INSTITUTE OF NATURAL RESOURCES

UNIVERSITY OF THE SOUTH PACIFIC

ENVIRONMENTAL STUDIES REPORT NO. 36

ENVIRONMENTAL MONITORING OF THE TREASURE ISLAND MARINE SEWAGE OUTFALL

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1. Introduction

The purpose of the INR investigation of the new Treasure Island sewerage scheme was to assess the following conditions as set down in the letter of the Central Board of Health (Appendix 1) to Harrison and Grierson Consultants Ltd of the 15 October 1984.

i) that an appropriate test be carried out for a period of twelve months by the Developers to determine any adverse effects from the discharge of the raw sewage after maceration. The test to be carried out at an interval of two (2) weeks

ii) that there should be no discoloration of sea waters

iii) that the bacterial standard of the sea, swimming and snorkelling area to conform with the WHO standards

iv) that there are no physical or visible pollutions or nuisance

v) that there should be no discharge of grease with the contents

vi) that there are no destruction of marine ecosystems and biota

Studies examining the effects of sewage effluent on receiving waters close to outfall sites have proliferated greatly in recent times. Large numbers of these have been carried out in temperate waters looking for evidence of eutrophication or ecological change [e.g. Turner (1965), Bellan (1970), McIntyre and Johnson (1974)].

As noted by Russo (1980) sewage outfalls present special problems in investigation both in the field survey techniques used and in data interpretation. This is even more true when coral reefs are concerned due to our lack of knowledge of natural longterm changes on reefs to small elevations in nutrient concentrations. Of particular use in Fiji are the extensive studies carried out in Hawaii over the last 20 years and published in the Water Resources Research Centre of the

University of Hawaii Technical Report series [e.g. Cox et al (1969), Russo (1980), Young et. al. (1976)].

In response to Central Board of Health conditions the Institute submitted a monitoring proposal (Appendix 2) which suggested that the twelve month monitoring period run from November 1984 until November 1985. Unfortunately after the first baseline sampling in November 1984 Cyclones Eric and Nigel severely damaged the Treasure Island resort and the resort was subsequently closed until July 1985. Thus the sampling period was postponed to include August 1985 until July 1986.

The initial monitoring proposal envisaged seven monitoring sample collections with INR staff responsible for the first two and thereafter Treasure Island Management and INR alternating (see Appendix 2). However in the event the Treasure Island Management had difficulty in organizing sample collection and INR staff made all collections.

Samples were collected and assessments made on the following dates 16 November 1984; 12 April 1985; 17 August 1985; 18 September 1985; 21 October 1985; 4 February 1986; 23 April 1986; 7 July 1986.

2. Location, Sampling Sites, Analytical Parameters

Treasure Island (Elevuka) is a small sand cay situated 10 km off Vuda Point in Nadi Bay (Figure 1). The resort has approximately 60 bures and can thus accommodate almost 200 guests although the normal number present at any one time is considerably less than this. Up until 1985 the sewerage system relied on a septic transpiration system but this gave considerable problems including objectionable odours, flies and the possibility of excess algal growth in the shallow offshore areas. The new system collects the sewage centrally, macerates it and discharges it through a 1 km long pipe into deep water (40

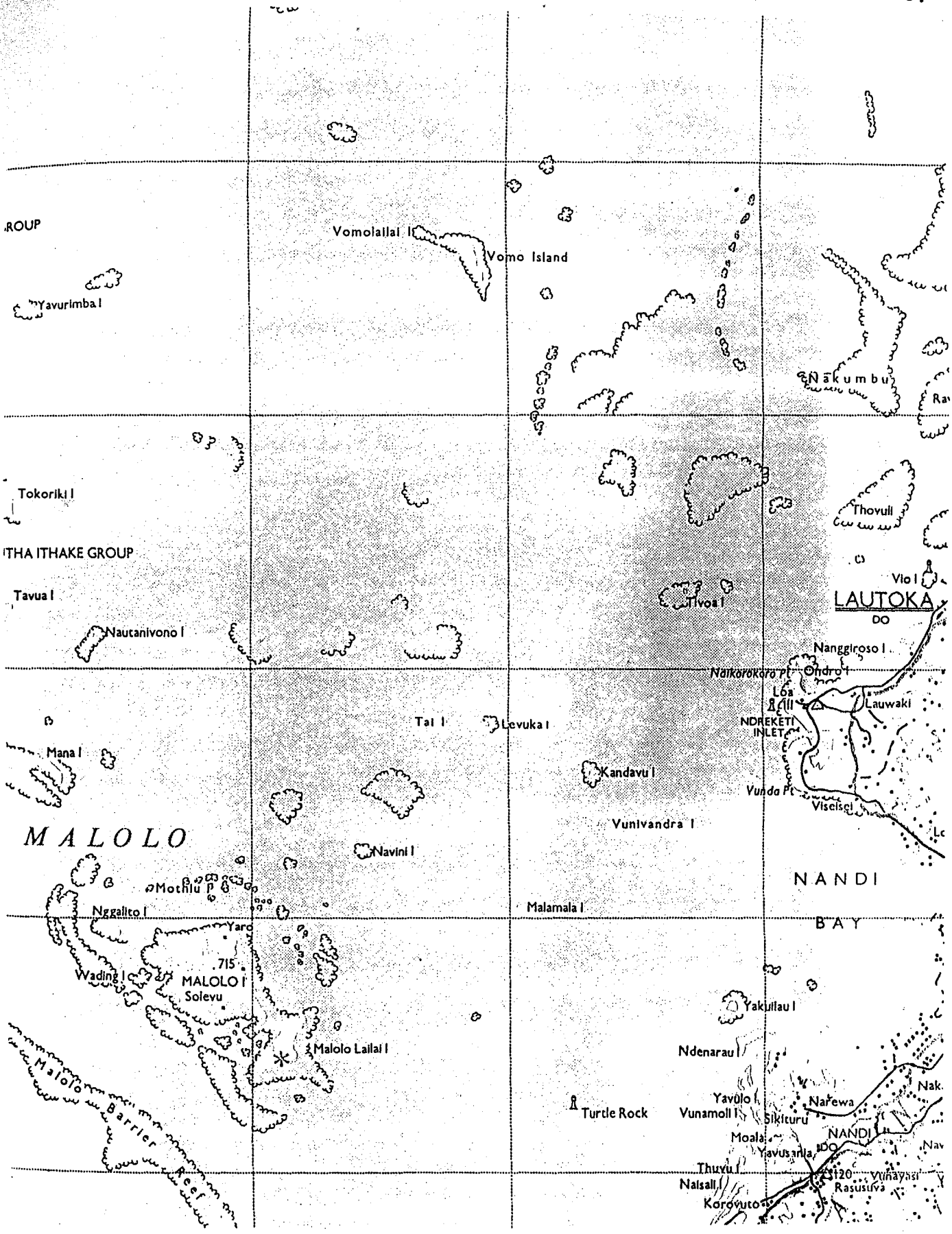
ROUP
Vomolailai I
Vomo Island
Yavurimba I
Nakumbu
Tokoriki I
ITHA ITHAKE GROUP
Thovuli
Tavua I
Tivoa I
Vio I
LAUTOKA
DO
Nautanivono I
Nanggiroso I
Naikorokoro Pt
Ondro I
Loa
Lauwaki
NDREKETI INLET
Tai I
Levuka I
Mana I
Kandavu I
Vunda Pt
Viseisei
Vunivandra I
MALOLO
Navini I
NANDI
Mothilu P
Malamala I
Nggalito I
BAY
Yaro
715
Wading I
MALOLO I
Solevu
Yakulilau I
Ndenarau
Malolo Lailai I
Malolo Barrier Reef
Turtle Rock
Yavulo I
Vunamoli I
Narewa
Sikituru
Moala
NANDI
DO
Yavusania
Thuvu I
Nalsali I
Korovuto
Rasusuva
Vunayasi

FIGURE 1

m) beyond the reef on the eastern side of the island (Figure 2). At the end of the pipe is a multiple arm diffuser.

Seven water sampling sites were chosen and these are shown by their number in Figure 2. Site 1 was situated at the discharge point. One sample was collected at the surface [1(a)] and one at 15 metres depth [1(b)]. Site 2 was halfway between the Site 1 and the reef edge. A surface sample [2(a)] and one from 12 m depth [2(b)] were collected. Site 3 was where the pipe intersected the reef edge. Only surface samples were collected from sites 3 to 7. Site 4, 5, 6 and 7 were spaced around the edge of the island in one metre depth water. Site 4 was in front of Vila 9, Site 5 where the pipe leaves the beach, Site 6 in front of Vila 55 and Site 7 in front of the diving equipment hire hut. Visual inspections for water discoloration and grease were made all around the island, in the area around the discharge point and between there and the island. Biota surveys were conducted on a marked transect on the reef between Sites 3 and 5.

The water quality parameters measured at each site are summarized in Table 1.

SITE	PARAMETERS
1	Total coliform (TC), faecal coliform (FC), Turbidity (Secchi Disc)
2	Total coliform, faecal coliform, Turbidity
3	Total coliform, faecal coliform, nitrate (NO_3^-), ammonia (NH_3), orthophosphate (PO_4^{3-})
4	Total coliform, faecal coliform, nitrate, ammonia, orthophosphate
5	Total coliform, faecal coliform, nitrate, ammonia, orthophosphate
6	Total coliform, faecal coliform, nitrate, ammonia, orthophosphate
7	Total coliform, faecal coliform, nitrate, ammonia, orthophosphate

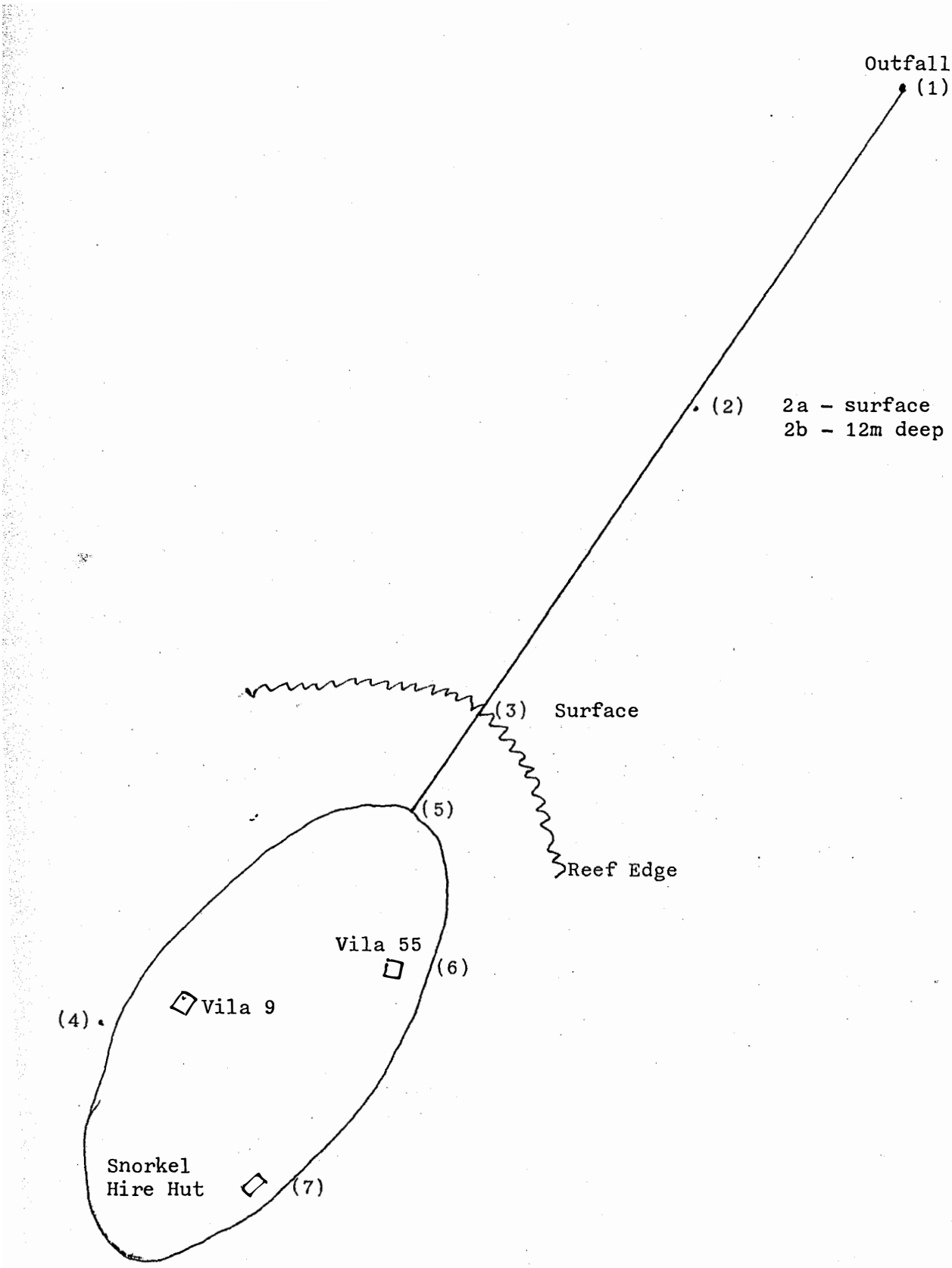

FIGURE 2. SAMPLING SITES

Along the reef transect standard methods were used to monitor the 'health of the reef'. These inclused measurements of coral type, diversity and cover, surveys of other invertebrates and algae and counts of fish types. A number of dye release experiments were also carried out to estimate the extent and direction of the sewage plume after release.

3. Methods

For total coliform, faecal coliforms, nitrate, ammonia and orthophosphate American Public Health Association standard methods were used (APHA, 1980). Turbidity (clarity) was measured with a Secchi disc. For coliform tests samples were collected in sterile bottles, glass for surface samples and metal for the deep samples. The deep samples were collected using SCUBA equipment and depth measured using a standard diving depth gauge. All samples were chilled to 4°C and analysed within 24 hours of collection.

Biota surveys were done using the methods of Dahl (UNEP, 1984) using SCUBA equipment and divers trained in identification of taxonomic groups. Some use was also made of the methods developed by the Australian Great Barrier Reef Marine Park Authority and UNESCO (GBRMPA, 1978; Stoddard & Johannes, 1978).

Photographs of coral heads along the chosen transect near the pipeline are included.

4. Results

The results of water quality tests are summarized in Table 2. The coliform counts are given as single figures without confidence ranges but these can be estimated. The limits of detection of the methods used were 10 µg/l for nitrate, 20 µg/l for ammonia and 18 µg/l for orthophosphate.

DATE	SITE 1(a)			SITE 1(b)		SITE 2(a)			SITE 2(b)		SITE 3					SITE 4					SITE 5					SITE 6					SITE 7				
	TC	FC	T	TC	FC	TC	FC	T	TC	FC	TC	FC	NO_3	NH_3	PO_4	TC	FC	NO_3	NH_3	PO_4	TC	FC	NO_3	NH_3	PO_4	TC	FC	NO_3	NH_3	PO_4	TC	FC	NO_3	NH_3	PO_4
Nov 1984	0	0		0	0	0	0		0	0	0	0	50	<20	120	0	0	70	<20	120	0	0	50	<20	120	0	0	330	<20	74	0	0	60	<20	98
April 1985	150	6	21.0	120	0	1000	185	14.1	75	0	0	0	90	<20	<18	0	0	70	20	<18	0	0	90	<20	<18	64	0	210	<20	61	50	0	200	<20	60
Aug 1985	0	0		0	0	0	0		0	0	0	0	<10	<20	170	0	0	210	<20	210	0	0	110	<20	260	0	0	310	<20	169	0	0	<10	<20	210
Sept 1985	0	0		0	0	0	0		0	0	0	0	140	620	110	0	0	12	48	110	0	0	<10	66	240	0	0	99	52	153	0	0	80	60	110
Oct 1985	30	2		0	0	0	0		3	0	0	0	<10	20	280	2	0	34	21	260	20	4	31	<20	270	19	6	96	20	184	30	0	59	<20	210
Feb 1986	0	0	16.2	0	0	0	0	13.5	0	0	0	0	<10	<20	150	0	0	12	<20	46	0	0	19	<20	92	0	0	19	<20	46	12	12	<10	<20	92
April 1986	0	0	17.7	0	0	0	0	11.9	0	0	0	0	<10	<20	<18	0	0	<10	<20	<18	0	0	<10	<20	<18	0	0	<10	<20	<18	0	0	<10	<20	<18
July 1986	0	0	20.4	ND	ND	9	0	15.3	ND	ND	0	0	ND	ND	ND	0	0	ND	ND	ND	41	0	ND	ND	ND	20	0	ND	ND	ND	34	0	ND	ND	ND

TC = Total coliforms per 100 ml
FC = Faecal coliforms per 100 ml
T = Turbidity (metres by Secchi Disc)
NO_3 = Nitrate in µg/l
NH_3 = Ammonia in µg/l
PO_4 = Orthophosphate in µg/l
--- = Start of discharge
ND = Not done

TABLE 2

The results of the biota surveys are summarized in Tables 3, 4 & 5. Photographs showing coral heads along the survey transect are shown in Figures 3, 4, 5 and 6.

5. Discussion

5.1 Bacterial levels. In general these were uniformly low and in fact the only significant elevated level occurred at site 2 in April, 1985 i.e. before the new plant was in use. In all cases the levels meet international standards for swimming beaches e.g. US Federal Water Pollution Control Administration "The Faecal Coliform content of primary contact recreational waters shall not exceed a log mean of 200/100 ml nor shall more than 10% of total samples during any 30 day period exceed 400/100 ml." There are very few other results from Fijian coastal waters for comparison but a few isolated measurements have been made by INR at the Suva Point beach (i.e. near Beach Road). These have occasionally shown faecal coliform levels of greater than 200 per 100 ml.

5.2 Nutrient levels. For any real predictions of long term effects of nutrients on the reef the data set is very limited in numbers of samples, geographic area and time span. However, these limitations could not be overcome without a complete study of the Nadi Bay area continued over a number of years and this of course was not possible for the present project. The other difficulty faced in interpreting the nutrient data is the almost complete lack of similar data from any other coastal area in Fiji. Thus we are forced to use data from other, hopefully similar, tropical areas of the world. In particular comparison with the Kaneohe Bay area of O'ahu in the state of Hawaii was made. In Kaneohe Bay extensive studies have been made (Cox et al., 1969;

TABLE 3

CORAL REEF MONITORING DATA SHEET

Locality Treasure Island	Date 12-4-1985		Recorder J. Brodie					
Circle number	1			2				
Location on reef	See Fig. 2			See Fig. 2				
Water depth	1-3 m			6-8 m				
FISH COUNTS (100 metre line)								
Predators				4				
Butterfly fish				8				
PERCENT COVER	Code: 0% = 0	1-5% = 1	6-30% = 2	31-50% = 3	51-75% = 4	76-100%=5		
Sediment: mud	0			0				
Sediment: sand	1			3				
Sediment: rubble	1			0				
Sediment: blocks	5			3				
Live hard coral	2			3				
Soft corals and sponges	3			1				
Dead standing coral	3			2				
Crustose corallines	1			1				
Marine plants	0			1				
FORMS PRESENT AND DOMINANT	Size code: fist = 1			forearm = 2			arm span = 3	
	PRES	DOM	SIZE	PRES	DOM	SIZE	PRES	DOM	SIZE
Hard corals: branching	x		3	x		2			
Hard corals: staghorn	x		2	x		2			
Hard corals: massive	x	x	3	x	x	3			
Hard corals: encrusting	x		2	x		2			
Hard corals: tabulate/flat				x		2			
Hard corals: erect foliose	x		2	x		2			
Hard corals: cup-shaped									
Hard corals: mushroom	x		1	x		1			
Soft coral and sponges: massive	x		2	x		2			
Soft coral and sponges: fans and whips				x		2			
Plants: thick turf									
Plants: long filaments	x		1	x		1			
Plants: large browns									
Plants: halimeda				x		1			
Plants: other fleshy	x		1	x		1			
Plants: sea grass									
COUNTS OF ANIMALS									
Mushroom coral	1			1					
Giant clams	1			0					
Synaptids	2			0					
Other holothurians	1			0					
Acanthaster	0			0					
Other starfish	6			1					
Urchins	6			11					
Trochus	1			0					
Other (specify)									
VISIBLE POLLUTION (specify/count)	Bldg. Material			Bldg. Material					
OTHER NOTES									

TABLE 4

CORAL REEF MONITORING DATA SHEET

Locality Treasure Island	Date 4-2-1986		Recorder J. Brodie					
Circle number	1			2				
Location on reef	See Fig. 2			See Fig. 2				
Water depth	1-3 m			6-8 m				
FISH COUNTS (100 metre line)								
Predators				4				
Butterfly fish				11				
PERCENT COVER	Code: 0% = 0	1-5% = 1	6-30% = 2	31-50% = 3	51-75% = 4	76-100%=5		
Sediment: mud	0			0				
Sediment: sand	1			3				
Sediment: rubble	1			0				
Sediment: blocks	5			3				
Live hard coral	2			3				
Soft corals and sponges	3			1				
Dead standing coral	3			2				
Crustose corallines	1			1				
Marine plants	0			1				
FORMS PRESENT AND DOMINANT	Size code: fist = 1		forearm = 2		arm span = 3			
	PRES	DOM	SIZE	PRES	DOM	SIZE	PRES	DOM	SIZE
Hard corals: branching	x		3	x		2			
Hard corals: staghorn	x		2	x		2			
Hard corals: massive	x	x	3	x	x	3			
Hard corals: encrusting	x		2	x		2			
Hard corals: tabulate/flat				x		2			
Hard corals: erect foliose	x		2	x		2			
Hard corals: cup-shaped									
Hard corals: mushroom	x		1	x		1			
Soft coral and sponges: massive	x		2	x		2			
Soft coral and sponges: fans and whips				x		2			
Plants: thick turf									
Plants: long filaments	x		1	x		1			
Plants: large browns									
Plants: halimeda				x		1			
Plants: other fleshy	x		1	x		1			
Plants: sea grass									
COUNTS OF ANIMALS									
Mushroom coral	1			0					
Giant clams	0			0					
Synaptids	1			0					
Other holothurians	2			1					
Acanthaster	0			0					
Other starfish	4			2					
Urchins	8			8					
Trochus	1			0					
Other (specify)									
VISIBLE POLLUTION (specify/count)	Bldg. Material			Bldg. Material					
OTHER NOTES									

TABLE 5 - Coral Types Identified

Site 1	Porites lutea
	Porites rus
	Diploastra heliopora
	Tubipora musica
	Millipora latifolia
	Millipora platyphylla
	Turbinaria sp.
	Acropora (hebes ?)
	Montipora sp.
	Pocilopora damacornis
	4 Acropora sp.
	Pocilopora sp.
	2 Galaxia sp.
Site 2	Porites lutea
	5 Acropora sp.
	Pocilopora damacornis
	Seriatopora hystrix
	Psamacora sp.
	Porites cylindrica
	Goniopora sp.
	Turbinaria reniformis
	Mycedium elephantatus
	Acropora (granulosa ?)
	Acropora (delicatula ?)

Young et. al., 1976) of sewage inputs and their effects on the Bay ecosystem including the extensive coral reefs. The principal studies were carried out in 1967/68 and 1975 and a large data set of nutrient values are available. In general the following comments can be made on the Treasure Island results compared to those from Kaneohe Bay. Orthophosphate levels in the early discharge period (August - October, 1985) were relatively high, although not as high as normally found in Kaneohe Bay but declined considerably in 1986. Nitrate and ammonia levels were uniformly low throughout the sampling period, often far lower than those found in Kaneohe Bay. Both the bacterial and nutrient data support the conclusions of the dye release experiments and visual diving evidence i.e. that wide dispersion of the sewage plume occurs before the plume reaches near surface waters.

5.3 Water Clarity. Water clarity remained good at sites 1 and 2 with no increase in turbidity after the discharge commenced.

5.4 Grease and Solids. Visual inspection of the circumference of the island during each sampling period showed no evidence of grease balls or sewage solids.

5.5 Dye Release Experiment. On the two occasions when dye was released through the maceration plant (18 August, 1985 and 21 October, 1985 when the system was pumping) the dye did not form a visible patch at the surface within two hours of release. The dye appeared to have moved out horizontally from the pipe end and to have spread over such a large area that eventually on reaching surface waters was so diluted as to be not visible.

5.6 Reef Baseline. The results in Tables 3, 4 & 5 are essentially baseline results for future reference. The sites have been marked with steel pegs and could be resurveyed for possible long term reef deterioration.

6. Conclusion

From the results of the monitoring of the Treasure Island sewerage system there appears to be no threat to public health or immediate threat to the island fringing reefs from the discharge. The more subtle long term effects of increased nutrient levels on the reef system cannot be predicted from the results but will require long term inspection by the resort operators.

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THE MINISTRY OF HEALTH & SOCIAL WELFARE
GOVERNMENT BUILDINGS
SUVA, FIJI
Fiji Insurance Bldgs.
P.O. Box 30 Suva.

315633

REF. NO. MC. 12/14/3

DATE 15 October 198

Messrs Harrison & Grierson Consultants Limited
6 Goodenough Street
SUVA.

Dear Sir

TREASURE ISLAND RESORT
DISPOSAL OF SEWERAGE

Your letter JDF/vb/3709 of 26th September 1984 is acknowledged with appreciation.

Subsequent to Hon. Mr. O.B. Costello the owners of the Developments and Mr. Jim Finlay the Consulting Engineer's representation in the meeting of Central Board of Health at the Ministry's Conference room on September 1984, the Board reviewed its earlier decision on the subject and had decided to allow the proposal of macerated raw sewage discharge from the Treasure Island Resort to sea. The decision was taken in view of the assurance of the representation and its letter JDF/vb/379 of 26th September 1984 of which both had advocated that (1) no problems will arise and (b) a trial period be invoke with a view to carry-out tests in order to ascertain the suitability of the proposal.

The Board in granting permission to discharge macerated raw sewage to sea imposes the following conditions:

(1) that this is a provisional approval for a period of twelve (12) months.

(2) that an appropriate test be carried out for a period of 1ve months by the Developers to determine any adverse effects from the discharge of the raw sewage after maceration. The test to be carried out at an interval of two (2) weeks.

(3) that the discharge points to be located at the distance of one (1) Km from the Island and also to be sufficient distance from the reef.

(4) that there should be no discoloration of sea waters.

(5) the bacterial standard of the sea, swimming and snorkling area to conform with the W.H.O. standards.

CONT:..2//

(6) that there are no physical or visible pollutions or nuisance.

(7) that there should be no discharge of grease with the contents.

(8) that there are no distruction of Marine ecosystems and biota.

(9) that test to be carried out are to be determined by the Ministry of Health and Social Welfare or its Consultants.

(10) that the Developers are to pay all cost pertaining to the test and related matters.

The meeting reaffirm that the Board's letter MD.17/18/7 of 25th July 1984 would become applicable should the conditions of approval have not been complied with in anyway and in unequivocal terms regarded the proposal permission as an isolated case and is restricted to the Treasure Island only.

Yours faithfully

Acting Secretary
CENTRAL BOARD OF HEALTH.

3709

RDL

c.c.
Hon Mr. O.B. Costello
Island in the Sun (Fiji) Group
P.O. Box 364
LAUTOKA.

The Secretary
Lautoka Rural Local Authority

The Director
Town & Country Planning

MIA/svn.

APPENDIX 2

PROPOSAL FOR MONITORING SEWAGE DISPOSAL AT TREASURE ISLAND

In response to the request of Mr Jim Finlay of Harrison & Grierson Ltd. and in accordance with discussions between Mr Finlay, Mr Hasrat Ali of the Ministry of Health and Social Welfare and Mr Jon Brodie of the Institute of Natural Resources (INR), USP on 18 October, 1984 INR proposes the following monitoring scheme for the new Treasure Island sewerage system. The monitoring scheme aims to satisfy the conditions laid down by the Central Board of Health in their letter of 15 October to Harrison & Grierson.

1. Samping Frequency and Responsibility:

Sampling will occur every two weeks for the first three months of operation, the first sampling period being before discharge commences. There will be thus seven sampling periods in the first three months. INR will be responsible for the first two sampling periods, the Treasure Island Management (TIM) for the third and alternatively after that. Thus responsibility will be as follows:

Sampling Period	Responsibility
1	INR
2	INR
3	TIM · 2 weeks after flows st
4	INR
5	TIM
6	INR — 2 "
7	TIM 2

During the first sampling period underwater photographs of the discharge site and surrounding areas will be recorded. These can provide a baseline record in future assessments. Sampling frequency and responsibility for the remaining months of the trial period will be reviewed in consultation with the Central Board of Health and Harrison & Grierson after the initial three months of monitoring.

TREASURE ISLAND SEWERAGE SCHEME MONITORING

ORGANIZATIONAL ARRANGEMENTS

1. The first sampling period will require two days and INR will supply an underwater photographer but will not charge a fee for his services (except for film, developing and printing costs, scuba air refills, etc.). Thus transport and accommodation costs for two people will be met by TIM.

2. For sampling periods 2, 4, 6 one person for one day will be necessary. TIM will provide transport (Suva - Treasure Island - Suva) and use of a small boat to work from. It would ease transport problems if Scuba tanks could be provided at Treasure Island if these are available.

3. For sampling periods 3, 5, 7 the samples must be collected by TIM and delivered to the INR laboratory on the same day. Samples should normally be analysed with six hours of collection but up to 24 hours can be tolerated. Details of sampling methods will be provided during the first sampling period.

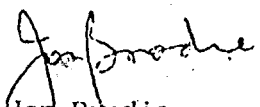
COSTING

This will depend somewhat on the number of samples collected and number of parameters measured but the following gives an approximate breakdown.

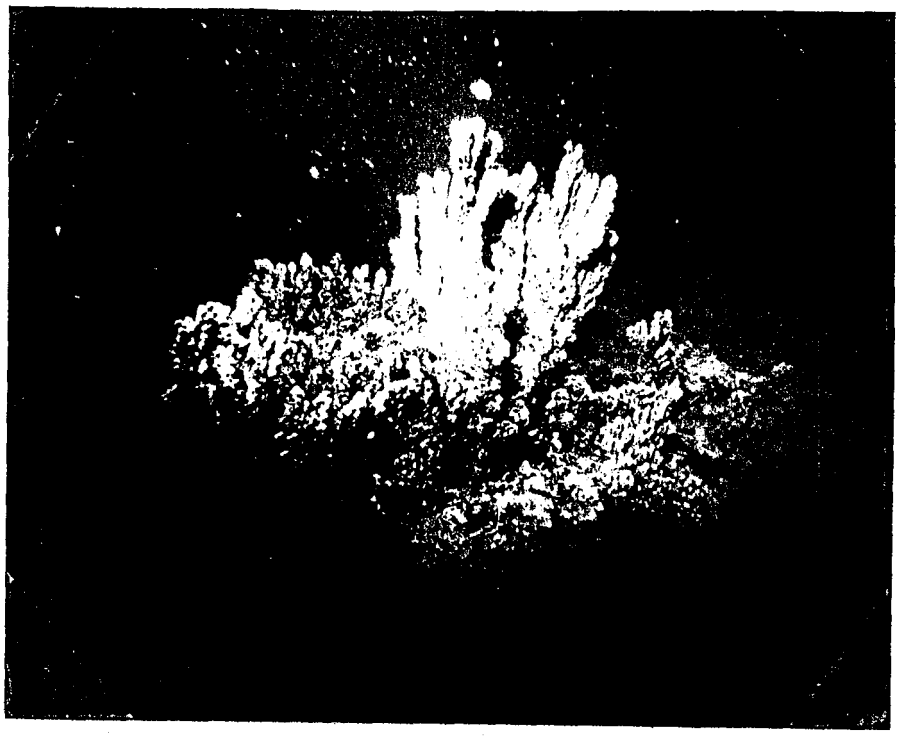
Sample Period 1 :	Consultant Time	$320.00
	Photographic costs	$ 80.00
	8 Total coliform samples	$ 80.00
	8 Faecal coliform samples	$ 80.00
	5 Nutrient samples	$ 60.00
	Meals (if not supplied)	$100.00
	Report preparation	$ 10.00
		$730.00
Sample Period 2 :	Consultant time	$160.00
	8 Total coliform samples	$ 80.00
	8 Faecal coliform samples	$ 80.00
	5 Nutrient samples	$ 60.00
	Meals	$ 12.00
		$392.00

Sample Period 3 :	8 Faecal coliform samples	$ 80.00
Sample Period 4 :	Consultant time	$160.00
	8 Faecal coliform samples	$ 80.00
	5 Nutrient samples	$ 60.00
	Meals	$ 12.00
		$312.00

The remaining sample periods will be as for periods 3 and 4. Over three months the cost will be approximately $2,000 plus transport and accommodation costs.



Jon Brodie
INSTITUTE OF NATURAL RESOURCES



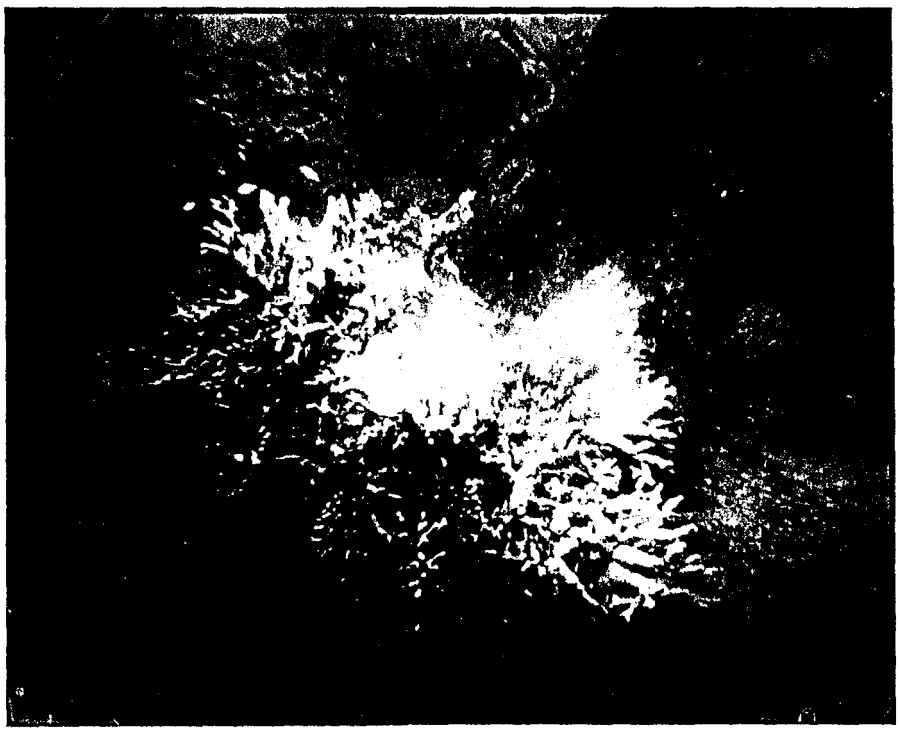


FIGURE 3. CORAL FORMATIONS

FIGURE 4. CORAL FORMATIONS

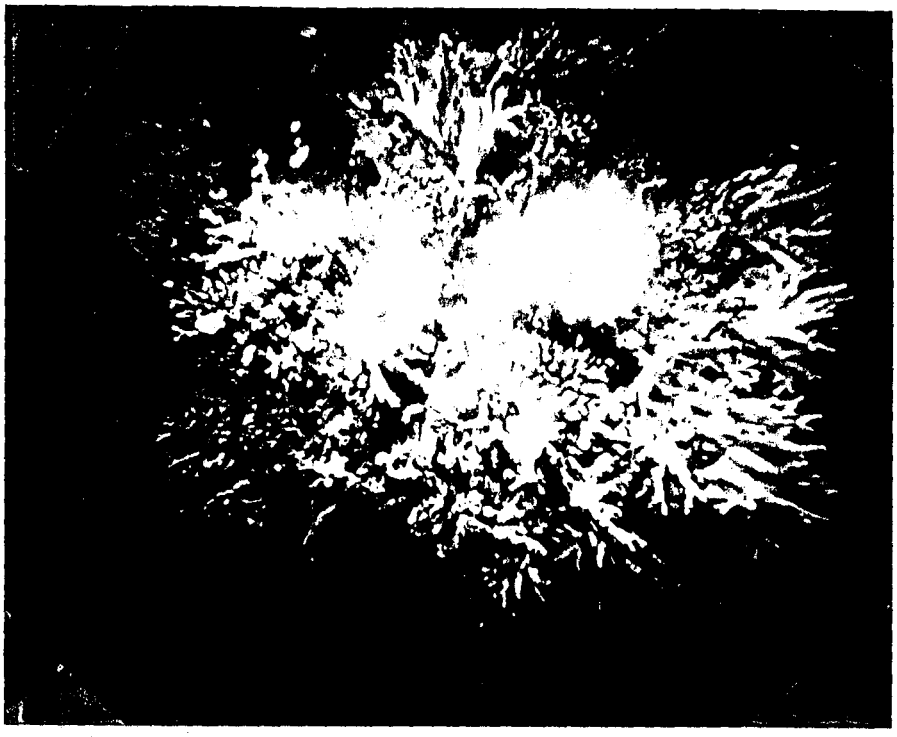


FIGURE 5. CORAL FORMATIONS

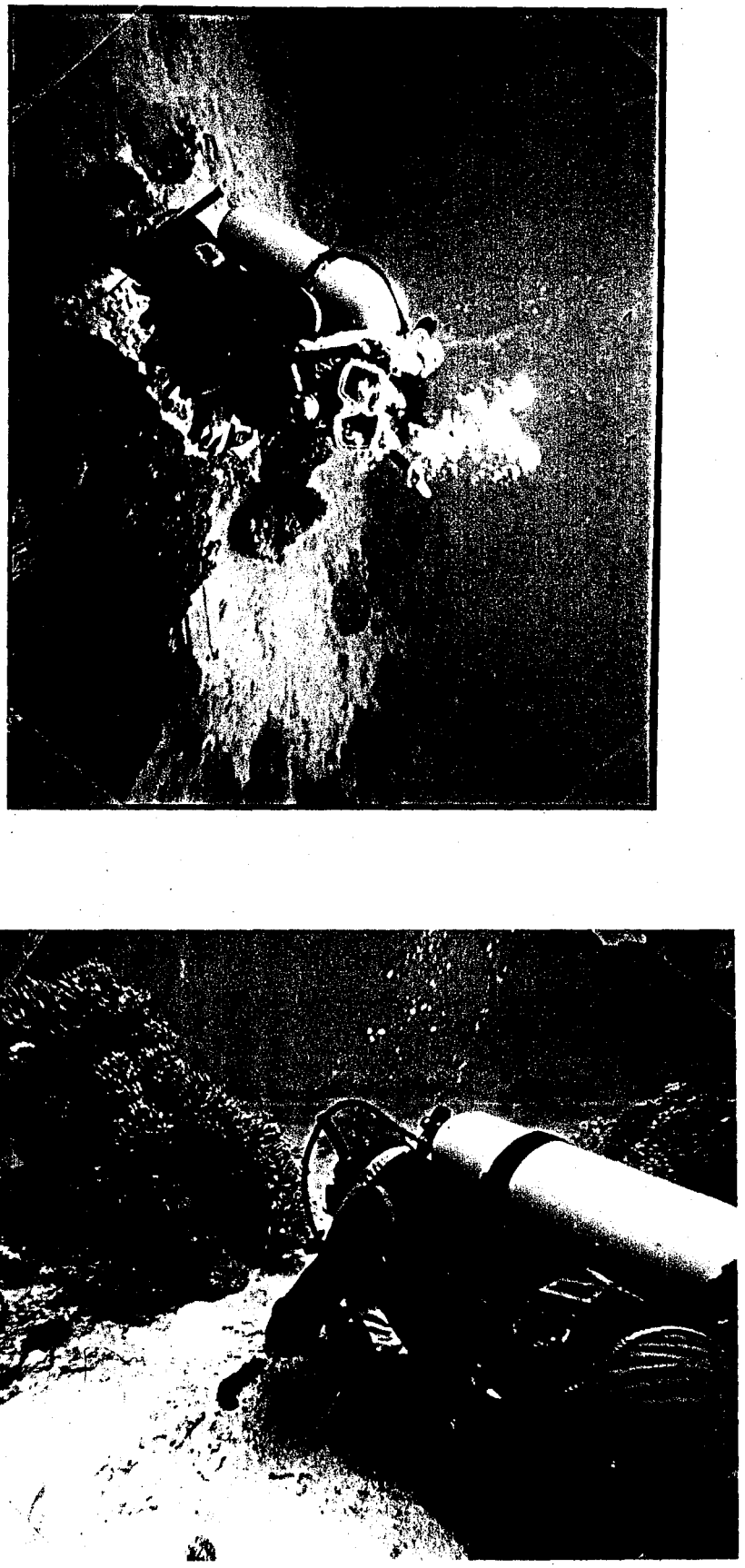


FIGURE 6. MARKED TRANSECT