (1.8)	237 (3.2)	412 (5.5)	494 (6.7)	682 (9.2)	587 (7.9)	7427 (100.0)	* *

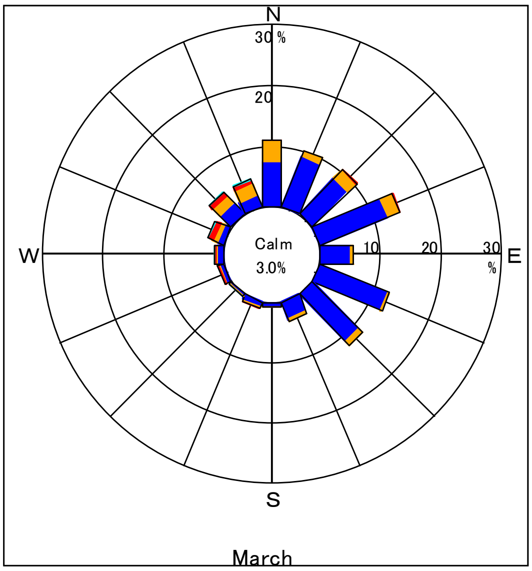
1.2 Monthly Wind Rose (1999 - 2008)

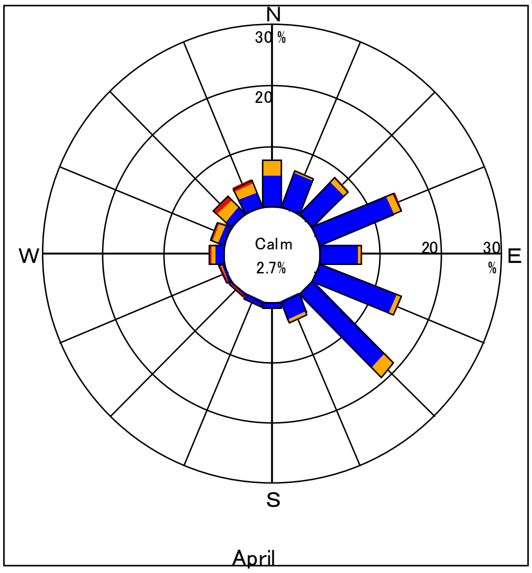
【Legend】

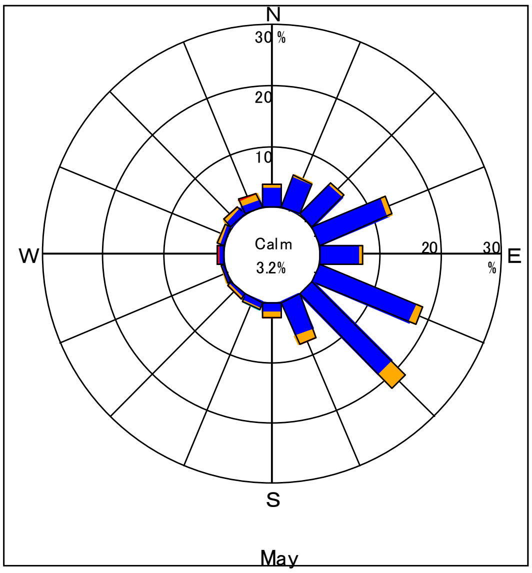
- 0.5 − 3.9 (m/sec)
- 4.0 − 7.9 (m/sec)
- 8.0 −11.9 (m/sec)
- 12.0 (m/sec) <

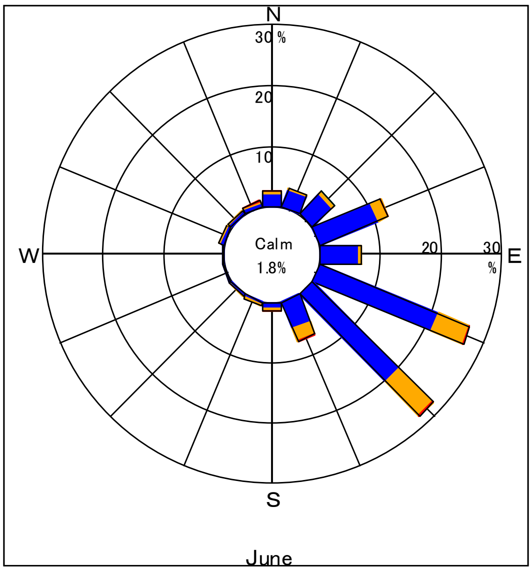

N
30 %
20
10
20
30
%
W
E
S
Calm
2.4%
January

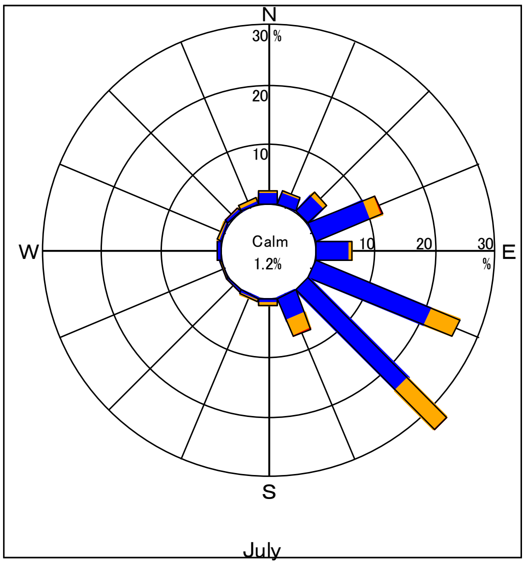

N
30 %
20
10
20
30
%
W
E
S
Calm
2.2%
February

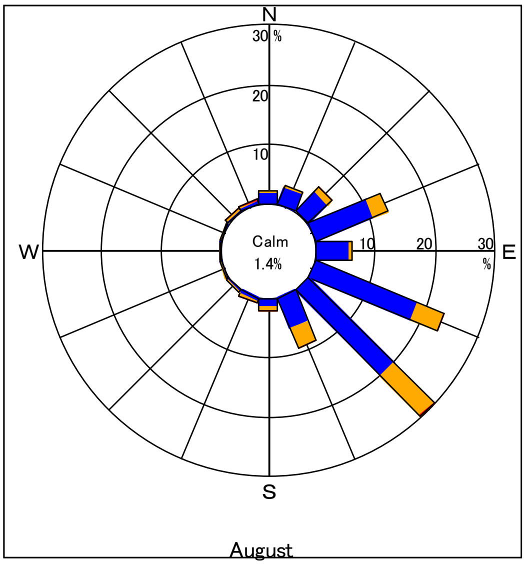

N
30 %
20
10
20
30
%
W
E
S
Calm
3.0%
March

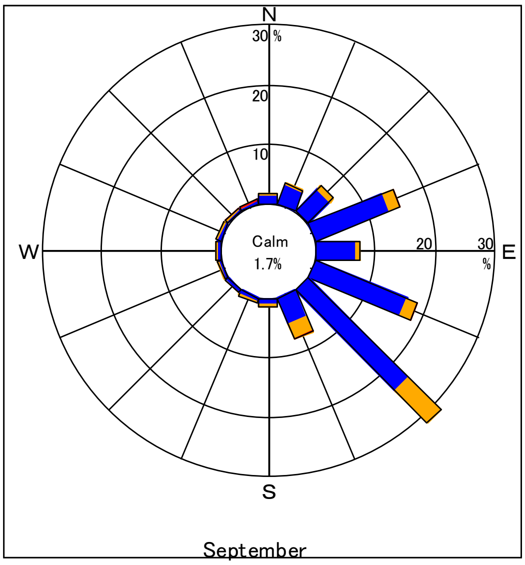

N
30 %
20
20
30
%
W
E
S
Calm
2.7%
April

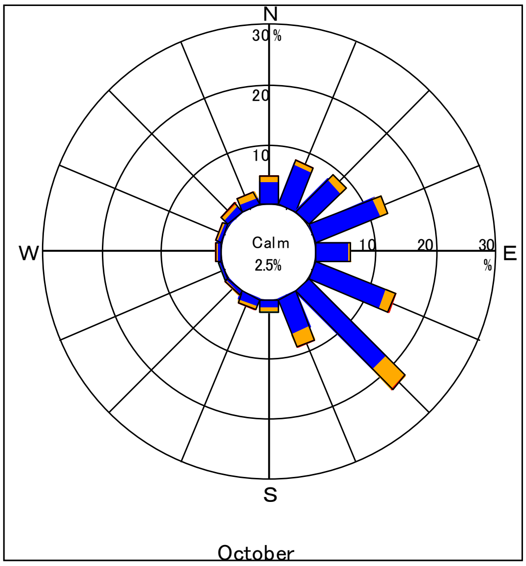

N
30 %
20
10
20
30
%
W
E
S
Calm
3.2%
May

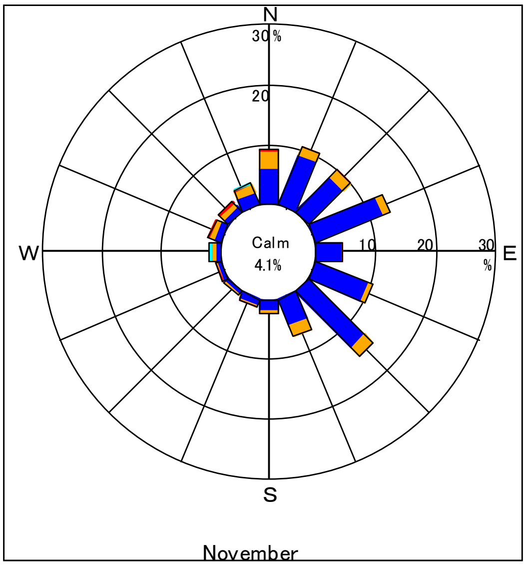

N
30 %
20
10
20
30
%
W
E
S
Calm
1.8%
June

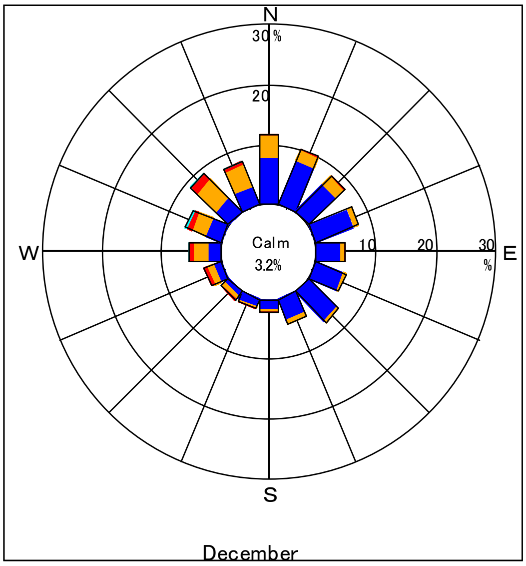

N
30 %
20
10
W
Calm
1.2%
10
20
30
%
E
S
July


N
30 %
20
10
W
Calm
1.4%
10
20
30
%
E
S
August


N
30 %
20
10
W
Calm
1.7%
20
30
%
E
S
September


N
30 %
20
10
W
Calm
2.5%
10
20
30
%
E
S
October


N
30 %
20
W
Calm
4.1%
10
20
30
%
E
S
November


N
30 %
20
W
Calm
3.2%
10
20
30
%
E
S
December

1.3 Monthly Wind Speed at Funafuti (1994 - 2009)

(1.3-1)

Year	Month	Wind Speed (m/sec)		Max.Wind Gust (m/sec)	Remarks
		Max. (Dir.)	Mean	(Dir.: degree)	(No. of No Data)
1994	January	11.0 (-)	3.0	16.5 (-)	(699)
	February	8.5 (309)	2.3	12.1 (90)	
	March	15.7 (319)	2.9	20.8 (319)	
	April	11.8 (296)	3.2	17.9 (313)	
	May	9.1 (114)	2.8	15.9 (70)	8
	June	9.0 (154)	3.2	15.2 (148)	59
	July	8.9 (106)	3.3	12.4 (115)	148
	August	8.5 (300)	2.8	15.0 (300)	408
	September	9.5 (108)	3.2	13.8 (148)	64
	October	9.5 (287)	2.5	13.7 (144)	
	November	9.2 (312)	2.5	16.5 (284)	12
	December	19.7 (285)	4.5	24.6 (285)	
1995	January	12.4 (306)	4.3	18.7 (239)	(315)
	February	12.5 (269)	2.9	16.8 (307)	3
	March	10.1 (335)	2.6	13.4 (350)	101
	April	13.9 (311)	2.9	18.9 (333)	72
	May	8.2 (246)	2.5	13.5 (111)	8
	June	9.9 (185)	3.3	15.2 (81)	20
	July	8.1 (14)	2.7	11.7 (12)	24
	August	8.6 (110)	3.1	14.0 (111)	6
	September	7.8 (51)	3.0	14.7 (321)	12
	October	8.8 (317)	2.7	12.3 (139)	9
	November	9.6 (196)	2.7	12.7 (196)	13
	December	15.4 (307)	3.4	19.5 (330)	47
1996	January	11.1 (-)	3.4	14.3 (-)	17 (113)
	February	10.2 (322)	3.6	13.5 (285)	56
	March	13.7 (313)	4.1	19.4 (308)	8
	April	8.5 (193)	2.3	13.6 (135)	1
	May	9.5 (230)	2.5	14.0 (143)	
	June	8.5 (110)	2.7	13.0 (147)	
	July	8.1 (67)	3.5	16.5 (118)	7
	August	7.8 (57)	3.5	13.8 (136)	1
	September	8.5 (126)	3.0	18.3 (116)	7
	October	10.1 (181)	2.8	14.6 (114)	14
	November	9.5 (320)	2.9	14.2 (40)	1
	December	11.5 (198)	3.2	18.1 (261)	1

(1.3-2) (to be continued)

Year	Month	Wind Speed (m/sec)		Max.Wind Gust (m/sec) (Dir.: degree)	Remarks (No. of no data)	
		Max. (Dir.)	Mean			
1997	January	13.2 (324)	3.5	15.1 (255)	23	(97)
	February	13.1 (303)	3.3	16.7 (298)	1	
	March	19.2 (291)	5.8	24.1 (311)	21	
	April	10.2 (51)	2.4	13.7 (5)	4	
	May	8.0 (-)	3.3	17.4 (313)	10	
	June	13.3 (302)	4.3	18.2 (286)	1	
	July	7.9 (114)	3.5	13.9 (129)	14	
	August	7.5 (-)	2.9	17.6 (-)	5	
	September	8.2 (-)	3.4	14.4 (-)	2	
	October	10.6 (294)	3.8	15.4 (-)	13	
	November	8.0 (314)	2.9	13.9 (314)	3	
	December	11.3 (276)	3.8	16.1 (178)		
1998	January	- (-)	-	- (-)	744	(950)
	February	12.8 (302)	3.6	18.1 (273)	4	
	March	12.2 (292)	5.1	18.8 (292)		
	April	12.1 (311)	2.4	13.6 (311)	4	
	May	8.8 (136)	3.7	13.5 (111)	2	
	June	8.1 (136)	3.5	12.1 (116)	7	
	July	9.8 (149)	4.1	15.1 (149)	8	
	August	9.2 (129)	3.7	14.1 (124)	117	
	September	9.0 (-)	3.6	13.9 (-)	62	
	October	9.7 (340)	2.9	15.6 (143)		
	November	10.2 (356)	2.6	15.4 (340)	2	
	December	11.3 (264)	3.9	16.8 (272)		
1999	January	10.4 (319)	3.9	21.5 (7)		(38)
	February	10.0 (314)	4.5	15.1 (-)		
	March	8.0 (9)	2.3	14.6 (135)	3	
	April	8.7 (330)	2.3	15.1 (91)	6	
	May	6.8 (134)	2.4	11.9 (69)	4	
	June	9.4 (181)	2.5	12.2 (127)	4	
	July	7.6 (52)	3.1	12.4 (113)	12	
	August	7.2 (113)	3.2	12.7 (125)	7	
	September	6.9 (161)	2.5	12.8 (128)	1	
	October	7.5 (47)	2.7	11.8 (47)	1	
	November	7.2 (45)	2.5	12.1 (257)		
	December	11.3 (309)	3.8	16.8 (218)		

(1.3-3) (to be continued)

Year	Month	Wind Speed (m/sec)		Max.Wind Gust (m/sec) (Dir.: degree)	Remarks (No. of no data)	
		Max. (Dir.)	Mean			
2000	January	11.2 (324)	3.8	16.5 (60)	1	(12)
	February	9.2 (311)	3.5	12.0 (49)		
	March	8.8 (53)	3.1	13.9 (282)	5	
	April	8.6 (333)	2.5	13.0 (50)	2	
	May	7.7 (43)	2.3	12.3 (60)		
	June	10.0 (57)	2.7	16.6 (356)		
	July	7.3 (156)	2.5	15.3 (112)	4	
	August	8.0 (44)	2.9	14.0 (4)		
	September	6.9 (133)	2.7	14.5 (55)		
	October	8.1 (300)	2.7	12.9 (111)		
	November	9.1 (23)	2.9	14.5 (23)		
	December	11.5 (313)	3.7	17.7 (300)		
2001	January	9.0 (60)	3.1	14.3 (70)		(9)
	February	9.6 (238)	3.5	14.6 (238)		
	March	14.6 (231)	3.1	19.7 (231)		
	April	11.6 (319)	3.0	14.6 (337)		
	May	9.4 (232)	2.1	13.6 (232)		
	June	7.5 (347)	2.7	14.1 (112)		
	July	8.0 (64)	2.7	15.2 (64)		
	August	9.0 (339)	3.1	14.7 (315)	5	
	September	7.2 (132)	2.8	13.5 (55)	1	
	October	8.8 (145)	2.9	12.6 (337)		
	November	10.1 (308)	2.7	12.8 (308)	1	
	December	16.4 (313)	5.2	20.8 (313)	2	
2002	January	12.6 (326)	2.8	16.4 (326)	2	(8)
	February	16.2 (318)	3.9	23.6 (308)		
	March	9.7 (295)	2.6	14.0 (44)	3	
	April	6.2 (136)	2.0	11.8 (65)	3	
	May	10.1 (191)	2.2	12.9 (192)		
	June	13.6 (56)	3.5	18.5 (56)		
	July	7.8 (139)	2.8	11.9 (139)		
	August	9.6 (38)	2.9	17.7 (359)		
	September	8.1 (338)	2.8	12.1 (157)		
	October	13.3 (249)	2.7	17.6 (165)		
	November	13.4 (353)	2.7	18.1 (353)		
	December	12.1 (231)	3.7	17.4 (301)		

(1.3-4) (to be continued)

Year	Month	Wind Speed (m/sec)		Max.Wind Gust (m/sec) (Dir.: degree)	Remarks (No. of no data)
		Max. (Dir.)	Mean		
2003	January	15.6 (251)	5.0	22.3 (295)	(0)
	February	12.9 (280)	3.3	19.7 (268)	
	March	14.8 (297)	2.8	20.3 (330)	
	April	14.5 (301)	2.7	17.9 (304)	
	May	8.6 (164)	2.1	12.8 (164)	
	June	9.6 (155)	2.9	13.9 (94)	
	July	8.4 (152)	2.9	15.0 (160)	
	August	7.8 (177)	2.8	10.9 (83)	
	September	8.6 (62)	3.2	14.5 (307)	
	October	8.1 (152)	2.4	13.3 (145)	
	November	10.3 (9)	2.2	19.1 (355)	
	December	12.2 (250)	2.8	17.4 (258)	
2004	January	15.7 (320)	4.3	19.4 (301)	(0)
	February	7.9 (169)	2.4	13.6 (50)	
	March	11.7 (336)	3.4	17.6 (117)	
	April	15.4 (278)	4.0	19.5 (278)	
	May	7.5 (358)	2.4	12.0 (55)	
	June	7.7 (198)	2.6	13.2 (117)	
	July	9.7 (262)	2.6	15.7 (103)	
	August	7.8 (249)	2.4	10.3 (98)	
	September	7.0 (278)	2.7	12.9 (61)	
	October	9.0 (203)	2.5	13.8 (259)	
	November	11.5 (319)	2.0	16.5 (320)	
	December	13.5 (328)	3.3	18.2 (289)	
2005	January	11.3 (328)	3.3	20.1 (305)	4 (31)
	February	14.8 (321)	6.5	19.4 (243)	1
	March	18.4 (280)	3.6	24.5 (280)	3
	April	11.0 (323)	3.2	17.5 (276)	
	May	12.0 (198)	2.7	16.3 (198)	5
	June	7.4 (157)	2.8	17.6 (33)	
	July	9.8 (140)	3.5	15.6 (76)	6
	August	7.2 (18)	2.7	12.0 (122)	9
	September	8.5 (152)	2.7	11.4 (152)	1
	October	9.3 (333)	2.8	14.7 (126)	2
	November	12.6 (331)	2.2	13.9 (331)	
	December	7.8 (345)	2.4	12.7 (323)	

(1.3-5) (to be continued)

Year	Month	Wind Speed (m/sec)		Max.Wind Gust (m/sec) (Dir.: degree)	Remarks (No. of no data)
		Max. (Dir.)	Mean		
2006	January	13.2 (320)	4.1	21.7 (231)	(7)
	February	14.2 (283)	4.1	20.4 (323)	
	March	9.4 (197)	2.4	18.5 (58)	
	April	7.3 (49)	1.9	14.6 (36)	
	May	11.8 (316)	2.5	14.0 (316)	
	June	8.1 (173)	2.7	13.6 (198)	1
	July	9.1 (168)	2.8	13.5 (80)	
	August	11.3 (181)	3.1	15.7 (181)	3
	September	8.3 (66)	2.6	15.2 (64)	2
	October	9.9 (169)	2.3	13.1 (146)	1
	November	10.3 (268)	2.7	13.5 (67)	
	December	8.1 (329)	2.4	13.1 (359)	
2007	January	16.5 (303)	4.0	22.0 (303)	(23)
	February	12.2 (330)	3.2	17.6 (26)	2
	March	8.9 (332)	2.3	12.2 (346)	4
	April	6.8 (182)	2.3	14.7 (159)	5
	May	8.1 (264)	2.0	10.8 (164)	
	June	9.3 (135)	3.3	16.0 (142)	1
	July	7.7 (222)	2.9	13.0 (134)	
	August	8.4 (146)	3.3	14.7 (141)	
	September	9.4 (73)	2.7	14.0 (71)	
	October	10.4 (306)	2.4	13.3 (307)	
	November	13.8 (272)	4.1	17.2 (259)	
	December	9.5 (319)	3.0	13.7 (334)	11
2008	January	12.8 (318)	4.5	19.1 (318)	(101)
	February	6.1 (38)	2.6	11.5 (70)	
	March	7.6 (13)	2.4	14.5 (74)	
	April	7.0 (62)	2.2	15.4 (67)	4
	May	9.3 (340)	2.5	12.2 (122)	
	June	8.5 (156)	2.8	13.3 (159)	1
	July	7.7 (138)	2.9	12.7 (126)	
	August	7.7 (131)	3.4	14.1 (130)	
	September	6.3 (133)	2.6	11.9 (44)	88
	October	9.1 (32)	3.1	17.6 (44)	8
	November	8.7 (351)	2.5	13.6 (88)	
	December	8.7 (48)	2.6	14.7 (54)	

(1.3-6) (to be continued)

Year	Month	Wind Speed (m/sec)		Max.Wind Gust (m/sec) (Dir.: degree)	Remarks (No. of no data)
		Max. (Dir.)	Mean		
2009	January	8.8 (324)	3.7	14.5 (358)	(15)
	February	7.9 (73)	3.2	14.7 (136)	
	March	12.1 (326)	2.3	14.3 (327)	1
	April	16.2 (292)	3.8	19.7 (315)	1
	May	10.2 (303)	2.6	15.3 (278)	1
	June	8.5 (112)	3.2	16.1 (113)	
	July	10.9 (113)	4.1	15.8 (116)	10
	August	10.2 (117)	3.3	15.4 (137)	
	September	8.9 (116)	3.6	14.9 (126)	2
	October	12.0 (344)	3.1	14.6 (322)	
	November	9.8 (76)	3.4	15.4 (109)	
	December	13.6 (303)	3.5	18.2 (289)	
Max./Min./Mean (Date)		19.7 m/sec (Dec.14, 1994)	3.05 m/sec	24.6 m/sec (Dec.14, 1994)	Total : 2418

2. Air Temperature, Water Temperature and Atmospheric Pressure Data

(Monthly Air Temperature, Water Temperature and Atmospheric Pressure at Funafuti (1994 - 2009))

Monthly Water Temperature, Air Temperature and Atmospheric Pressure (1994 - 2009)

(2-1)

Year	Month	Air Temp. (˚C)		Water Temp.(˚C)		Atmospheric Pressure (hPa)	
		Max.	Min.	Max.	Min.	Max.	Min.
1994	January	30.4	23.4	29.5	29.2	1010.6	1004.1
	February	30.4	25.3	30.8	29.2	1013.1	1003.6
	March	31.1	24.4	31.6	29.4	1013.9	1000.1
	April	31.6	25.1	31.4	28.9	1012.7	1003.5
	May	30.4	24.9	30.9	29.2	1013.4	1005.2
	June	30.3	24.8	29.9	28.4	1012.8	1005.7
	July	29.9	24.1	30.5	28.6	1012.4	1005.5
	August	30.2	24.0	29.1	28.4	1011.6	1005.7
	September	30.2	24.1	30.3	28.6	1014.3	1006.4
	October	30.9	23.8	31.8	29.1	1012.9	1006.5
	November	30.6	23.9	30.9	29.0	1012.1	1003.6
	December	30.9	24.0	31.0	28.7	1012.3	1000.1
1995	January	30.7	24.4	31.5	28.0	1012.6	1001.7
	February	30.8	24.8	30.2	28.7	1012.6	1003.6
	March	31.2	25.2	31.0	28.8	1013.0	1002.5
	April	30.6	24.8	31.3	29.4	1011.3	1004.4
	May	31.5	25.3	31.0	29.4	1012.6	1004.9
	June	30.6	25.1	30.7	29.0	1013.7	1006.3
	July	31.6	24.2	30.1	29.0	1013.2	1005.6
	August	30.7	25.0	29.5	28.8	1014.1	1005.0
	September	30.0	24.3	30.1	28.8	1013.9	1006.9
	October	30.1	24.1	31.4	28.8	1014.0	1005.2
	November	31.0	24.4	32.0	29.1	1012.1	1004.1
	December	30.7	24.5	31.2	28.8	1011.9	1003.6
1996	January	30.4	23.8	30.8	29.3	1011.7	1003.2
	February	30.1	24.8	30.8	29.1	1011.1	1002.1
	March	30.4	24.3	30.1	28.5	1014.8	1002.6
	April	30.3	24.3	30.5	28.6	1011.7	1003.7
	May	30.4	23.4	30.2	28.9	1013.2	1004.7
	June	30.4	24.9	30.7	29.0	1015.7	1005.6
	July	-	-	29.3	28.2	1013.5	1005.7
	August	31.3	25.2	29.6	28.4	1014.7	1006.4
	September	30.0	24.5	29.9	28.5	1014.0	1004.6
	October	30.0	25.0	30.0	28.7	1013.3	1004.4
	November	30.6	24.9	30.8	29.2	1013.0	1002.9
	December	30.6	24.8	31.7	28.9	1010.7	1001.4

(2-2)

Year	Month	Air Temp. (˚)		Water Temp. (˚)		Atmospheric Pressure (hPa)	
		Max.	Min.	Max.	Min.	Max.	Min.
1997	January	30.8	24.5	31.1	28.9	1011.0	1004.2
	February	30.3	24.4	31.0	28.5	1010.7	1002.3
	March	29.6	24.4	30.4	27.7	1013.8	995.4
	April	30.1	24.4	30.3	28.9	1014.1	1004.9
	May	30.1	23.2	30.3	28.8	1013.2	1003.1
	June	29.3	23.8	29.7	27.9	1014.2	1002.9
	July	29.7	24.8	29.0	28.3	1011.7	1005.1
	August	29.8	24.4	30.2	28.6	1013.7	1005.9
	September	30.1	24.2	30.0	28.6	1014.7	1004.0
	October	30.1	24.8	31.0	28.5	1013.5	1003.8
	November	30.6	24.4	31.5	29.2	1015.7	1006.5
	December	30.4	24.2	31.2	29.3	1011.9	1000.7
1998	January	30.0	24.9	30.5	27.6	1011.5	1002.3
	February	30.1	25.0	30.3	28.0	1013.9	1005.1
	March	31.6	23.9	31.5	28.2	1013.2	1004.0
	April	31.0	24.9	31.3	28.9	1013.9	1006.3
	May	30.1	25.4	29.7	28.8	1015.1	1005.8
	June	29.9	24.7	29.4	28.6	1013.4	1005.9
	July	29.3	24.4	29.3	27.7	1016.4	1007.3
	August	29.4	24.7	28.6	27.7	1013.8	1007.2
	September	30.2	24.7	28.8	28.0	1015.0	1007.1
	October	30.7	24.2	29.9	28.3	1014.9	1005.8
	November	30.1	23.7	30.6	28.5	1011.8	1003.9
	December	30.4	23.3	31.2	28.6	1011.3	1003.9
1999	January	29.6	22.8	29.4	27.9	1011.2	1003.8
	February	29.6	24.0	29.6	28.2	1012.9	1004.0
	March	30.3	24.0	29.7	28.3	1011.5	1004.8
	April	30.4	24.5	30.2	28.6	1012.5	1005.3
	May	30.1	24.3	30.0	28.8	1012.7	1005.6
	June	29.7	24.4	29.7	28.7	1013.2	1006.7
	July	29.7	24.6	29.2	28.5	1013.8	1005.8
	August	29.3	24.2	28.9	28.2	1014.9	1007.2
	September	29.9	23.4	30.6	28.1	1014.7	1007.4
	October	29.8	24.5	29.7	28.9	1014.0	1005.9
	November	30.1	23.9	30.8	29.1	1012.2	1004.4
	December	29.8	23.4	30.2	28.6	1010.9	1004.8

(2-3)

Year	Month	Air Temp. (˚)		Water Temp. (˚)		Atmospheric Pressure (hPa)	
		Max.	Min.	Max.	Min.	Max.	Min.
2000	January	29.8	24.2	30.1	28.7	1011.6	1002.7
	February	30.1	23.8	30.0	28.5	1012.9	1005.9
	March	29.6	23.4	29.9	28.2	1012.6	1005.9
	April	30.0	23.1	29.8	28.8	1012.1	1004.8
	May	30.1	24.5	29.9	29.2	1012.8	1005.5
	June	29.8	24.5	29.5	28.7	1013.7	1005.2
	July	29.7	24.9	29.7	28.7	1013.5	1005.3
	August	29.4	23.3	29.0	28.3	1012.8	1004.8
	September	29.7	25.5	29.3	28.7	1014.9	1006.5
	October	30.0	23.7	29.9	28.9	1012.0	1004.5
	November	30.2	24.4	30.0	29.3	1012.2	1003.3
	December	30.1	24.8	31.3	28.9	1010.3	1003.3
2001	January	30.5	24.3	30.5	29.0	1011.5	1004.6
	February	30.3	24.2	30.3	28.4	1011.6	1000.3
	March	30.4	24.4	29.9	28.8	1011.9	1004.8
	April	30.5	24.3	31.0	29.4	1012.1	1005.1
	May	31.0	25.7	31.2	29.6	1012.8	1004.3
	June	30.2	25.1	31.0	28.8	1011.3	1005.2
	July	30.1	23.7	30.3	28.7	1012.8	1005.3
	August	29.8	24.6	30.2	28.4	1013.1	1002.5
	September	30.1	23.8	30.9	28.9	1013.2	1005.4
	October	31.1	24.5	31.0	29.2	1014.1	1005.0
	November	31.0	24.0	32.7	29.3	1011.6	1003.4
	December	31.0	24.6	31.1	28.5	1009.7	1001.0
2002	January	30.9	25.3	31.3	29.4	1012.6	1003.0
	February	30.8	24.4	31.1	28.6	1011.5	1000.2
	March	31.0	24.7	32.0	29.2	1012.0	1003.5
	April	31.0	23.6	31.6	29.8	1012.1	1004.1
	May	30.7	24.5	31.0	29.3	1013.5	1002.2
	June	30.5	25.1	30.4	29.0	1012.9	1003.9
	July	30.3	24.3	30.3	28.8	1013.0	1006.5
	August	31.3	24.6	30.1	28.6	1013.1	1004.4
	September	30.3	24.3	31.1	29.0	1013.9	1005.8
	October	31.1	24.2	30.4	28.4	1012.2	1003.0
	November	31.3	25.3	31.8	29.3	1012.4	999.8
	December	32.6	25.0	32.1	29.0	1010.9	1002.5

(2-4)

Year	Month	Air Temp. (˚)		Water Temp. (˚)		Atmospheric Pressure (hPa)	
		Max.	Min.	Max.	Min.	Max.	Min.
2003	January	31.2	24.7	31.4	28.5	1011.7	1000.3
	February	31.7	24.9	32.1	28.5	1010.4	1002.4
	March	32.4	24.6	31.9	29.1	1014.3	1001.2
	April	30.7	24.1	30.8	28.9	1012.0	1003.5
	May	30.6	25.8	31.4	29.6	1011.8	1003.2
	June	30.3	24.6	30.6	28.6	1012.8	1006.2
	July	29.9	23.7	29.7	28.3	1012.2	1005.4
	August	30.1	23.8	30.0	28.5	1013.2	1005.8
	September	30.4	24.0	29.8	28.7	1013.5	1005.9
	October	31.8	24.9	31.1	28.8	1012.3	1005.3
	November	31.1	24.8	32.5	29.2	1012.5	1004.2
	December	31.7	23.3	31.6	29.5	1010.4	999.6
2004	January	31.0	24.7	30.8	28.6	1010.7	998.3
	February	31.4	24.6	30.7	29.7	1011.3	1002.7
	March	31.9	24.3	30.9	28.6	1011.3	1002.7
	April	30.7	24.8	30.4	28.9	1012.4	1003.7
	May	30.5	25.5	30.2	29.1	1013.5	1003.9
	June	30.7	24.3	30.6	29.1	1012.4	1005.3
	July	33.5	24.5	29.6	28.7	1012.9	1005.8
	August	-	-	29.7	28.8	1014.0	1004.9
	September	-	-	29.6	28.8	1013.9	1006.0
	October	-	-	31.2	29.1	1013.9	1004.2
	November	-	-	31.1	29.7	1011.6	1004.5
	December	-	-	31.1	29.1	1010.8	1002.7
2005	January	-	-	31.2	29.4	1011.8	1001.3
	February	-	-	31.4	27.9	1008.6	999.2
	March	-	-	31.0	28.5	1012.1	1003.3
	April	-	-	30.7	29.5	1012.3	1003.7
	May	-	-	30.0	28.7	1012.2	1004.5
	June	-	-	30.5	28.8	1012.3	1005.5
	July	30.4	24.3	29.5	28.6	1013.2	1004.7
	August	30.4	24.2	29.2	28.4	1014.4	1005.9
	September	31.8	25.4	30.7	28.7	1014.9	1005.6
	October	31.2	25.1	30.7	29.3	1013.0	1005.0
	November	33.7	23.5	32.4	29.0	1011.4	1002.7
	December	32.1	24.8	31.7	29.4	1011.5	1002.1

(2-5)

Year	Month	Air Temp. (˚)		Water Temp. (˚)		Atmospheric Pressure (hPa)	
		Max.	Min.	Max.	Min.	Max.	Min.
2006	January	31.9	24.2	30.5	28.6	1010.7	1001.9
	February	30.7	23.9	30.6	27.9	1011.4	1002.7
	March	30.6	24.1	30.1	28.6	1011.9	1003.4
	April	31.0	25.1	31.0	29.3	1012.0	1004.2
	May	32.3	24.8	30.9	29.2	1012.2	1005.2
	June	30.1	23.9	29.5	28.3	1013.5	1004.0
	July	30.4	24.0	29.5	28.7	1012.9	1006.2
	August	31.2	23.6	29.9	28.1	1012.4	1004.0
	September	30.8	24.5	30.3	28.9	1012.7	1004.8
	October	32.4	24.3	31.6	29.3	1013.4	1003.7
	November	32.7	23.6	30.4	29.3	1012.5	1003.3
	December	32.6	25.5	31.3	29.5	1011.1	1003.4
2007	January	32.8	24.5	32.1	28.6	1009.3	1000.4
	February	32.7	25.4	31.8	29.4	1012.8	1002.8
	March	32.4	23.8	30.8	29.4	1011.6	1003.8
	April	31.7	24.4	30.9	29.5	1014.2	1004.7
	May	31.8	24.3	31.2	29.2	1015.5	1004.5
	June	31.4	24.2	30.0	29.0	1012.1	1003.0
	July	30.3	24.0	30.4	29.0	1014.3	1004.6
	August	31.1	23.7	30.3	28.2	1013.2	1006.0
	September	30.7	23.7	29.6	28.6	1013.2	1005.9
	October	30.3	23.8	30.2	28.5	1013.3	1005.6
	November	31.4	24.1	30.1	28.5	1010.9	1002.1
	December	32.7	23.4	30.6	29.0	1012.5	1003.4
2008	January	31.5	23.6	29.6	27.3	1010.8	1002.1
	February	-	-	29.3	28.0	1013.0	1004.7
	March	-	-	30.1	28.7	1012.5	1005.6
	April	-	-	29.8	29.2	1011.8	1004.1
	May	-	-	30.8	29.0	1013.2	1005.5
	June	-	-	29.5	28.6	1014.0	1006.0
	July	-	-	29.0	28.4	1013.6	1006.7
	August	-	-	28.8	28.1	1014.7	1006.5
	September	-	-	30.8	28.2	1013.8	1005.8
	October	-	-	29.8	28.7	1014.3	1005.7
	November	31.2	23.4	30.3	28.8	1013.9	1004.4
	December	30.6	24.4	30.6	29.1	1010.9	1004.6

(2-6)

Year	Month	Air Temp. (˚C)		Water Temp.(˚C)		Atmospheric Pressure (hPa)	
		Max.	Min.	Max.	Min.	Max.	Min.
2009	January	30.2	24.3	29.8	28.8	1013.6	1003.2
	February	30.2	24.4	29.4	28.7	1012.1	1004.1
	March	30.4	24.8	30.5	29.0	1013.3	1004.4
	April	32.2	23.6	29.8	28.3	1012.6	1004.5
	May	30.4	26.1	−	−	1013.2	1004.6
	June	30.3	24.3	−	−	1012.2	1004.7
	July	30.1	25.5	29.1	28.6	1012.0	1005.0
	August	30.7	24.7	29.9	28.6	1012.4	1006.2
	September	30.4	24.6	29.5	28.9	1012.8	1003.4
	October	30.3	24.2	31.4	29.0	1012.2	1004.7
	November	30.4	24.7	30.4	29.2	1012.2	1003.0
	December	30.6	24.8	30.9	28.9	1011.6	1001.6
Max. & Min. (Date & Time)		33.7˚C Nov.19, 2005	22.8˚C Jan.14, 1999	32.7˚C Nov.26, 2001	27.3˚C Jan.30, 2008	1016.4hPa July 2, 1998	995.4hPa March 5, 1997

(Note) Total Mean of Air Temperature : 28.46 ˚C
Total Mean of Water Temperature : 29.46 ˚C
Total Mean of Atmospheric Pressure : 1008.52 hPa

3. Sea Level Data

(Monthly Sea Level at Funafuti (1994 - 2009))

(3-1)

Year	Month	Highest Level (m)	Lowest Level (m)	Mean (m)	Remarks (No. of No Data)
1994	January	3.091	1.080	2.055	
	February	3.241	1.101	2.107	
	March	3.159	0.959	2.098	
	April	3.150	0.898	2.038	
	May	3.131	0.971	2.017	
	June	3.016	0.986	1.991	12 (9th -10th)
	July	3.036	1.074	1.947	144 (26th -31st)
	August	2.885	1.008	1.935	409 (1st -18th)
	September	2.966	0.941	1.939	
	October	3.041	0.882	1.934	
	November	3.124	0.902	1.991	
	December	3.172	0.934	2.007	
1995	January	3.145	0.847	1.961	
	February	2.987	0.933	1.972	
	March	3.101	1.064	2.095	97 (10th -14th)
	April	3.198	1.078	2.139	49 (1st -3rd)
	May	3.188	1.042	2.083	
	June	3.159	0.973	2.040	
	July	3.107	0.945	2.005	
	August	3.017	0.895	1.955	
	September	3.043	1.045	2.021	
	October	3.027	0.996	1.992	
	November	3.133	1.009	2.033	
	December	3.119	0.875	1.957	25 (21st -22nd)
1996	January	3.255	0.984	2.052	
	February	3.312	1.087	2.149	
	March	3.200	1.061	2.143	
	April	3.065	1.154	2.083	
	May	3.063	1.151	2.025	
	June	3.086	0.940	1.988	
	July	3.097	0.865	1.962	
	August	3.117	0.855	1.987	
	September	3.008	0.885	1.962	
	October	2.983	0.998	1.940	
	November	2.896	1.054	1.973	
	December	2.987	0.978	1.954	

(3-2) (to be continued)

Year	Month	Highest Level (m)	Lowest Level (m)	Mean (m)	Remarks (No. of no data)
1997	January	3.058	0.846	1.962	
	February	3.255	0.867	2.062	
	March	3.304	1.028	2.123	
	April	3.148	1.065	2.057	
	May	3.014	1.053	2.022	
	June	2.855	0.958	1.921	
	July	2.950	0.932	1.898	
	August	3.094	0.851	1.917	
	September	3.121	0.806	1.947	
	October	3.067	0.878	1.953	
	November	2.972	0.915	1.888	
	December	2.829	0.832	1.841	
1998	January	2.896	0.684	1.807	
	February	2.817	0.531	1.684	
	March	2.833	0.549	1.691	
	April	2.790	0.633	1.673	
	May	2.756	0.747	1.714	
	June	2.792	0.849	1.774	
	July	2.686	0.851	1.752	
	August	2.794	0.863	1.779	115 (18th -23rd)
	September	2.839	0.700	1.720	27(11th ,29-30th)
	October	2.958	0.695	1.832	
	November	3.064	0.883	1.957	
	December	3.080	0.899	1.986	
1999	January	3.171	1.016	2.067	
	February	3.207	1.065	2.098	
	March	3.184	1.047	2.083	
	April	3.036	0.944	1.991	
	May	3.069	0.955	1.976	
	June	2.939	0.873	1.896	
	July	3.036	1.009	1.959	
	August	2.972	1.050	1.988	
	September	2.990	0.981	1.966	
	October	3.102	0.995	1.994	
	November	3.112	0.949	2.034	
	December	3.155	1.014	2.058	

(3-3) (to be continued)

Year	Month	Highest Level (m)	Lowest Level (m)	Mean (m)	Remarks (No. of no data)
2000	January	3.236	1.064	2.082	
	February	3.175	1.074	2.095	
	March	3.193	1.221	2.149	
	April	3.072	1.174	2.091	
	May	3.039	1.100	1.974	
	June	3.047	0.995	1.948	
	July	3.015	0.844	1.921	
	August	3.094	0.849	1.984	
	September	3.028	1.011	1.976	
	October	2.978	1.125	2.043	
	November	3.051	1.137	2.046	
	December	3.122	1.075	2.073	
2001	January	3.177	1.030	2.073	
	February	3.322	1.095	2.147	
	March	3.347	1.127	2.157	
	April	3.137	1.118	2.075	
	May	2.966	1.072	1.974	
	June	2.942	1.012	1.936	
	July	2.959	0.880	1.902	
	August	3.090	0.862	1.979	
	September	3.080	0.900	1.975	
	October	3.038	0.912	1.968	
	November	3.017	1.097	2.017	
	December	2.974	1.016	1.988	
2002	January	3.226	1.032	2.039	
	February	3.309	1.057	2.144	
	March	3.303	1.089	2.163	
	April	3.196	1.096	2.131	
	May	2.954	1.005	2.047	
	June	2.915	1.175	2.027	
	July	2.951	1.112	1.996	
	August	3.043	1.045	2.007	
	September	3.085	0.917	1.988	
	October	3.179	0.973	1.993	
	November	3.177	0.952	2.050	
	December	3.135	1.053	2.023	

(3-4) (to be continued)

Year	Month	Highest Level (m)	Lowest Level (m)	Mean (m)	Remarks (No. of no data)
2003	January	3.044	1.043	2.000	
	February	3.070	0.939	1.994	
	March	3.149	1.012	2.073	
	April	3.253	1.067	2.125	
	May	3.246	1.086	2.119	
	June	3.056	1.070	2.022	
	July	2.952	1.060	1.991	
	August	2.983	0.981	2.005	
	September	3.049	1.039	2.017	
	October	3.111	0.883	1.946	
	November	3.151	1.025	2.001	
	December	3.087	0.997	2.022	
2004	January	3.050	0.980	2.006	
	February	3.085	1.045	2.049	
	March	3.125	1.174	2.132	
	April	3.145	1.161	2.102	
	May	3.123	1.068	2.061	
	June	3.055	1.062	2.011	
	July	3.077	1.006	1.996	
	August	3.096	0.969	1.981	
	September	2.989	1.062	2.001	
	October	2.986	1.098	2.015	
	November	3.069	1.113	2.036	
	December	3.059	1.008	2.012	
2005	January	3.122	0.984	2.033	
	February	3.198	0.910	1.975	
	March	2.998	0.724	1.884	
	April	3.098	1.064	2.077	
	May	2.993	1.100	2.035	
	June	3.022	1.041	2.016	
	July	3.115	1.004	1.996	
	August	3.154	0.962	2.029	
	September	3.163	0.925	2.032	
	October	3.066	1.042	2.042	
	November	3.001	1.198	2.068	
	December	3.122	1.112	2.097	

(3-5) (to be continued)

Year	Month	Highest Level (m)	Lowest Level (m)	Mean (m)	Remarks (No. of no data)
2006	January	3.358	1.109	2.158	
	February	3.415	1.131	2.215	
	March	3.370	1.075	2.147	
	April	3.106	1.097	2.067	
	May	2.989	1.158	2.025	
	June	2.815	1.082	1.939	
	July	2.902	0.927	1.897	
	August	3.085	0.900	1.929	
	September	3.089	0.805	1.953	
	October	3.149	0.923	2.001	
	November	3.099	1.030	1.997	
	December	2.962	1.070	2.020	
2007	January	3.029	1.012	2.015	
	February	3.190	0.974	2.047	
	March	3.241	1.027	2.113	
	April	3.262	1.133	2.142	
	May	3.105	1.129	2.079	
	June	2.981	1.124	2.049	
	July	3.007	1.087	2.027	
	August	3.014	0.978	1.987	
	September	3.109	0.934	1.980	
	October	3.193	1.068	2.054	
	November	3.131	1.048	2.080	
	December	3.139	1.134	2.056	
2008	January	3.218	1.193	2.149	
	February	3.167	1.231	2.169	
	March	3.176	1.162	2.106	
	April	3.121	1.073	2.078	
	May	3.131	1.062	2.026	
	June	3.046	1.049	1.999	
	July	3.008	0.992	1.985	
	August	3.013	1.014	1.953	
	September	2.917	1.034	1.966	
	October	3.015	1.058	1.980	
	November	3.065	1.021	1.995	
	December	3.072	0.991	2.039	

(3-6) (to be continued)

Year	Month	Highest Level (m)	Lowest Level (m)	Mean (m)	Remarks (No. of no data)
2009	January	3.234	1.057	2.108	
	February	3.271	1.061	2.131	
	March	3.128	1.032	2.104	
	April	3.033	1.161	2.090	
	May	2.973	1.088	2.035	
	June	3.031	1.004	1.970	
	July	3.001	0.867	1.899	
	August	3.102	0.889	1.954	
	September	3.049	0.994	2.000	
	October	2.949	1.065	1.979	
	November	2.932	1.048	2.011	
	December	3.090	1.013	2.014	
Max./Min./Mean (Date)		3.415 m (Feb.28, 2006)	0.531 m (Feb.27, 1998)	2.007 m	Total : 878

4. Borrow Pit Data

(Site Photos of Borrow Pits (No.1 to No.10))

Borrow Pit No. 1

Northern End of Borrow Pit No.1

North End to South Direction

North Direction

South Direction

View from Breaching Point

South Part to North Direction

South Part to South Direction

South End

South End to North Direction

Disposal Site at Southern End

Borrow Pit No. 2

Area covered with Jungle

Small Pond with Water

Borrow Pit No. 3

Northern End

North End to South Direction

Central Part to North Direction

Central Part to South Direction

South Part to North Direction

Southern End

Borrow Pit No. 4

North End

Central Part to South Direction

Central Part to North Direction

South Part to South Direction

South End to North Direction

Borrow Pit No. 5

North End to South Direction

North Part to North End

North Part to South Direction

South Part to North Direction

South Part to South End

Southern End to North Direction

Borrow Pit No. 6

Borrow Pit with Waste Disposal

Small Pond with Water

Borrow Pit No. 7

North Part of Borrow Pit separated by a House

South Part of Borrow Pit separated by a House

Borrow Pit No. 8

North End to South Direction

Northern Part

Southern Part

South End to North Direction

Borrow Pit No. 9

North End to South Direction

North to South Direction

South to North Direction

Bridge near Timber Factory

South End to North Direction

Southern End with Plastics

Borrow Pit No. 10

Exact position/area could not find (covered with Jungle)