
**WATER QUALITY DATA REPORT
AITUTAKI**

January – December 2008



May 2009

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Annual Report 2008

INSHORE AND AQUACULTURE DIVISION



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1. Introduction

Aitutaki is one of the islands in the Cook Islands that is developing rapidly and because of its pristine lagoon, it attracts a considerable number of tourists and tourism is one of the main sources of income for the people on the island. Therefore, it is vital that the health of the lagoon is monitored and action is taken to protect the health of the lagoon, coral reef and the people that use it.

In 2004, the Ministry of Marine Resources started to monitor Aitutaki lagoon with 11 lagoon sampling sites. In 2005 Paradise Cove and Waste Management were added and in 2006 4 stream sites and 4 lagoon sites were introduced to the programme with 2 old marine sites (Maina Ra'ui and Atuatane) eliminated from the program. Measurements made include temperature, dissolved oxygen, pH, salinity, nutrients, chlorophyll *a*, suspended solids and bacterial contamination to measure long term changes in water quality of the lagoons and streams.

Temperature varies seasonally and influences the occurrence and growth of aquatic plants and animals. The solubility of dissolved oxygen (DO) is regulated by temperature however other factors also affect DO including water flow. In the water, DO is either absorbed directly from the atmosphere or is produced by algae via photosynthesis and is removed by respiration and decomposition of organic matter. The recommended minimum for DO saturation is not less than 75% saturation for oceanic waters, embayments, open coastal waters and estuaries and not less than 80% for streams (Department of Health, Clean Water Branch Hawaii 1994). Salinity varies little in most marine environments and saltwater is normally between 34ppt and 36ppt in areas away from freshwater influences (Smith 2004). Mosely et al. (2004) in water quality guidelines developed for Pacific Countries suggest that pH should be between 8.0 and 8.4 in lagoon type environments. The Department of Health, Clean Water Branch Hawaii (1994) pH standard for open coastal waters is between 7.6 and 8.6 and can be as low as 7.0 in areas influenced by freshwater input.

Nutrients such as nitrate and phosphate which are naturally present in seawater are essential for the growth of phytoplankton and other algae which form the base of the food web. Elevated nutrients concentration can lead to an increase in algae and aquatic plants biomass which can have detrimental impacts on the coral reef health.

The guidelines for nutrient concentrations for the protection of coral reef health are 14µg/L for dissolved inorganic nitrogen (DIN), which is made up of nitrate and ammonia (NO₃-N + NH₄-N), and 2.6µg/L for dissolved reactive phosphorus (DRP) (Bell 1992). The ANZECC guideline values for streams or lowland rivers that are a cause for concern in Australia tropical areas based on measured values are 10µg/L for nitrate (NO₃-N) and ammonia (NH₄-N), and 4µg/L for DRP (ANZECC 2000).

Chlorophyll *a* and total suspended solids measure phytoplankton biomass, inorganic and organic particulate material in the water respectively. Elevated concentrations of both have been shown to impact negatively on coral reef health above concentration of 0.5mg/L and 4-5mg/L Bell (1992) respectively.

Increased inorganic and organic materials entering lagoons are often associated with increases in bacteria numbers and are disease causing organisms. Enterococci bacteria are used to indicate the potential presence of human pathogens in marine and freshwater environment. Guidelines have been developed by the World Health Organisation (WHO) for contact recreation using Enterococci numbers (Table 1). This guideline is also used for freshwater samples to evaluate the bacterial water quality of the streams as they flow directly into the lagoon and are likely to impact the bacterial water quality of the lagoon.

Table 1. WHO Standards for Bathing Water Quality.

Category	Indicator Counts	Microbiological Assessment
A.	≤ 40 Enterococci /100ml	Suitable for swimming
B.	≥ 41 to ≤ 200 Enterococci /100ml	Suitable for swimming but requires surveillance
C.	≥ 201 to ≤ 500 Enterococci /100ml	Not suitable for swimming, requires assessment
D.	≥ 501 Enterococci /100ml	Not suitable for swimming, public warnings

This report is a Data Report summary of the findings of the water quality sampling program in 2008 in support of the Water Quality Report Card. The Water Quality Report Card Aitutaki 2009 is attached to this report.

2. Methods

2.1 Sampling

All the water quality parameters were measured monthly for both lagoon and streams. In total, there are 15 marine sites and 4 stream sites for Aitutaki (Figure 1 and Table 2 & 3). Water samples from Aitutaki were stored in the dark on ice and the samples were air freighted to Rarotonga and processed within 9 hours of sample collection.

2.2 Aitutaki Marine and Stream Sampling Site Map

- Marine Sites
- Stream Sites



Figure 1. Aitutaki Water Quality Sampling Sites – Marine & Streams.

Table 2. Aitutaki Lagoon sampling site locations.

Site Numbers	Location	Latitude	Longitude
1	Akitua	S18 51.058	W159 45.494
2	Samade	S18 50.816	W159 45.671
3	Tepaki Site	S18 50.381	W159 45.659
4	Vaipeka	S18 50.866	W159 46.431
5	Vaipae Wharf	S18 52.287	W159 46.441
6	Tautu Wharf	S18 52.925	W159 46.352
7	New Jerusalem	S18 58.607	W159 47.282
8	Waste Management	S18 53.002	W159 47.647
9	Maina Sunset	S18 52.599	W159 47.919
10	Arutanga Wharf	S18 51.825	W159 48.061
11	Pacific Resort	S18 50.806	W159 47.704
12	Paradise Cove	S18 50.174	W159 46.983
13	TCI Mast Airport	S18 49.509	W159 46.525
14	Maina Nursery	S18 54.393	W159 49.140
15	One Foot Island	S18 56.180	W159 44.178

Table 3. Aitutaki Stream sampling site locations.

Stream site	Location	Latitude	Longitude
1	Vaitiare	S18 50.866	W159 46.431
2	Vaipae	S18 52.268	W159 46.511
3	Pata	S18 52.908	W159 47.699
4	Arutanga	S18 51.871	W159 47.942

2.3 Physical Parameters

At each site temperature (°C), dissolved oxygen (DO), % saturation and concentration, pH, and salinity (‰) were measured using a YSI 556 Probe. The individual probes were calibrated before use in the field and measurements were made at each site at the time of sampling (Hall et al., 2007). Temperature was measured using a Eutech digital thermometer at Maina Nursery and One Foot Island.

2.4 Nutrients

All water samples for nutrient analysis were filtered through a Whatman GF/F glass fibre filter into a 250ml acid washed plastic bottle. These samples were stored frozen until they were shipped on ice in chilly bins to National Institute of Water and

Atmospheric Research Limited (NIWA) for analysis. All nutrient analysis was conducted using an Astoria Pacific autoanalyser 300 series with methods from the Astoria Pacific International Methods Manual (A 6/00). Nitrate was analysed by the cadmium column reduction method (Astoria 305-A177), DRP by the molybdenum blue method (Astoria 305-A204) and NH₄-N by the indophenol blue method (Astoria 305-A026).

2.5 Chlorophyll *a* and Suspended Solids

Samples for chlorophyll *a* and total suspended solids analysis of known volumes were filtered on to GF/F filters and the chlorophyll *a* filter was frozen immediately. The frozen filters for chlorophyll *a* were then analyzed later by acetone extraction and fluorometry (APHA 1998) in the MMR laboratory (Hall et al., 2007). Total suspended solids analysis followed Hall et al., (2007).

2.6 Bacteria

Water samples collected for Enterococci were analyzed in duplicate using Membrane Filtration method and placed on Enterococci agar. The volumes filtered differed depending on how clean the water was and on previous results. Enterococci plates were incubated at 37⁰C for 24 hours (Hall et al., 2007).

2.7 Missing Data

Lagoon:

All temperature and dissolved oxygen data in February were deleted due to problems with the probe, all salinity data for November were deleted because the readings were too high although the instrument calibration were within specification. All pH data were deleted in June and August to December because of instrument error. Nutrient water sample for Tepaki site in March was not received by NIWA. Arutanga Wharf suspended solid data for July is missing and Pacific Resort in November had no bacteria data.

Stream:

All temperature and dissolved oxygen data in February deleted due to problems with the probe. The following streams were dry at Vaitiare (March, August-December), Pata (February, March, August-December) and for all streams in November.

3. Acknowledgments

We thank Drs Julie Hall and Els Maas for both technical advice and editorial comments, Mike Crump and his team at NIWA for their technical support, and the staffs of the Ministry of Marine Resources for editorial and Aitutaki Marine Research Station staff for sample collecting. We also thank the Cook Islands Meteorological Services for providing the rain gauge. The Ministry of Marine Resources would also like to thank NZAid for all the funding support.

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5. Appendix

5.1 Appendix 1. Water Quality data lagoon sites.

Location	Site Number	Date	Temperature (°C)	Salinity (ppt)	DOSat (%)	DO (mg/L)	pH	DRP (µg/L)	NH4-N (µg/L)	NO3-N (µg/L)	DIN (µg/L)	Extraction (Chl a µg/L)	Invivo (Chl a µg/L)	TSS (mg/L)	VSS (mg/L)	Enterococci (Count/100ml)
Akitua	1	29-Jan-08	25.4	35.7	76.3	5.1	7.4	4	5	5	10		0.3	4.8	0.6	2
Akitua	1	14-Feb-08		35.8			8.0	2	4	2	6		1.1	1.7	0.5	23
Akitua	1	11-Mar-08	28.3	36.0	91.2	5.8	7.8	5	5	5	10		1.6	2.8	0.6	0
Akitua	1	08-Apr-08	27.0	35.6	86.6	5.7	7.9	4	5	3	8		0.2	4.5	0.9	1
Akitua	1	13-May-08	27.2	35.5	96.9	6.3	7.9	3	4	2	6		2.4	2.5	1.5	2
Akitua	1	13-Jun-08	23.3	35.4	105.6	7.4		2	3	5	8		1.3	5.4	1.0	2
Akitua	1	09-Jul-08	25.3	36.1	100.2	6.7	8.3	0.5	0.5	5	5.5	1.7		3.4	3.4	15
Akitua	1	27-Aug-08	24.7	36.3	90.0	6.1		4	8	11	19		0.1	2.1	0.5	6
Akitua	1	10-Sep-08	24.0	36.1	92.9	6.4		3	9	2	11		0.1	1.5	0.4	64
Akitua	1	15-Oct-08	26.2	36.2	99.0	6.5		0.5	6	3	9	1.1	1.4	7.5	0.5	10
Akitua	1	13-Nov-08	26.4		101.8	5.2		2	6	2	8	0.2	0.2	2.0	0.4	5
Akitua	1	03-Dec-08	25.0	36.0	89.6	6.0		4	12	5	17	0.2	0.2	2.3	0.4	2
Samade	2	29-Jan-08	26.5	35.7	93.9	6.2	7.6	2	8	8	16		0.7	4.6	0.7	15
Samade	2	14-Feb-08		35.9			8.0	3	13	4	17		1.1	2.6	0.2	2
Samade	2	11-Mar-08	27.6	35.9	70.9	4.6	7.7	1	25	2	27		1.4	3.6	0.1	37
Samade	2	08-Apr-08	27.0	35.5	62.3	4.1	7.9	5	9	1	10		0.2	4.4	0.5	14
Samade	2	13-May-08	27.2	35.6	89.8	5.8	7.8	6	8	0.5	8.5		2.5	15.2	3.5	61
Samade	2	13-Jun-08	21.8	35.2	110.0	7.9		1	11	2	13		1.7	16.7	7.4	41
Samade	2	09-Jul-08	25.3	36.1	91.0	6.1	8.2	0.5	2	1	3	1.4		7.0	0.9	0
Samade	2	27-Aug-08	24.4	36.3	83.1	5.7		2	5	0.5	5.5		0.1	2.6	0.3	85
Samade	2	10-Sep-08	23.2	36.1	92.2	6.4		2	9	1	10		0.2	7.0	0.6	125
Samade	2	15-Oct-08	25.8	36.2	90.7	6.0		1	5	2	7	1.3	1.8	10.7	0.3	5
Samade	2	13-Nov-08	25.6		65.8	3.4		0.5	3	0.5	3.5	0.3	0.2	3.4	0.3	14
Samade	2	03-Dec-08	24.6	35.6	82.0	5.6		3	20	6	26	0.6	0.6	7.5	1.2	90
Tepaki	3	29-Jan-08	26.0	35.7	90.5	6.0	7.9	2	32	4	36		1.7	28.6	3.4	25
Tepaki	3	14-Feb-08		35.6			7.9	7	56	5	61		1.6	19.0	1.5	15
Tepaki	3	11-Mar-08	27.7	35.3	47.2	3.1	7.8						1.1	18.1	2.3	11
Tepaki	3	08-Apr-08	27.0	35.4	74.7	4.9	7.9	0.5	31	1	32		1.1	9.1	1.3	6
Tepaki	3	13-May-08	27.3	35.1	70.8	4.6	7.9	4	31	3	34		1.1	16.7	3.9	3
Tepaki	3	13-Jun-08	21.4	33.8	109.9	8.0		1	9	2	11		3.0	13.5	0.6	30
Tepaki	3	09-Jul-08	25.8	35.8	80.9	5.4	8.1	0.5	9	0.5	9.5	1.8		10.7	10.7	3

Location	Site Number	Date	Temperature (°C)	Salinity (ppt)	DOSat (%)	DO (mg/L)	pH	DRP (µg/L)	NH4-N (µg/L)	NO3-N (µg/L)	DIN (µg/L)	Extraction (Chl a µg/L)	Invivo (Chl a µg/L)	TSS (mg/L)	VSS (mg/L)	Enterococci (Count/100ml)
Tepaki	3	27-Aug-08	23.6	35.7	67.0	4.6		2	16	0.5	16.5		0.5	9.5	1.3	74
Tepaki	3	10-Sep-08	21.1	36.5	82.3	5.9		3	11	1	12		1.2	8.7	1.2	55
Tepaki	3	15-Oct-08	25.6	36.0	74.7	5.0		1	13	2	15	1.1	1.1	9.0	1.4	61
Tepaki	3	13-Nov-08	29.1		46.2	2.2		1	38	0.5	38.5	0.8	1.3	19.8	2.0	10
Tepaki	3	03-Dec-08	24.1	33.7	85.4	5.9		0.5	14	2	16	0.9	0.9	9.6	1.6	260
Vaiepeka	4	29-Jan-08	26.2	34.8	73.3	4.9	8.0	0.5	4	2	6		1.2	8.8	1.6	0
Vaiepeka	4	14-Feb-08		37.8			8.1	5	23	3	26		0.5	1.3	0.6	2
Vaiepeka	4	11-Mar-08	29.2	36.4	135.1	8.5	8.0	3	29	21	50		0.3	1.1	0.2	17
Vaiepeka	4	08-Apr-08	27.6	34.7	57.8	3.8	7.9	6	11	2	13		0.4	4.1	0.3	11
Vaiepeka	4	13-May-08	28.7	33.8	122.2	7.8	8.0	5	6	2	8		0.4	4.3	1.9	2
Vaiepeka	4	13-Jun-08	21.1	34.6	110.1	8.0		1	9	5	14		1.5	22.3	8.2	40
Vaiepeka	4	09-Jul-08	24.0	36.6	99.1	6.8	8.2	0.5	7	0.5	7.5	1.2		2.8	0.3	0
Vaiepeka	4	27-Aug-08	22.9	37.0	90.5	6.3		4	12	5	17		0.6	15.3	2.8	10
Vaiepeka	4	10-Sep-08	21.0	25.3	96.1	7.4		0.5	14	3	17		0.7	32.7	6.5	134
Vaiepeka	4	15-Oct-08	23.4	36.9	89.4	6.2		0.5	6	3	9	0.9	0.9	1.9	0.3	57
Vaiepeka	4	13-Nov-08	26.3		99.3	4.8		0.5	10	5	15	0.3	0.3	1.4	0.3	2
Vaiepeka	4	03-Dec-08	24.0	32.5	96.7	6.8		0.5	14	6	20	0.9	0.8	4.3	0.7	8
Vaipae Wharf	5	29-Jan-08	26.5	34.2	39.4	2.6	7.9	3	15	4	19		1.1	4.9	1.1	22
Vaipae Wharf	5	14-Feb-08		36.0			8.0	6	33	6	39		2.8	7.4	1.1	3
Vaipae Wharf	5	11-Mar-08	29.2	36.1	66.9	4.2	7.8	5	56	16	72		2.5	11.5	2.2	12
Vaipae Wharf	5	08-Apr-08	27.6	35.0	68.7	4.5	7.9	12	41	12	53		2.1	8.3	1.8	50
Vaipae Wharf	5	13-May-08	26.5	33.7	77.6	5.2	7.9	2	32	5	37		1.1	4.8	2.4	20
Vaipae Wharf	5	13-Jun-08	21.5	34.9	112.7	8.1		4	22	8	30		1.1	23.1	3.0	595
Vaipae Wharf	5	09-Jul-08	25.3	35.6	77.1	5.2	8.2	0.5	19	2	21	1.1		9.1	0.4	29
Vaipae Wharf	5	27-Aug-08	23.6	35.0	87.0	6.0		7	7	5	12		1.3	7.6	1.2	15
Vaipae Wharf	5	10-Sep-08	21.2	35.9	94.6	6.8		4	10	0.5	10.5		0.8	32.3	7.6	93
Vaipae Wharf	5	15-Oct-08	24.6	36.2	88.8	6.0		10	8	3	11	0.7	0.9	11.5	2.2	50
Vaipae Wharf	5	13-Nov-08	27.3		87.2	4.3		3	13	0.5	13.5	1.4	1.4	5.2	1.1	14
Vaipae Wharf	5	03-Dec-08	23.7	32.9	95.0	6.7		3	12	6	18	0.6	0.7	9.6	1.4	54
Tautu Wharf	6	29-Jan-08	26.4	34.1	62.8	4.2	7.9	1	9	2	11		0.6	3.9	0.8	65
Tautu Wharf	6	14-Feb-08		35.9			7.9	5	43	6	49		3.0	12.0	1.9	3
Tautu Wharf	6	11-Mar-08	28.6	35.8	41.8	2.7	7.7	4	94	6	100		1.9	7.3	1.8	37
Tautu Wharf	6	08-Apr-08	27.1	35.0	66.2	4.3	7.6	9	23	9	32		0.9	5.2	1.3	24
Tautu Wharf	6	13-May-08	27.1	34.6	64.5	4.2	7.8	2	57	4	61		1.7	3.7	1.9	15
Tautu Wharf	6	13-Jun-08	21.6	34.5	104.1	7.5		5	24	2	26		1.2	34.6	6.0	25
Tautu Wharf	6	09-Jul-08	26.0	35.1	98.7	6.6	8.3	0.5	25	2	27	1.1		7.6	1.9	0
Tautu Wharf	6	27-Aug-08	23.5	34.9	88.9	6.2		10	1	2	3		0.5	6.4	0.8	2

Location	Site Number	Date	Temperature (°C)	Salinity (ppt)	DOSat (%)	DO (mg/L)	pH	DRP (µg/L)	NH4-N (µg/L)	NO3-N (µg/L)	DIN (µg/L)	Extraction (Chl a µg/L)	Invivo (Chl a µg/L)	TSS (mg/L)	VSS (mg/L)	Enterococci (Count/100ml)
Tautu Wharf	6	10-Sep-08	22.1	36.1	92.6	6.6		2	10	0.5	10.5		0.9	8.6	1.5	43
Tautu Wharf	6	15-Oct-08	24.8	36.4	87.7	5.9		5	11	3	14	1.0	1.2	4.6	4.6	14
Tautu Wharf	6	13-Nov-08	26.4		84.7	4.3		6	11	2	13	0.8	0.8	1.8	0.4	19
Tautu Wharf	6	03-Dec-08	24.2	32.7	84.1	5.9		3	21	3	24	2.0	2.2	6.1	0.7	290
New Jerusalem	7	29-Jan-08	26.6	34.7	65.0	4.3	7.9	5	50	4	54		0.6	16.0	2.0	24
New Jerusalem	7	14-Feb-08		35.8			7.9	3	13	2	15		1.4	21.8	2.2	2
New Jerusalem	7	11-Mar-08	26.6	34.5	78.2	5.2	7.7	6	54	5	59		0.3	6.4	1.1	3
New Jerusalem	7	08-Apr-08	26.6	30.3	50.1	3.4	7.7	6	4	1	5		0.8	5.5	1.0	2
New Jerusalem	7	13-May-08	26.1	31.0	91.7	6.2	7.9	7	30	4	34		0.5	6.7	2.6	35
New Jerusalem	7	13-Jun-08	21.7	34.4	110.3	7.9		3	5	0.5	5.5		0.8	40.0	2.6	75
New Jerusalem	7	09-Jul-08	24.8	35.6	87.9	6.0	8.2	0.5	0.5	0.5	1	0.4		8.6	0.7	2
New Jerusalem	7	27-Aug-08	23.2	36.6	87.7	6.1		4	17	3	20		0.5	5.6	0.9	0
New Jerusalem	7	10-Sep-08	21.4	36.0	98.5	7.1		3	8	0.5	8.5		0.5	12.7	1.9	43
New Jerusalem	7	15-Oct-08	24.3	36.5	93.8	6.4		2	3	3	6	0.2	1.1	30.0	0.9	9
New Jerusalem	7	13-Nov-08	26.0		83.5	4.2		3	18	0.5	18.5	0.4	0.5	14.3	1.3	1
New Jerusalem	7	03-Dec-08	24.6	31.5	90.7	6.3		3	30	3	33	1.4	1.3	5.9	1.1	14
Waste Management	8	29-Jan-08	27.1	35.3	88.7	5.8	8.0	8	69	6	75		1.5	14.5	2.7	64
Waste Management	8	14-Feb-08		33.7			7.9	5	13	3	16		0.9	13.1	2.3	13
Waste Management	8	11-Mar-08	28.0	30.2	52.9	3.5	7.7	7	20	3	23		0.7	8.8	2.3	30
Waste Management	8	08-Apr-08	27.6	32.6	58.8	3.9	7.6	9	18	1	19		1.1	13.1	2.1	41
Waste Management	8	13-May-08	27.0	27.8	55.9	3.8	7.8	4	22	2	24		0.7	9.9	2.9	31
Waste Management	8	13-Jun-08	21.8	34.3	97.4	7.0		4	15	1	16		0.5	12.9	1.3	60
Waste Management	8	09-Jul-08	25.7	31.3	75.1	5.1	8.1	0.5	5	2	7	0.5		9.0	0.9	0
Waste Management	8	27-Aug-08	25.5	34.8	51.3	3.5		7	19	5	24		0.6	14.7	2.9	22
Waste Management	8	10-Sep-08	21.6	35.8	73.5	5.3		4	10	3	13		0.6	6.3	0.6	169

Location	Site Number	Date	Temperature (°C)	Salinity (ppt)	DOSat (%)	DO (mg/L)	pH	DRP (µg/L)	NH4-N (µg/L)	NO3-N (µg/L)	DIN (µg/L)	Extraction (Chl a µg/L)	Invivo (Chl a µg/L)	TSS (mg/L)	VSS (mg/L)	Enterococci (Count/100ml)
Waste Management	8	15-Oct-08	26.3	35.5	57.3	3.8		8	22	3	25	1.4	1.3	14.0	2.5	105
Waste Management	8	13-Nov-08	27.9		57.1	2.8		5	10	0.5	10.5	0.6	0.7	4.5	0.5	31
Waste Management	8	03-Dec-08	25.0	26.5	74.1	5.3		7	12	3	15	1.0	1.0	7.7	1.0	460
Maina Sunset	9	29-Jan-08	28.1	31.1	71.5	4.7	8.0	5	40	11	51		1.2	5.3	0.5	12
Maina Sunset	9	14-Feb-08		35.4			7.9	4	28	9	37		1.1	8.1	1.1	3
Maina Sunset	9	11-Mar-08	27.7	35.7	65.2	4.2	7.8	11	38	4	42		1.7	12.3	2.5	18
Maina Sunset	9	08-Apr-08	28.5	34.9	65.3	4.2	7.8	5	16	1	17		1.0	12.9	2.0	21
Maina Sunset	9	13-May-08	27.1	35.3	66.0	4.3	7.9	0.5	23	4	27		1.4	11.2	1.9	18
Maina Sunset	9	13-Jun-08	21.5	35.3	99.0	7.1		1	4	1	5		1.0	18.6	1.7	20
Maina Sunset	9	09-Jul-08	25.4	35.5	59.3	4.0	8.1	0.5	6	0.5	6.5	0.7		14.5	3.9	5
Maina Sunset	9	27-Aug-08	24.4	36.7	76.0	5.2		4	7	3	10		0.5	5.4	1.1	0
Maina Sunset	9	10-Sep-08	21.4	36.1	71.2	5.1		4	4	3	7		0.6	6.1	1.2	176
Maina Sunset	9	15-Oct-08	26.1	36.5	59.4	3.9		8	9	3	12	0.6	0.6	5.1	0.5	10
Maina Sunset	9	13-Nov-08	28.5		60.7	3.0		3	21	3	24	0.8	0.8	4.0	0.6	18
Maina Sunset	9	03-Dec-08	25.4	35.5	77.6	5.2		2	12	3	15	1.5	2.0	3.7	0.8	136
Arutanga Wharf	10	29-Jan-08	27.0	30.3	109.2	7.3	8.0	2	26	15	41		1.0	3.1	0.9	3
Arutanga Wharf	10	14-Feb-08		35.7			7.9	3	7	6	13		0.7	2.3	0.3	1
Arutanga Wharf	10	11-Mar-08	27.7	35.8	62.8	4.1	7.8	9	11	9	20		1.2	2.2	0.6	35
Arutanga Wharf	10	08-Apr-08	28.6	34.7	74.4	4.8	7.9	4	9	4	13		0.9	4.4	1.0	16
Arutanga Wharf	10	13-May-08	26.8	35.5	45.1	3.0	7.8	3	7	3	10		0.5	2.3	0.8	8
Arutanga Wharf	10	13-Jun-08	22.0	35.5	103.5	7.4		3	4	3	7		0.8	7.4	0.4	12
Arutanga Wharf	10	09-Jul-08	25.6	35.9	81.8	5.5	8.2	0.5	5	3	8	0.9		1.9		7
Arutanga Wharf	10	27-Aug-08	24.2	36.6	58.3	4.0		6	9	4	13		1.5	3.5	1.1	10
Arutanga Wharf	10	10-Sep-08	21.7	36.1	71.6	5.1		4	10	3	13		0.4	2.4	0.3	80
Arutanga Wharf	10	15-Oct-08	26.0	36.4	70.5	4.7		7	5	5	10	0.6	0.5	3.8	1.0	94
Arutanga Wharf	10	13-Nov-08	27.8		80.7	4.0		1	8	2	10	0.6	0.4	4.0	0.3	48
Arutanga Wharf	10	03-Dec-08	25.1	35.4	85.2	5.8		0.5	9	5	14	1.1	1.2	2.0	0.6	30
Pacific Resort	11	29-Jan-08	26.4	33.6	120.0	8.0	8.1	4	37	13	50		0.4	1.8	0.2	13

Location	Site Number	Date	Temperature (°C)	Salinity (ppt)	DOSat (%)	DO (mg/L)	pH	DRP (µg/L)	NH4-N (µg/L)	NO3-N (µg/L)	DIN (µg/L)	Extraction (Chl a µg/L)	Invivo (Chl a µg/L)	TSS (mg/L)	VSS (mg/L)	Enterococci (Count/100ml)
Pacific Resort	11	14-Feb-08		35.3			7.9	5	9	10	19		0.3	0.3	0.6	2
Pacific Resort	11	11-Mar-08	28.2	35.5	96.5	6.2	8.0	8	3	7	10		0.7	0.8	0.8	0
Pacific Resort	11	08-Apr-08	28.0	34.4	81.5	5.3	7.6	5	4	5	9		0.1	2.3	1.1	22
Pacific Resort	11	13-May-08	27.0	35.6	93.1	6.1	8.1	3	7	4	11		1.3	1.9	0.9	9
Pacific Resort	11	13-Jun-08	22.8	34.3	108.6	7.7		6	7	4	11		0.6	2.9	0.3	18
Pacific Resort	11	09-Jul-08	24.9	35.9	85.6	5.8	8.3	0.5	5	5	10	0.4		2.0	0.3	0
Pacific Resort	11	27-Aug-08	25.0	36.3	89.4	6.0		2	6	5	11		0.4	2.7	1.0	2
Pacific Resort	11	10-Sep-08	22.1	35.2	94.3	6.7		11	10	3	13		0.6	1.6	0.5	43
Pacific Resort	11	15-Oct-08	25.8	36.3	81.2	5.4		4	5	3	8	1.3	1.1	4.3	1.3	5
Pacific Resort	11	13-Nov-08	27.6		96.0	4.9		0.5	9	6	15	1.5	0.4	3.3	1.4	
Pacific Resort	11	03-Dec-08	24.6	34.2	93.2	6.4		4	13	15	28	1.2	1.2	2.6	0.9	18
Paradise Cove	12	29-Jan-08	27.6	33.2	137.0	9.0	8.2	5	14	27	41		1.3	2.9	1.0	33
Paradise Cove	12	14-Feb-08		34.6			7.9	6	7	13	20		0.9	1.2	1.2	3
Paradise Cove	12	11-Mar-08	28.3	34.8	54.5	3.5	7.9	5	12	11	23		0.5	2.8	0.6	7
Paradise Cove	12	08-Apr-08	28.5	35.1	60.1	3.8	7.6	4	4	4	8		0.8	3.0	1.1	41
Paradise Cove	12	13-May-08	26.7	35.3	87.4	5.7	8.1	4	10	4	14		0.6	3.5	1.3	5
Paradise Cove	12	13-Jun-08	22.9	34.3	103.4	7.3		3	5	7	12		0.4	1.9	0.3	10
Paradise Cove	12	09-Jul-08	24.8	35.9	78.3	5.3	8.3	3	10	10	20	0.3		2.8	0.4	0
Paradise Cove	12	27-Aug-08	25.1	35.9	79.9	5.4		10	12	7	19		0.7	3.8	0.6	0
Paradise Cove	12	10-Sep-08	22.3	34.8	69.5	4.9		10	9	11	20		0.4	1.1	0.7	183
Paradise Cove	12	15-Oct-08	25.9	35.9	88.6	5.9		10	6	5	11	0.5	0.5	1.9	1.9	14
Paradise Cove	12	13-Nov-08	28.0		58.4	3.0		9	15	4	19	0.9	0.5	4.2	0.8	29
Paradise Cove	12	03-Dec-08	24.8	34.4	91.5	6.2		9	19	10	29	0.7	0.7	4.7	0.9	19
TCI Mast Airport	13	29-Jan-08	29.1	32.2	146.6	9.4	8.2	7	9	3	12		0.2	1.1	0.1	1
TCI Mast Airport	13	14-Feb-08		35.6			8.0	9	11	2	13		0.1	0.6	0.6	0
TCI Mast Airport	13	11-Mar-08	26.0	35.3	33.6	2.2	7.4	3	8	7	15		0.4	0.9	0.6	39
TCI Mast Airport	13	08-Apr-08	27.8	35.4	83.8	5.4	7.9	5	3	2	5		0.4	2.1	0.4	0
TCI Mast Airport	13	13-May-08	25.6	34.9	61.7	4.1	7.3	3	5	4	9		0.3	0.3	0.6	87
TCI Mast Airport	13	13-Jun-08	23.8	35.7	103.5	7.1		3	3	2	5		0.8	1.2	1.2	5
TCI Mast Airport	13	09-Jul-08	24.6	35.2	60.9	4.2	7.9	2	8	3	11	0.4		2.5	0.3	27
TCI Mast Airport	13	27-Aug-08	24.1	36.3	91.8	6.3		2	11	5	16		0.1	2.3	0.6	10
TCI Mast	13	10-Sep-08	23.5	36.1	89.8	6.2		0.5	3	1	4		0.2	2.7	0.5	25

Location	Site Number	Date	Temperature (°C)	Salinity (ppt)	DOSat (%)	DO (mg/L)	pH	DRP (µg/L)	NH4-N (µg/L)	NO3-N (µg/L)	DIN (µg/L)	Extraction (Chl a µg/L)	Invivo (Chl a µg/L)	TSS (mg/L)	VSS (mg/L)	Enterococci (Count/100ml)
Airport																
TCI Mast Airport	13	15-Oct-08	23.6	35.9	77.7	5.4		2	1	1	2	0.2	0.2	2.0	0.3	4
TCI Mast Airport	13	13-Nov-08	25.0		81.4	4.3		1	4	2	6	0.3	0.1	2.4	0.3	3
TCI Mast Airport	13	03-Dec-08	25.2	36.0	93.7	6.3		2	6	4	10	0.4	0.3	2.5	0.4	31
Maina Nursery	14	29-Jan-08	24.2	35.8	89.1	6.1	8.2	4	6	8	14		0.4	0.6	0.4	0
Maina Nursery	14	14-Feb-08		35.7			8.0	3	8	17	25		0.4	0.3	0.1	2
Maina Nursery	14	11-Mar-08	27.2	35.5	103.7	6.8	8.0	4	0.5	4	4.5		0.2	0.3	0.3	0
Maina Nursery	14	08-Apr-08	27.0	35.7	110.3	7.4	8.0	7	8	5	13		0.1	0.7	0.3	0
Maina Nursery	14	13-May-08	27.2	34.3	97.3	6.4	8.1	4	0.5	0.5	1		3.5	0.3	0.8	1690
Maina Nursery	14	13-Jun-08	22.4	35.9	92.5	6.5		5	0.5	0.5	1		0.1	0.8	0.3	43
Maina Nursery	14	09-Jul-08	26.4	35.7	81.7	5.5	8.2	5	0.5	0.5	1	0.1		0.9	0.9	0
Maina Nursery	14	27-Aug-08	22.2	36.3	98.1	6.9		3	8	2	10		0.1	0.3	0.3	0
Maina Nursery	14	10-Sep-08	20.6	36.4	67.1	4.9		4	6	4	10		0.1	0.3	0.3	136
Maina Nursery	14	15-Oct-08	25.0	36.0	90.5	6.0		2	1	0.5	1.5	0.1	0.2	1.1	0.6	3
Maina Nursery	14	13-Nov-08	26.0		80.2	4.3		2	3	4	7	0.0	0.0	0.3	0.3	0
Maina Nursery	14	03-Dec-08	24.5	33.8	81.8	5.8		2	3	5	8	0.2	0.2	0.7	0.3	17
One Foot Island	15	29-Jan-08	26.2	35.8	120.3	8.0	8.2	4	3	2	5		0.1	0.4	0.3	0
One Foot Island	15	14-Feb-08		35.6			8.0	5	9	4	13		0.1	0.4	0.2	8
One Foot Island	15	11-Mar-08	27.2	34.3	96.5	6.3	7.9	7	3	1	4		0.1	0.8	0.5	0
One Foot Island	15	08-Apr-08	27.0	35.7	88.6	5.8	8.0	0.5	2	1	3		0.0	0.7	0.3	0
One Foot Island	15	13-May-08	27.3	35.7	69.3	4.5	8.1	0.5	9	1	10		0.7	0.3	0.7	11
One Foot Island	15	13-Jun-08	21.2	36.2	104.8	7.5		4	1	2	3		0.3	1.4	0.8	9
One Foot Island	15	09-Jul-08	25.2	35.6	86.4	5.8	8.3	3	3	0.5	3.5	0.4		0.4	0.4	0
One Foot Island	15	27-Aug-08	22.9	36.9	74.2	5.2		7	9	2	11		0.1	0.3	0.3	0
One Foot Island	15	10-Sep-08	22.8	36.1	78.6	5.5		4	5	2	7		0.1	0.5	0.3	73
One Foot Island	15	15-Oct-08	26.0	36.1	99.9	6.6		3	2	0.5	2.5	0.1	0.1	0.4	0.4	1
One Foot Island	15	13-Nov-08	27.0		83.1	4.3		3	4	1	5	0.1	0.0	0.3	0.3	16
One Foot Island	15	03-Dec-08	25.0	36.1	88.5	6.6		3	5	3	8	0.4	0.2	0.5	0.3	129

5.2 Appendix 2. Water Quality data stream sites.

Location	Site Number	Date	Temperature (°C)	Salinity (ppt)	DOSat (%)	DO (mg/L)	pH	DRP (µg/L)	NH4-N (µg/L)	NO3-N (µg/L)	TSS (mg/L)	VSS (mg/L)	Enterococci (Count/100ml)
Vaitiare	1	29-Jan-08	25.0	0.4	235.3	19.4	6.4	55	22	0.5	3.5	0.6	1100
Vaitiare	1	14-Feb-08		0.3			7.0	17	33	0.5	18.6	5.8	365
Vaitiare	1	11-Mar-08											
Vaitiare	1	08-Apr-08	25.5	0.3	11.6	1.0	7.6	13	21	4	44.4	14.4	1150
Vaitiare	1	13-May-08	25.5	0.2	14.1	1.2		38	21	2	30.4	8.2	725
Vaitiare	1	13-Jun-08	22.4	0.3	82.1	7.1		26	19	0.5	6.2	4.4	2350
Vaitiare	1	09-Jul-08	23.6	0.5	47.1	4.0		2	78	0.5	13.3	0.3	200
Vaitiare	1	27-Aug-08											
Vaitiare	1	10-Sep-08											
Vaitiare	1	15-Oct-08											
Vaitiare	1	11-Nov-08											
Vaitiare	1	03-Dec-08											
Vaipae	2	29-Jan-08	28.1	0.2	148.4	11.6	7.6	0.5	31	10	3.1	1.0	1700
Vaipae	2	14-Feb-08		0.2			7.1	0.5	43	4	4.2	2.0	760
Vaipae	2	11-Mar-08	26.9	0.2	102.4	8.2	7.3	0.5	39	27	9.8	1.6	560
Vaipae	2	08-Apr-08	27.5	0.2	73.8	5.8	7.8	0.5	55	55	5.0	1.0	485
Vaipae	2	13-May-08	27.3	0.2	56.9	4.5		0.5	54	87	4.4	4.4	345
Vaipae	2	13-Jun-08	24.0	0.2	91.9	7.7		0.5	65	164	5.3	0.3	80
Vaipae	2	09-Jul-08	25.9	0.2	64.7	5.3		0.5	15	102	3.3	0.7	140
Vaipae	2	27-Aug-08	25.0	0.2	58.3	4.8		2	11	45	5.8	1.3	665
Vaipae	2	10-Sep-08	22.9	0.2	49.7	4.3		0.5	9	47	8.7	4.1	4300
Vaipae	2	15-Oct-08	24.8	0.3	60.5	5.0		0.5	40	4	2.8	2.4	610
Vaipae	2	11-Nov-08											
Vaipae	2	03-Dec-08	25.2	0.3	65.8	5.4		1	96	11	12.5	2.5	1290
Pāta	3	29-Jan-08	26.1	0.2	50.2	4.1	7.4	0.5	33	1	5.7	2.2	520
Pāta	3	14-Feb-08											

Location	Site Number	Date	Temperature (°C)	Salinity (ppt)	DOSat (%)	DO (mg/L)	pH	DRP (µg/L)	NH4-N (µg/L)	NO3-N (µg/L)	TSS (mg/L)	VSS (mg/L)	Enterococci (Count/100ml)
Pāta	3	11-Mar-08											
Pāta	3	08-Apr-08	24.1	0.2	10.6	0.9	8.0	0.5	50	2	0.5	1.0	400
Pāta	3	13-May-08	24.7	0.2	12.3	1.0		5	52	1	6.5	0.5	260
Pāta	3	13-Jun-08	22.8	0.2	34.0	2.9		0.5	71	0.5	3.0	0.4	305
Pāta	3	09-Jul-08	23.8	0.2	5.2	0.4		0.5	92	0.5	5.3	1.2	25
Pāta	3	27-Aug-08											
Pāta	3	10-Sep-08											
Pāta	3	15-Oct-08											
Pāta	3	11-Nov-08											
Pāta	3	03-Dec-08											
Arutanga Wharf	4	29-Jan-08	27.7	0.2	105.0	8.3	7.5	1	6	828	0.4	0.2	780
Arutanga Wharf	4	14-Feb-08		0.2			7.5	1	9	886	8.3	2.1	350
Arutanga Wharf	4	11-Mar-08	27.0	0.2	90.2	7.2	7.4	0.5	5	564	2.2	0.2	795
Arutanga Wharf	4	08-Apr-08	27.3	0.2	71.3	5.7	8.3	1	13	461	5.7	1.8	785
Arutanga Wharf	4	13-May-08	26.8	0.2	94.8	7.6		6	0.5	1020	1.2	0.2	115
Arutanga Wharf	4	13-Jun-08	26.5	0.2	116.1	9.3		1	7	861	1.7	0.1	155
Arutanga Wharf	4	09-Jul-08	26.7	0.2	93.2	7.5		2	2	767	1.8	0.2	1660
Arutanga Wharf	4	27-Aug-08	26.2	0.2	89.8	7.3		4	4	694	2.5	0.6	1725
Arutanga Wharf	4	10-Sep-08	25.5	0.2	94.4	7.7		4	4	640	6.6	2.3	7250
Arutanga Wharf	4	15-Oct-08	26.4	0.2	89.6	7.2		5	9	421	2.7	1.4	5300
Arutanga Wharf	4	11-Nov-08											
Arutanga Wharf	4	03-Dec-08	26.5	0.2	75.6	6.1		22	2	261	7.6	1.4	4740