

INSTITUTE OF APPLIED SCIENCES

THE UNIVERSITY OF THE SOUTH PACIFIC

WATER QUALITY IN THE MONASAVU
RESERVOIR AND WAILOA RIVER
IN 1997

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by

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WATER QUALITY IN THE MONASAVU RESERVOIR

THE FIVE WEIR SITES AND THE WAILOA RIVER

1.0 INTRODUCTION

The Institute of Applied Sciences, University of the South Pacific (USP), as done previously, prepares a report annually on the Water Quality status of the Monasavu Dam, the Five Weir sites and the Wailoa River. With funding provided by the Fiji Electricity Authority (FEA), USP has been monitoring the Monasavu Dam and Wailoa river since 1985. A further five sites were included in 1990 upon request by the FEA. These are the weirs - Wainisavulevu, Wainabua, Wainikasou (North and South) and Nabilabila. There are usually two monitoring programmes carried out during the year: July (winter monitoring), and December (summer monitoring).

A biological (invertebrate) study is carried out once yearly at the dam and weir sites by the School of Pure and Applied Sciences (SPAS). This year (1997) the invertebrate study was undertaken during the December monitoring.

The presence of water weeds in the weirs has caused some concern and had prompted the FEA to seek assistance from the Ministry of Agriculture. A month prior to the IAS July visit, the Fisheries Department officials conducted a study on the weed problems at the dam and weir sites. Subsequently selected fish species were then released in the water to control growth of weeds.(per.comm; John/Ram). This is discussed in some detail below.

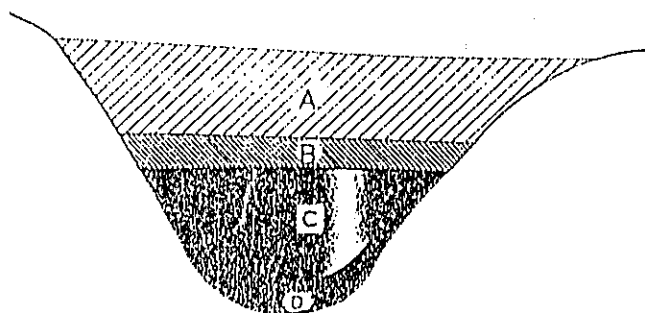
2.0 BACKGROUND

The monitoring programme over the last 13 years has highlighted certain trends about the water quality of the dam, the weirs, and the Wailoa river. This years report however would focus on any major differences from these. Some established phenomena include the following :

1. Fiji's seasonal climate is a result of its tropical location and high rising topography, in relation to the wind patterns of the Southern hemisphere. Fiji lies in the Southeast tradewinds belt. Effects of this is very visible from the peaks of the Monasavu hills where there is a marked difference in the vegetation type: rainforests towards the east, and sunburnt ("talasiga") lands towards the west. The dam is located on the wetter, eastern slopes of the Nakauvadra range.
2. Water levels in the dam are usually lower in winter, the cool and dry season. However, comparison of 1996 and 1997 dam levels (Appendix A) showed levels differing by as much as 10 - 15 meters. 1996 was extremely dry with the dam level hovering about the critical height of 725 meters. In contrast, 1997 saw levels fluctuating around the 740 meter mark, with the spillway spilling in many occasions. These are evidence of the extreme weather conditions brought about by the El Nino. For our study, the increased discharge into the reservoir in 1997 is one of the possible explanations for the sharp increase in the levels on nitrates.
3. The water quality of the dam has been improving over the years. (Chand and Fung, 1996). Nutrient levels and other parameters in the reservoir are generally within the standards recommended for Fiji under the Recreation Water Criteria (NEMP, 1992).
4. There is usually a clearly-defined impact of the seasonal variation on the Monasavu reservoir. During the December summer monitoring, (unless disturbed), surface water temperatures of the lake are usually higher contrasting sharply with

cooler, more dense waters underneath. Stratification thus occurs due to thermal resistance to mixing (Chand and Fung, 1996). During the July winter monitoring, the cooler ambient temperatures disrupt this stratification.

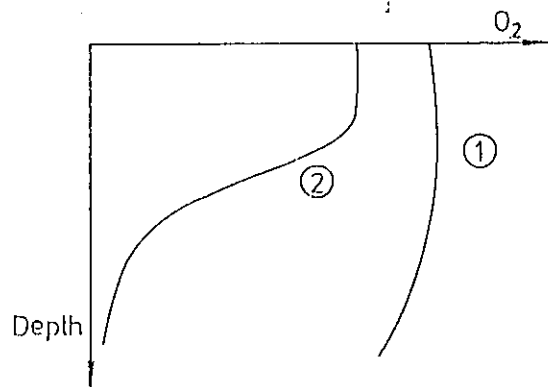
Figure 1.0 An example of thermal stratification. A) Epilimnion B) Thermocline C) Hypolimnion D) Mud



(source : page 85, Jørgensen and Johnson)

5. Temperature and density stratification in waters results in poor circulation throughout the water column. Previous data for the reservoir shows that the distribution of dissolved oxygen is much better in winter than in summer. (Fig 4, 5, 6). However low oxygen levels characterise the bottom waters due to thermocline barriers and the decomposition and respiration activities that demand oxygen. High dissolved oxygen levels at the surface are due to a combination of atmospheric reaeration, turbulence, and photosynthetic processes by algae and phytoplankton.

Figure 1.1 Oxygen profile in a stratified lake : winter condition (1), summer condition (2). (source : page 84, Jørgensen and Johnson)



6. The body of water in the dam is able to maintain a stable status for most of its parameters, regardless of the changing conditions over winter and summer, e.g. pH, alkalinity and the metals iron and manganese. Concentrations of total nitrogen, ammonia and nitrates are usually lower near the surface where uptake by phytoplankton is a major activity. Levels tend to increase towards the bottom as light penetration and phytoplankton presence become less prominent. Nutrient levels tend to increase in the summer, most probably as a consequence of increased rainfall.

7. Over the years, the concentrations of the metals iron and manganese have decreased to very low levels, in most cases below the detection limits for the IAS instrumentation. This is good for the Power station at Walloa.

8. In the last few years, the presence of the aquatic weeds of the *Chara* species and belonging to the *Characeae* family, or *lumi*, at some of the weirs has caused some concern. This becomes a problem when the weeds block the weirs, and cause a reduction in the amount of water flowing into the reservoir. Growth of the weeds was noted at three of the weirs; Wainisavulevu, Wainikasou North, and Wainikasou South. The weed control section of the Ministry of Agriculture provided assistance by releasing a few different species of fish (mainly *Tilapia* sp.) to graze on these weeds on the 15th - 16th of August in 1996. In the

summer, these weirs were observed, and it was found that there was no *lumi* (*Chara sp*) at Wainisavulevu and Wainikasou North, and only a small amount at Wainikasou South. These preliminary findings indicated that the scheme is having some success and that the fish are limiting the amount of aquatic weeds growing in the weirs. More work in this area is being proposed by MAFF.

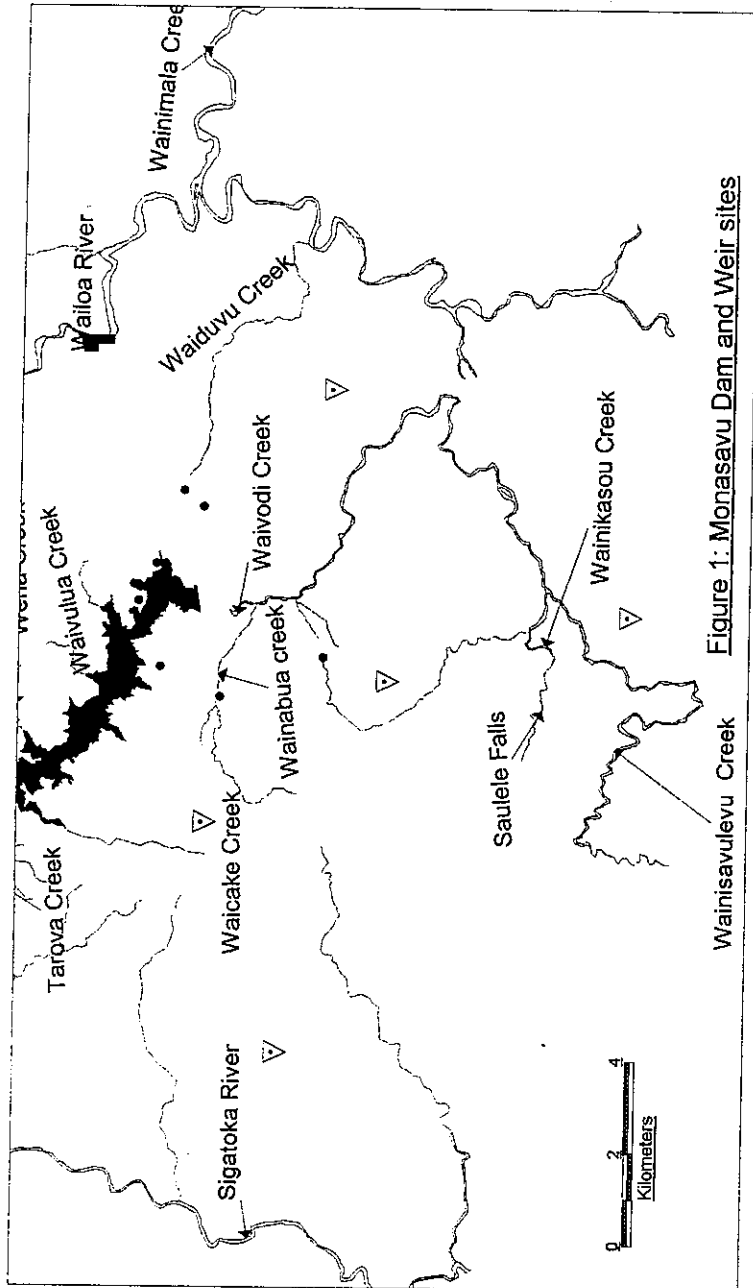


Figure 1: Monasavu Dam and Weir sites

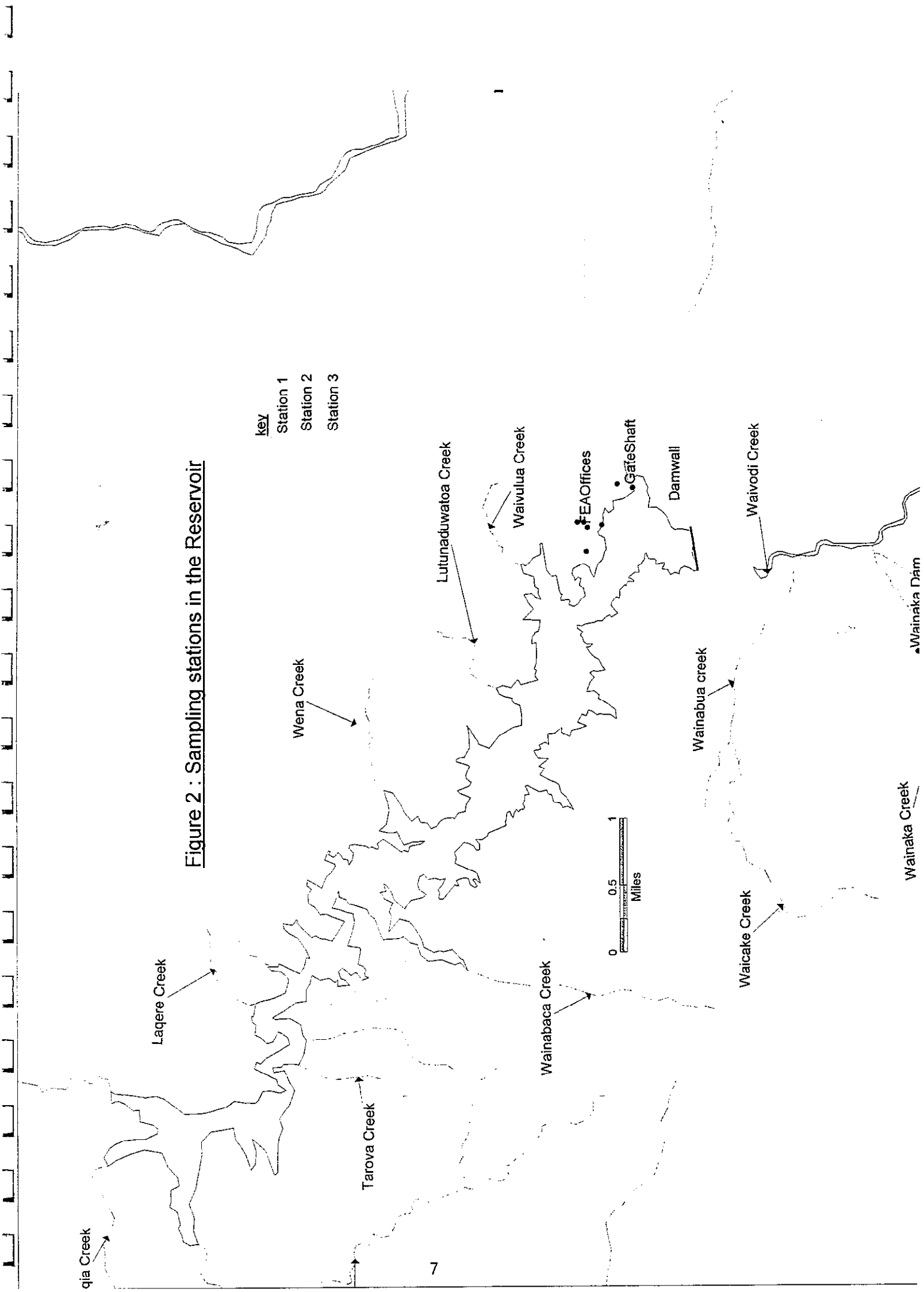


Figure 2 : Sampling stations in the Reservoir

- key**
- Station 1
 - Station 2
 - Station 3

0 0.5 1
Miles

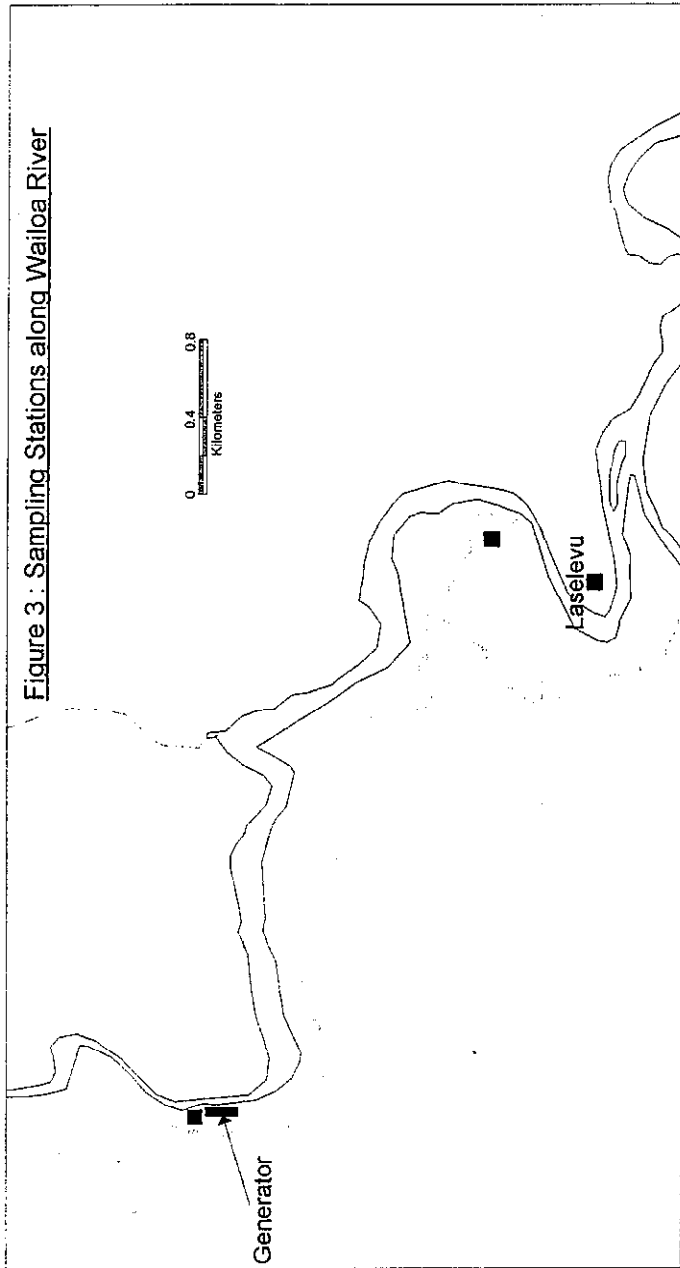


Table 1 : Summary of 1997 Water Quality Monitoring Programme

Location	No. Of sites Monitored	Description of Stations	Monitoring Sequence	Parameters Measured in lab	Parameters Measured on site
Reservoir	3 stations (surface - depth)	Station 1 - near dam wall Station 2 - near outflow to P.S. Station 3 - near the Wena Creek junction at the other end of the dam.	June 30th Dec 10th	pH, alkalinity, nutrients (nitrates, Total N, ammonia, Total P), iron (Fe) and manganese (Mn)	pH, clarity, depth, temperature/dissolved oxygen (DO) profiles, GPS readings. Water samples collected from surface, mid-depth and bottom.
Wailoa River	3 stations	Station 1 - 100m above Power St. Station 2 - Tailrace Station 3 - Wailoa at Laselevu village	July 1st Dec 9th	As above	As above (excluding depth and clarity). Water samples collected from near surface.
Weirs	5 stations	Wainisavulevu Wainikasou North Wainikasou South Wainabua Nabilabila	June 30th Dec 9th	pH, total and dissolved Fe and Mn, total dissolved solids (TDS), total suspended solids (TSS)	pH, Temp., DO.

3.2 Methodology, Parameters and Sampling Stations

On-site measurements

At the weir sites and the Wailoa river the parameters were measured in the surface waters. Sampling is usually done on the first day of field work. In the dam, temperature and dissolved oxygen were measured at 1 meter intervals down to the bottom. The maximum depth of the water at each station was determined using the water sampler.

A YSI Model 51B Dissolved oxygen meter was calibrated on site and set at its correct altitude to take DO and temperature readings. A Horiba multimeter was also taken and calibrated to take on-site measurements. Because of its short cord, it was not used in the dam stations at depth.

Altitude and positions of the site were determined with the use of the hand-held Ensign GPS (Trimble Navigation). A minimum of 3 satellites was required to get an accurate bearing which is then plotted on a map created by the use of GIS below. (Table 1.1).

Site Description	Time	Altitude	Longitude	Latitude
Wainikasou North	12.00	2900ft	178.0286	17.82363
Wainikasou South	12.20	2900ft	178.0286	17.82363
Nabilabila	12.33	2900ft	178.0377	17.80612
Wainisavulevu	10.50	2800ft	178.0233	17.83847
Wainabua	1.04	2600ft	178.0305	17.76062
Laselevu village	8.30		178.1300	17.74872
Above Power St	9.15		178.1023	17.73725
At Tailrace	9.25		178.1023	17.73725
At FEA Lodge	11.00	2500ft	178.0522	17.75215

Clarity was measured using the multimeter and the secchi disk. Clarity is the depth at which the disk is almost faintly visible under water.

A copy of the dam levels for over the past two years was obtained from FEA for comparisons with present levels. These are appended (Appendix A).

Laboratory Analysis

The samples were brought back to the lab and analysed immediately for nutrients. This was necessary as nutrients could deteriorate over time. A brief description of each analysis was given in 1996 report (Chand and Fung.) The procedures have remained the same. Spectrophotometry was the main technique used in the analysis of nutrients and metals. No chlorophyll measurements were taken.

Alkalinity was measured by titration.

pH was measured using the Orion model 250 pH meter

Nitrate was measured using the Cadmium Reduction/Colorimetric method.

Ammonia was analysed using the phenate method.

Dissolved phosphate was measured using the Molybdenum blue-Colorimetric Method.

Total Suspended and Dissolved solids were measured using the Filtration/Gravimetric method.

Metals were analysed by direct Atomic Absorption/Emission Spectrometry.

4. RESULTS AND DISCUSSION

The data on the water chemistry for the reservoir, weirs and the Wailoa river for the winter and summer monitoring are provided in tables 2 and 3 respectively. Figures 5-10 illustrate the temperature, nitrate and dissolved oxygen profiles from the reservoir stations for the winter monitoring, and figures 11-16 for the summer monitoring.

This year, due to limited staff availability, it was not possible to carry out sampling and analysis for chlorophyll, as has been done in previous years. Weed growth in some of the weirs is discussed in section 4.3.d below.

4.1 The Monasavu Reservoir

a) *Temperature and dissolved oxygen profiles*

For the winter sampling, both temperature and dissolved oxygen levels were fairly constant at each of the sites. Surface temperatures were all between 21.0°C and 21.5°C, declining very slightly (about 2°C) towards the bottom. (refer to figures 5-7). These values are not unusual for the reservoir. The dissolved oxygen levels for the whole water column varied from 5.2 to 7.6 mg/l, with the upper part of the water having greater saturation. The fact that temperature and dissolved oxygen values are practically constant throughout the water column, and at depth indicated that mixing within the water column has not been hampered by stratification or layering.

For the summer sampling, there is a greater range in water temperatures, with the surface values being between 23.5°C and 25.3°C, and cooling towards the bottom, to about 19.0°C. (figures 11-13) Unlike the winter results, there is definitely a layering of the water, with the thermocline situated at a depth of about 10 m. The dissolved oxygen levels start at around 6.5 mg/l at the surface, but decline rapidly, within the first few meters, to fairly low values of about 1.0 mg/l

Analytical Results for MONASAVU WATER

RS97/211

Client : Fiji Electricity Authority
 Attention : Mr Rupeni Mua

Date Received: 1/07/97

TABLE 2A : WATER QUALITY RESULTS FOR MONASAVU DAM AND WAILOA RIVER - JULY 1997

Description	Station 1 Surface	Station 1 Middle	Station 1 Bottom	Station 1 Surface	Station 2 Surface	Station 2 Middle	Station 2 Bottom	Station 2 Surface	Station 2 Middle	Station 2 Bottom	Station 3 Surface	Station 3 Middle	Station 3 Bottom	Wailoa Above PS	Wailoa Tailrace	Wailoa at Laselevu
Lab. No.	97/931	97/932	97/933	97/934	97/935	97/936	97/937	97/938	97/939	97/940	97/941	97/942				
Total Alkalinity [mg/L CaCO ₃]	13.7	13.5	12.9	13.7	13.0	14.4	13.6	15.7	14.4	37.6	13.0	24.2				
Clarity [m]	3.3			3.0												
pH on site	6.91	7.15	7.08	6.88	7.13	7.31	7.09	7.31	7.30	7.26	7.95	7.77				
Total N [mg/L]	0.7	1.2	1.5	1.8	2.6	2.2	2.7	2.2	0.3	0.4	0.2	0.5				
Total P [µg/L]	<20	<20	21	<20	<20	<20	151	<20	44	47	<20	24				
NO ₃ [µg/L]	225	274	499	239	472	548	120	267	548	336	232	259				
NH ₃ [µg/L]	<12.2	53.3	81.1	<12.2	9.5	<12.2	<12.2	<12.2	<12.2	<12.2	27.6	<12.2				
Dissolved Mn [mg/L]	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07				
Total Mn [mg/L]	<0.03	0.04	0.09	<0.03	<0.03	6.4	6.4	<0.03	<0.03	<0.03	<0.03	<0.03				
Dissolved Fe [mg/L]	<0.03	0.05	<0.03	0.03	<0.03	6.25	6.25	0.05	<0.03	<0.03	0.03	<0.03				
Total Fe [mg/L]	<0.12	0.20	0.50	<0.12	0.14	15.19	15.19	0.18	0.23	0.14	0.20	0.14				
Temperature [°C]	21.5	19.9	19.8	21.5	20.0	20.0	21.0	20.0	19.5	20.3	19.7	20.2				
Dissolved O ₂ [mg/L]	6.0	5.2	5.4	6.0	5.4	5.3	7.6	5.9	4.2	8.0	8.3	8.0				
Depth [m]	-	27.5	59	-	18	36	-	8	16	-	-	-				
Dissolved PO ₄ [µg/L]	<20	32	35	<20	<20	<20	<20	<20	<20	129	<20	61				

MONASAVU WATER SAMPLES (WEIRS)

TABLE 2B : WATER QUALITY RESULTS FOR MONASAVU WEIRS - JULY 1997

Description	Wainabua	Nabilabila	Wainakasou North	Wainakasou South	Wainisavulevu
Lab No.	97/944	97/943	97/946	97/945	97/947
pH on site	7.71	6.55	7.36	7.25	8.15
Dissolved Mn [mg/L]	<0.07	<0.07	<0.07	<0.07	<0.07
Total Mn [mg/L]	<0.03	<0.03	<0.03	<0.03	<0.03
Dissolved Fe [mg/L]	<0.03	0.10	0.05	<0.03	<0.03
Total Fe [mg/L]	<0.12	0.30	<0.12	0.16	<0.12
Temperature [°C]	17.9	17.8	17.0	18.0	18.2
Dissolved O ₂ [mg/L]	8.2	9.4	8.2	8.2	9.0
Total Dissolved Solids [mg/L]	45	38	57	44	53
Total Suspended Solids [mg/L]	1	2	3	1	1

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Date

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Analytical Results for MONASAVU WATER

RS97/384

Client : Fiji Electricity Authority
 Attention : Mr Rupeni Mua

Date Received: 10/12/97

TABLE 3A : WATER QUALITY RESULTS FOR MONASAVU DAM AND WAILOA RIVER - DECEMBER 1997

Description	Station 1 Surface	Station 1 Middle	Station 1 Bottom	Station 2 Surface	Station 2 Middle	Station 2 Bottom	Station 3 Surface	Station 3 Middle	Station 3 Bottom	Wailoa Above PS	Wailoa Tailrace	Wailoa at Laselevu
Lab. No.	97/1811	97/1812	97/1813	97/1814	97/1815	97/1816	97/1817	97/1818	97/1819	97/1805	97/1804	97/1803
Total Alkalinity [mg/L CaCO ₃]	11.8	11.7	12.3	12.6	11.7	13.3	13.5	12.6	13.6	32.1	12.5	23.4
Clarity [m]	1.0	-	-	1.0	-	-	0.8	-	-	-	-	-
pH on site	9.38	6.99	6.86	9.39	6.91	6.79	8.40	6.37	6.40	8.07	6.98	7.70
Total N [mg/L]	243.6	200.6	106.5	269.6	170.8	491.9	100.4	357.5	241.9	75.7	48.1	77.0
Total P [µg/L]	<20	42	28	25	29	53	21	24	<20	48	<20	31
NO ₃ [µg NO ₃ /L]	1015.4	338.6	1455.0	3062.7	2849.8	1263.0	267.6	874.6	988.6	994.2	313.7	622.4
NH ₃ [µg NH ₃ /L]	15.5	9.7	70.3	33.9	26.3	55.7	21.4	21.2	25.5	18.8	41.7	15.8
Dissolved Mn [mg/L]	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Total Mn [mg/L]	<0.2	<0.2	0.26	<0.2	<0.2	0.25	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Dissolved Fe [mg/L]	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Total Fe [mg/L]	<0.3	<0.3	0.64	<0.3	<0.3	2.09	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Temperature [°C]	24.4	20.8	19.0	23.5	21.0	19.5	25.3	24.0	21.7	23.1	21.0	23.0
Dissolved O ₂ [mg/L]	6.4	0.85	1.05	6.2	1.2	1.0	6.8	2.7	1.3	7.6	8.4	7.2
Depth [m]	60	-	-	38	-	-	13	-	-	-	-	-
Dissolved PO ₄ [µg/L]	<20	<20	<20	<20	<20	24	31	<20	36	125	<20	<20

MONASAVU WATER SAMPLES (WEIRS)

TABLE 3B : WATER QUALITY RESULTS FOR MONASAVU WEIRS - DECEMBER 1997

Description	Wainabua	Nabilabila	Wainakasou South	Wainakasou North	Wainisavulevu
Lab No.	97/1809	97/1810	97/1807	97/1806	97/1808
pH on site	-	-	-	-	-
Dissolved Mn [mg/L]	<0.2	<0.2	<0.2	<0.2	<0.2
Total Mn [mg/L]	<0.2	<0.2	<0.2	<0.2	<0.2
Dissolved Fe [mg/L]	<0.3	<0.3	<0.3	0.77	<0.3
Total Fe [mg/L]	<0.3	<0.3	<0.3	2.15	0.33
Temperature [°C]	21.0	23.0	22.2	21.1	21.7
Dissolved O ₂ [mg/L]	7.2	8.45	7.8	9.1	7.8
Total Dissolved Solids [mg/L]	47	33.	34	27	18
Total Suspended Solids [mg/L]	4	15	7	26	5

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Date :

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Figure 5 Station 1 - Dissolved Oxygen/Temperature Profiles for Monasavu - July 1997.

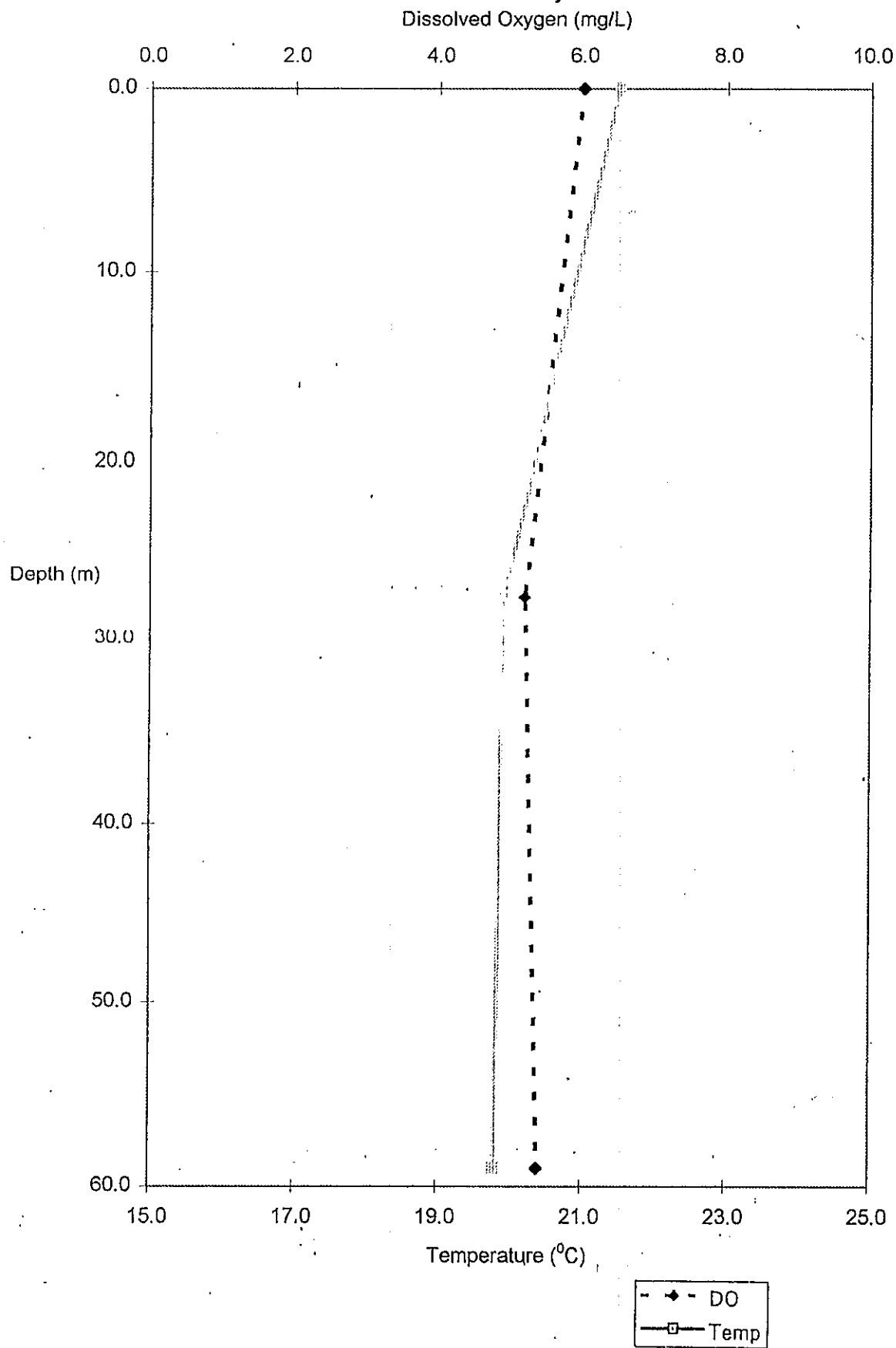


Figure 6 Station 2 - Dissolved Oxygen/Temperature Profiles for Monasavu - July 1997.

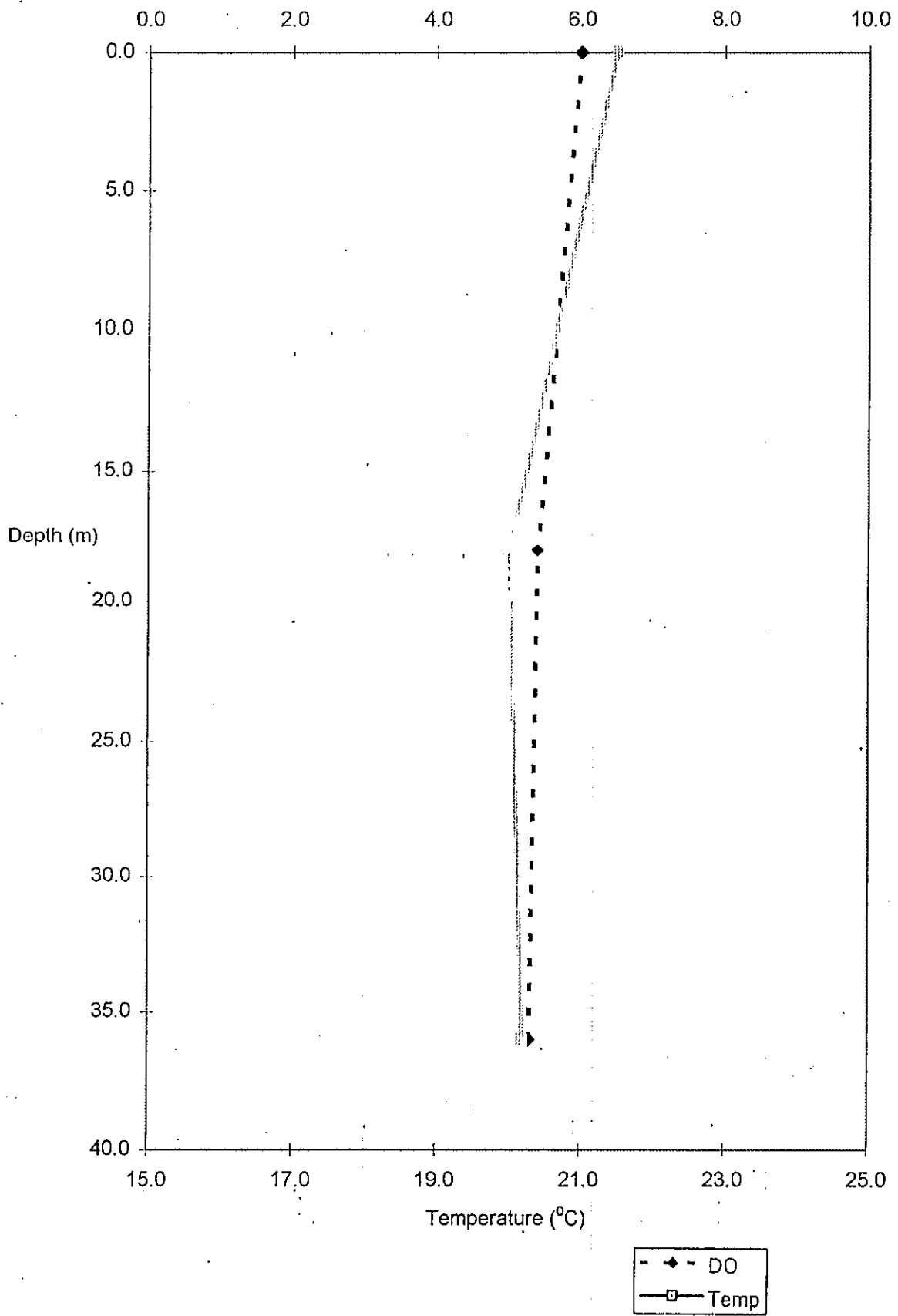


Figure 7 Station 3 - Dissolved Oxygen/Temperature Profiles for Monasavu - July 1997.

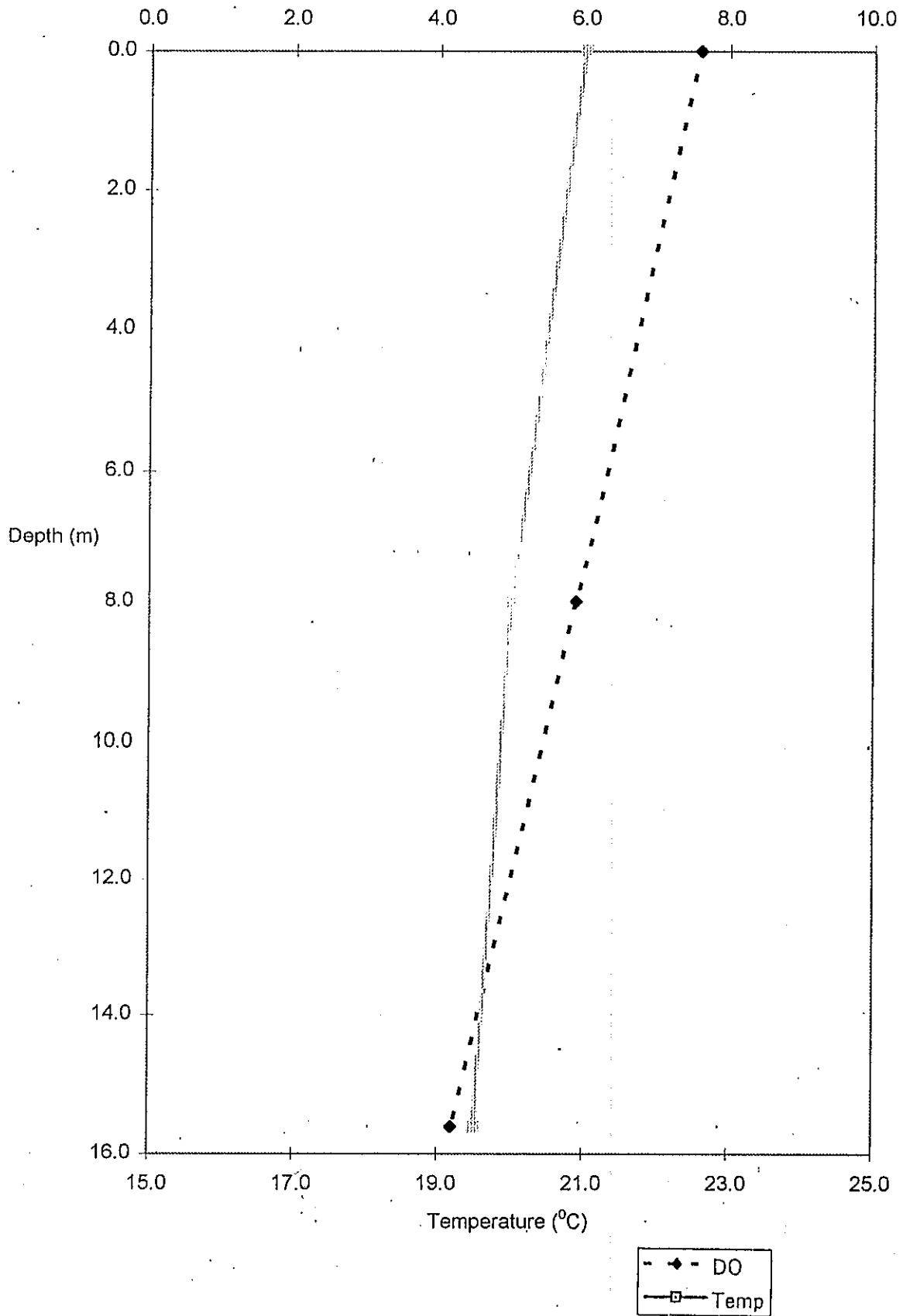


Figure 8 Station 1 - Nitrate/Temperature Profile for Monasavu - July 1997 Nitrates (ug/L)

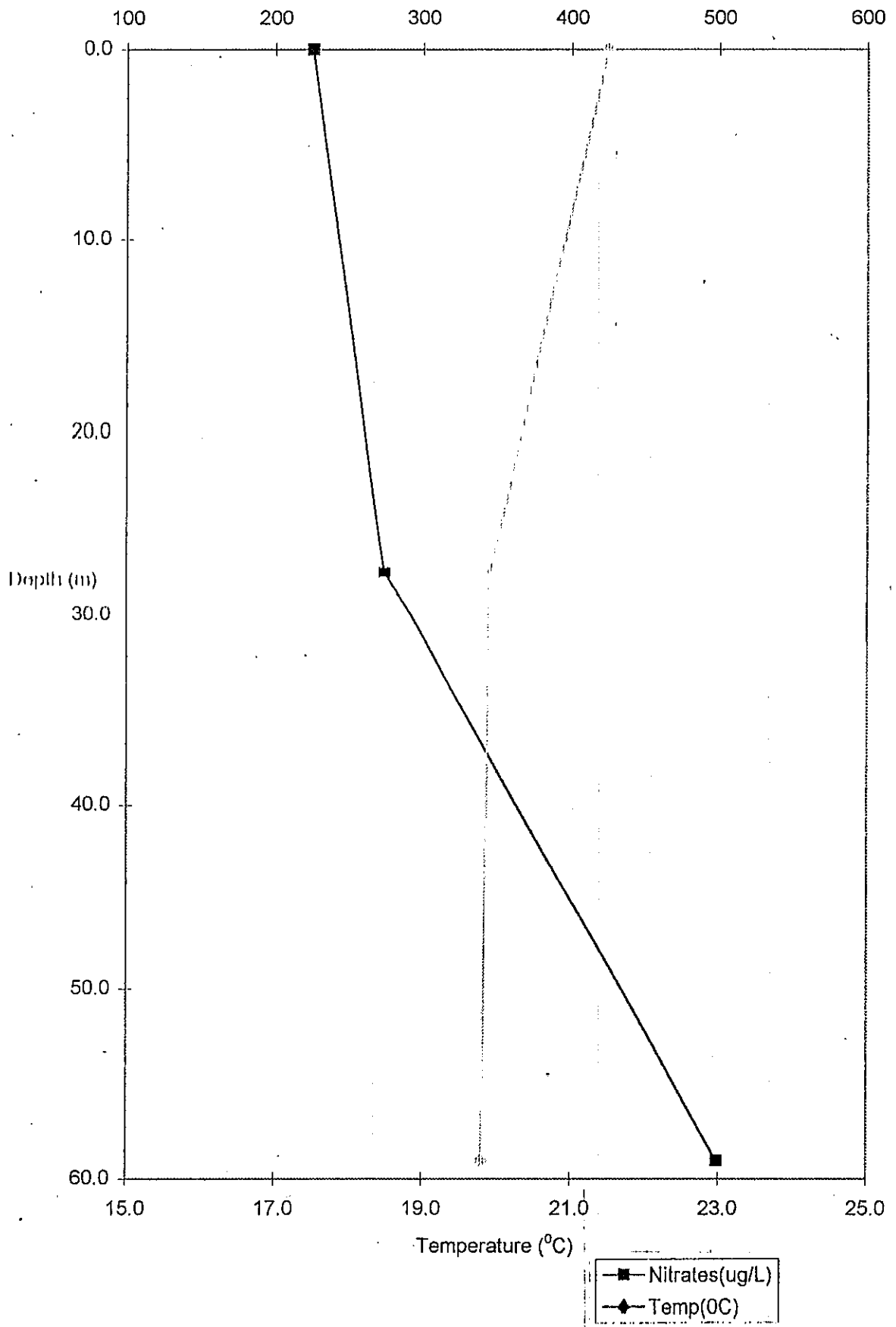


Figure 9 Station 2 - Nitrate/Temperature Profile for Monasavu - July 1997 Nitrates (ug/L)

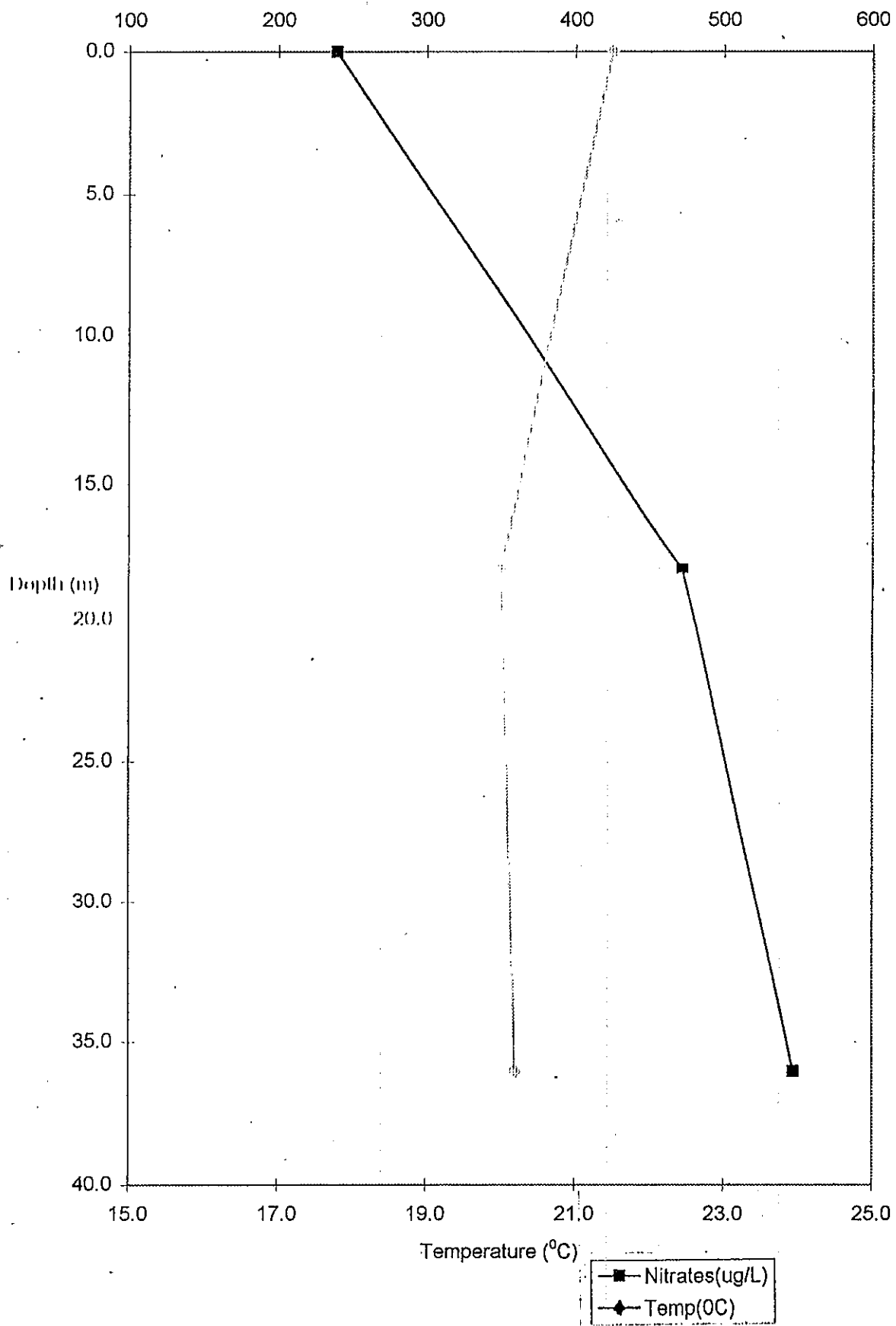


Figure 10 Station 3- Nitrate/Temperature Profile for Monasavu - July 1997 Nitrates (ug/L)

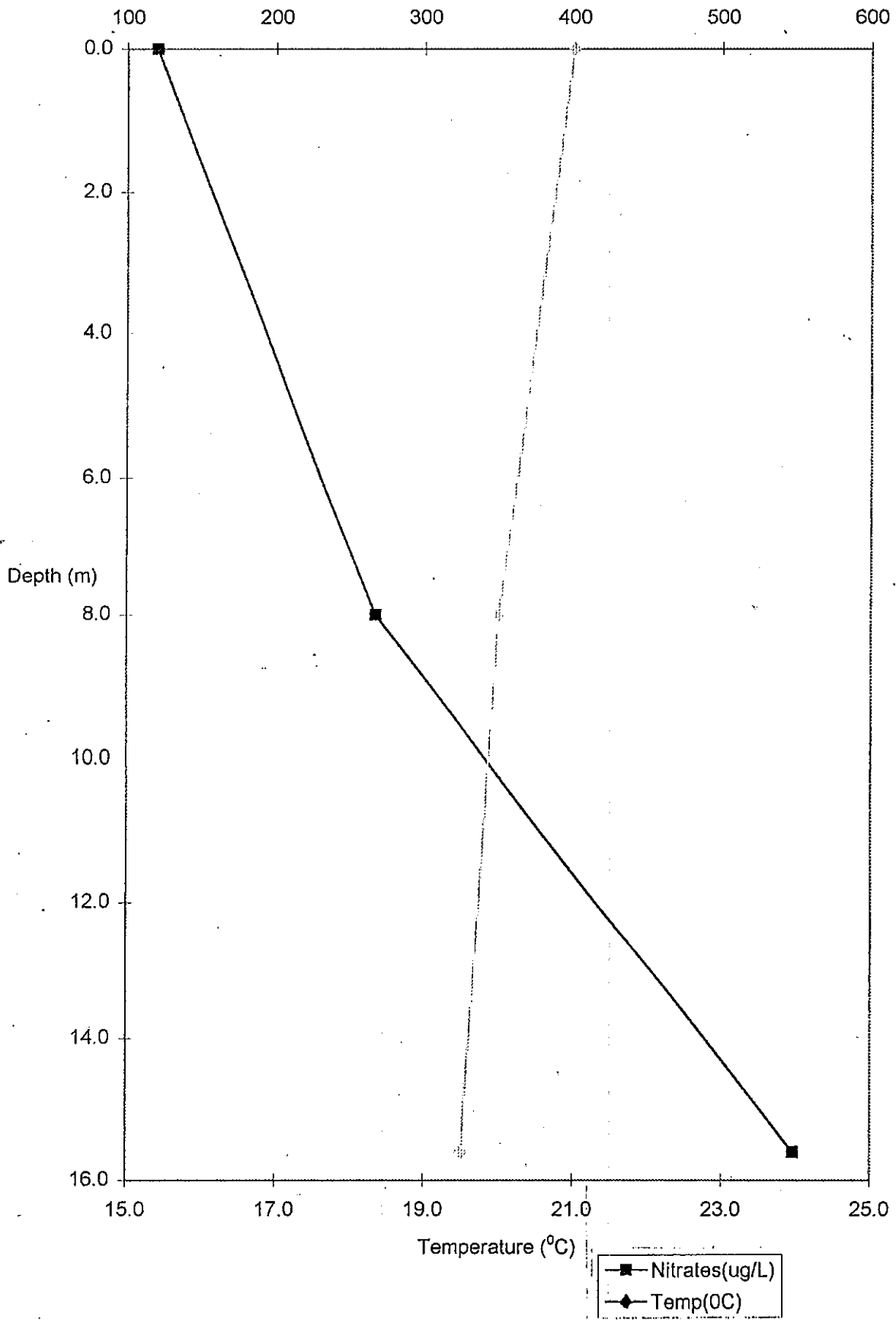


Figure 11 Station 1 - Dissolved Oxygen/Temperature Profiles for Monasavu - December 1997.

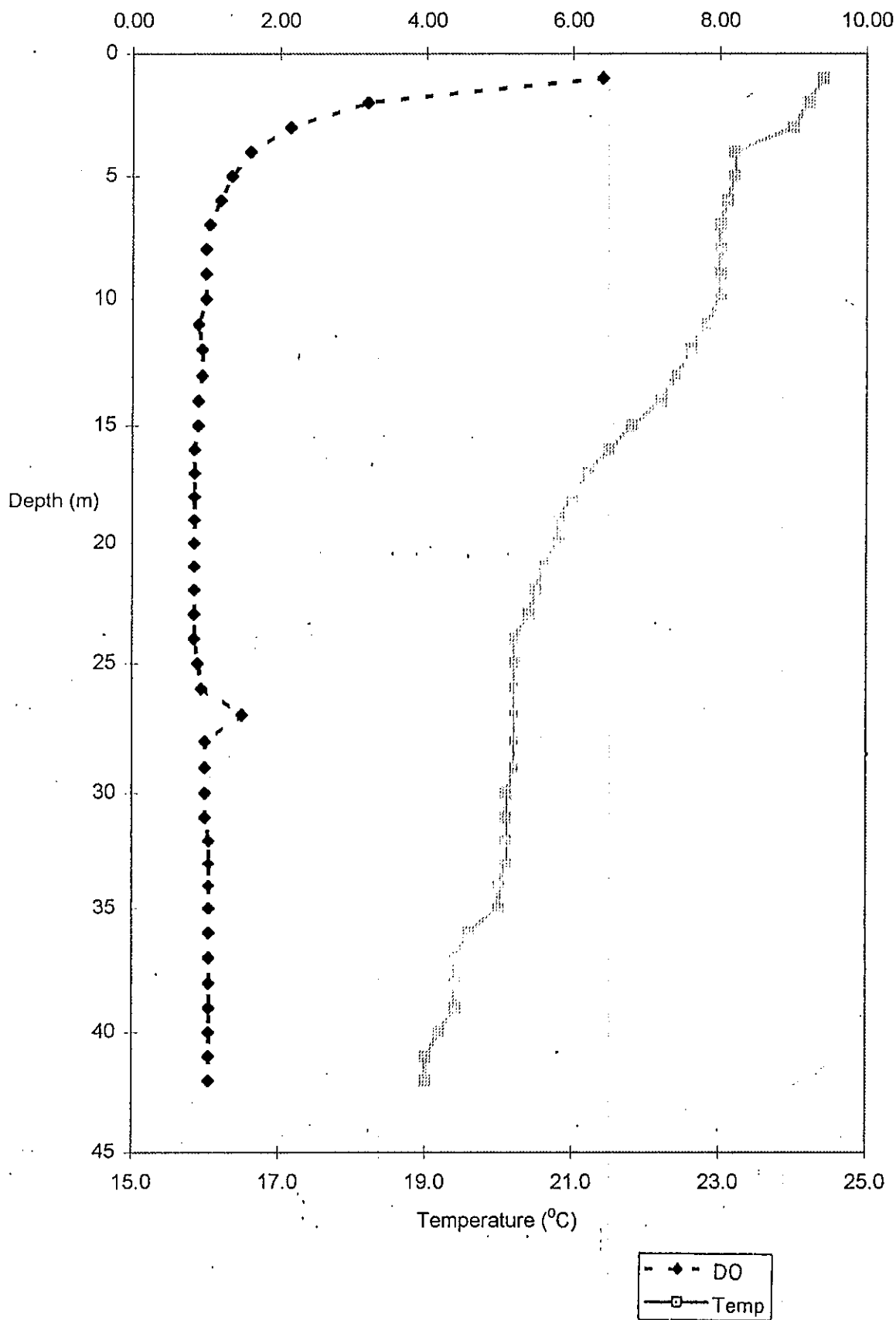


Figure 12 Station 2 - Dissolved Oxygen/Temperature Profiles for Monasavu - December 1997.

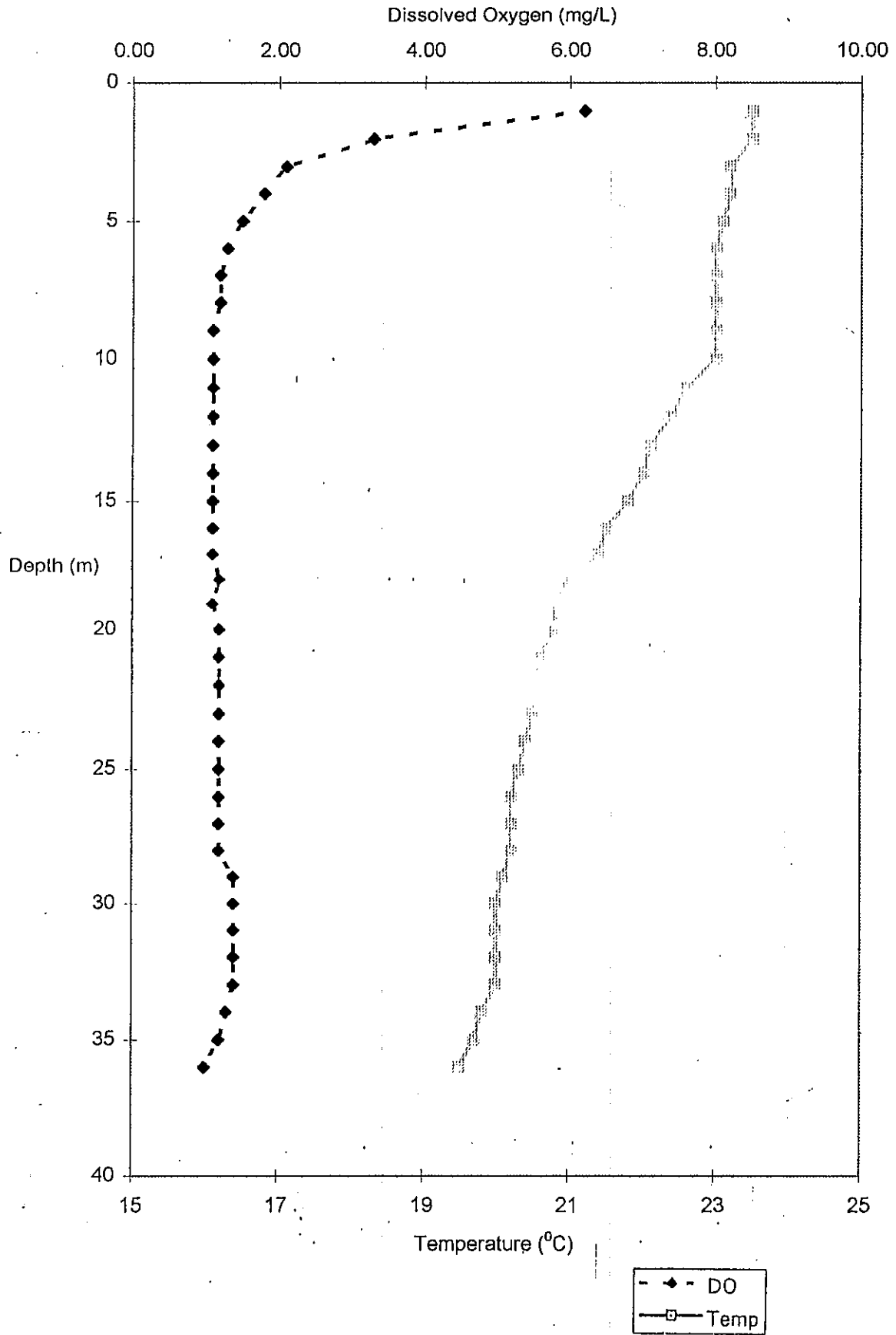


Figure 13 Station 3 - Dissolved Oxygen/Temperature Profiles for Monasavu - December 1997.
Dissolved Oxygen (mg/L)

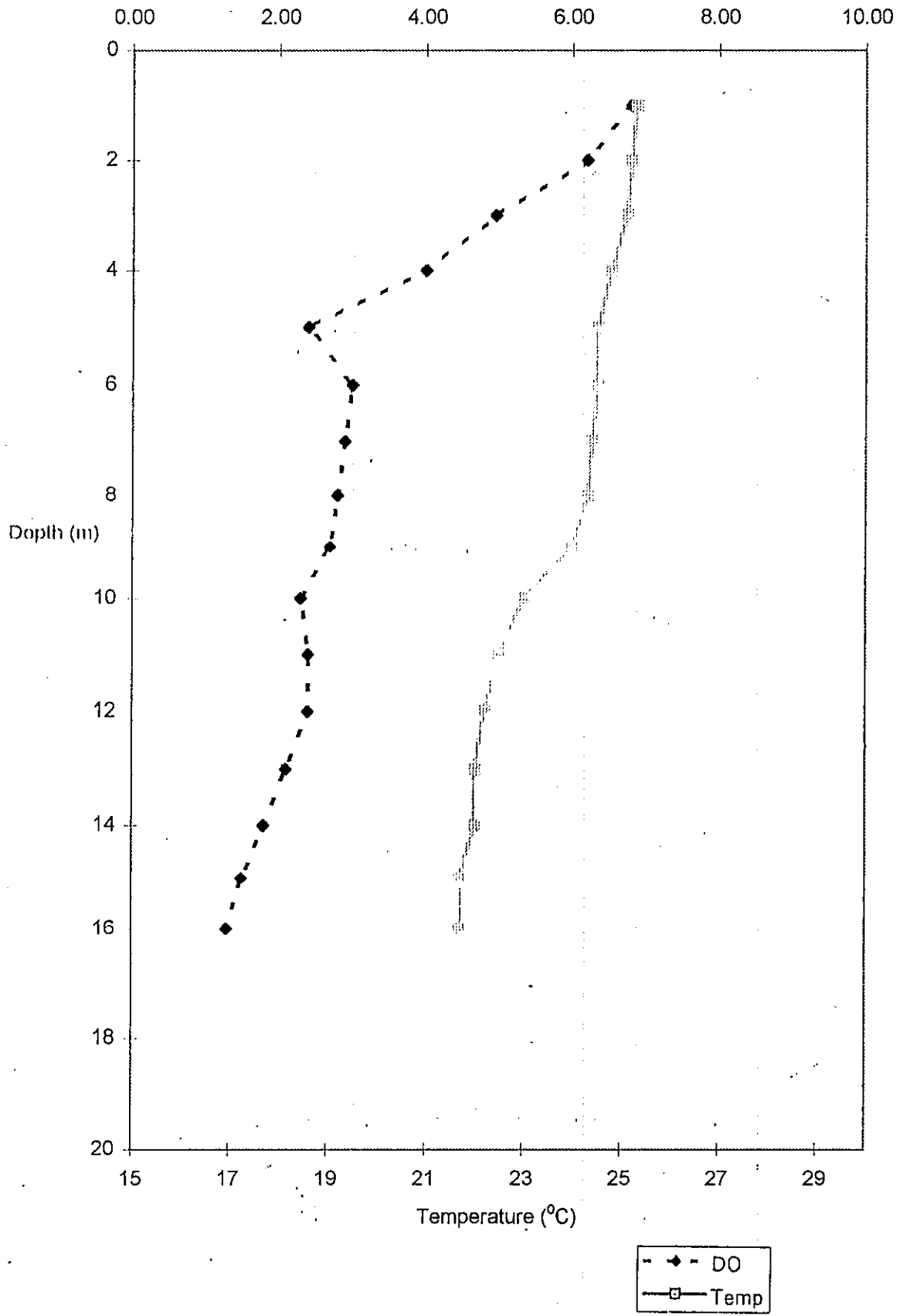


Figure 14 Station 1 - Nitrate/Temperature Profile for Monasavu - December 1997

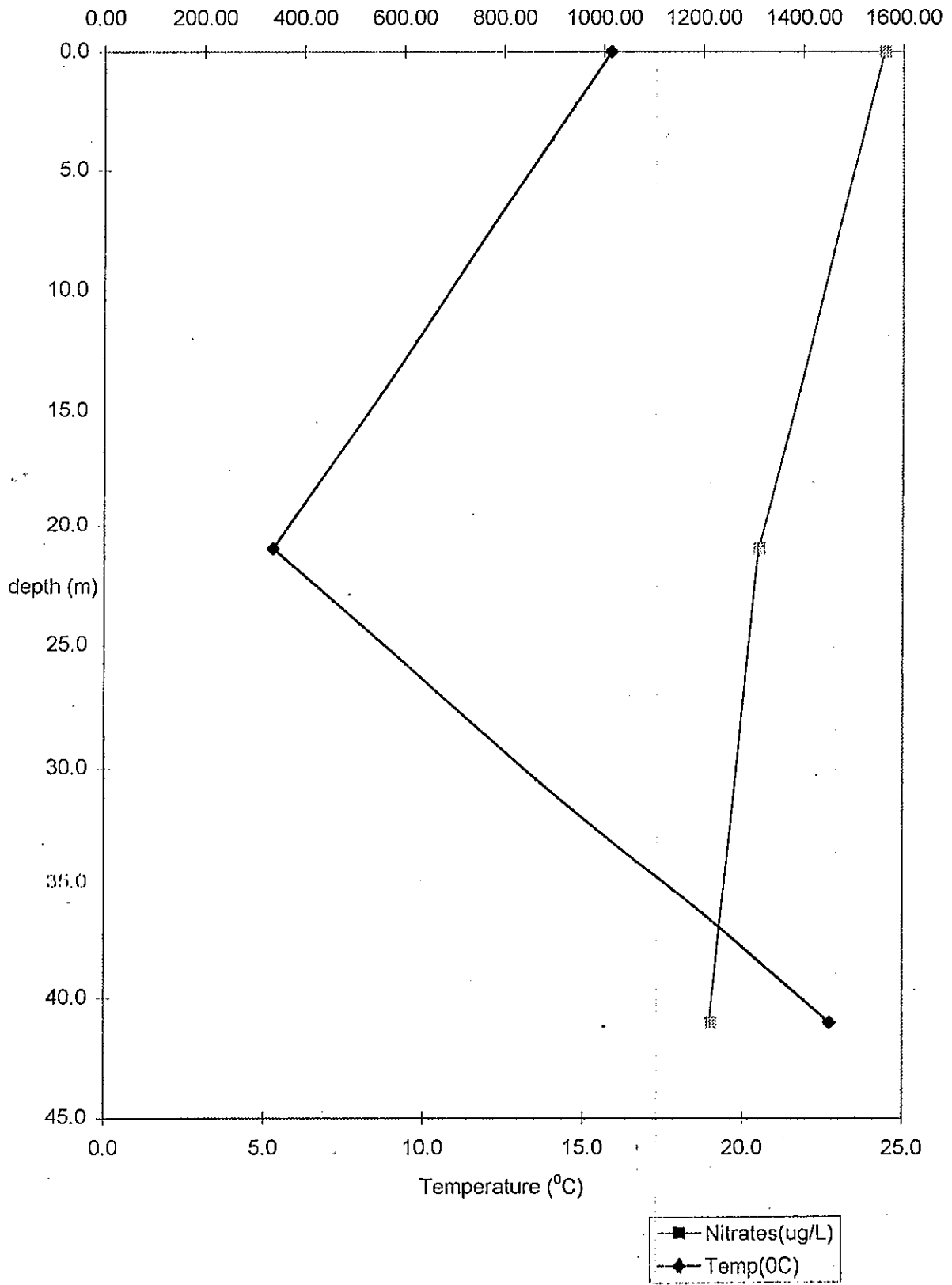


Figure 15 Station 2 - Nitrate/Temperature Profile for
 Monasavu - December 1997 Nitrates (ug/L)

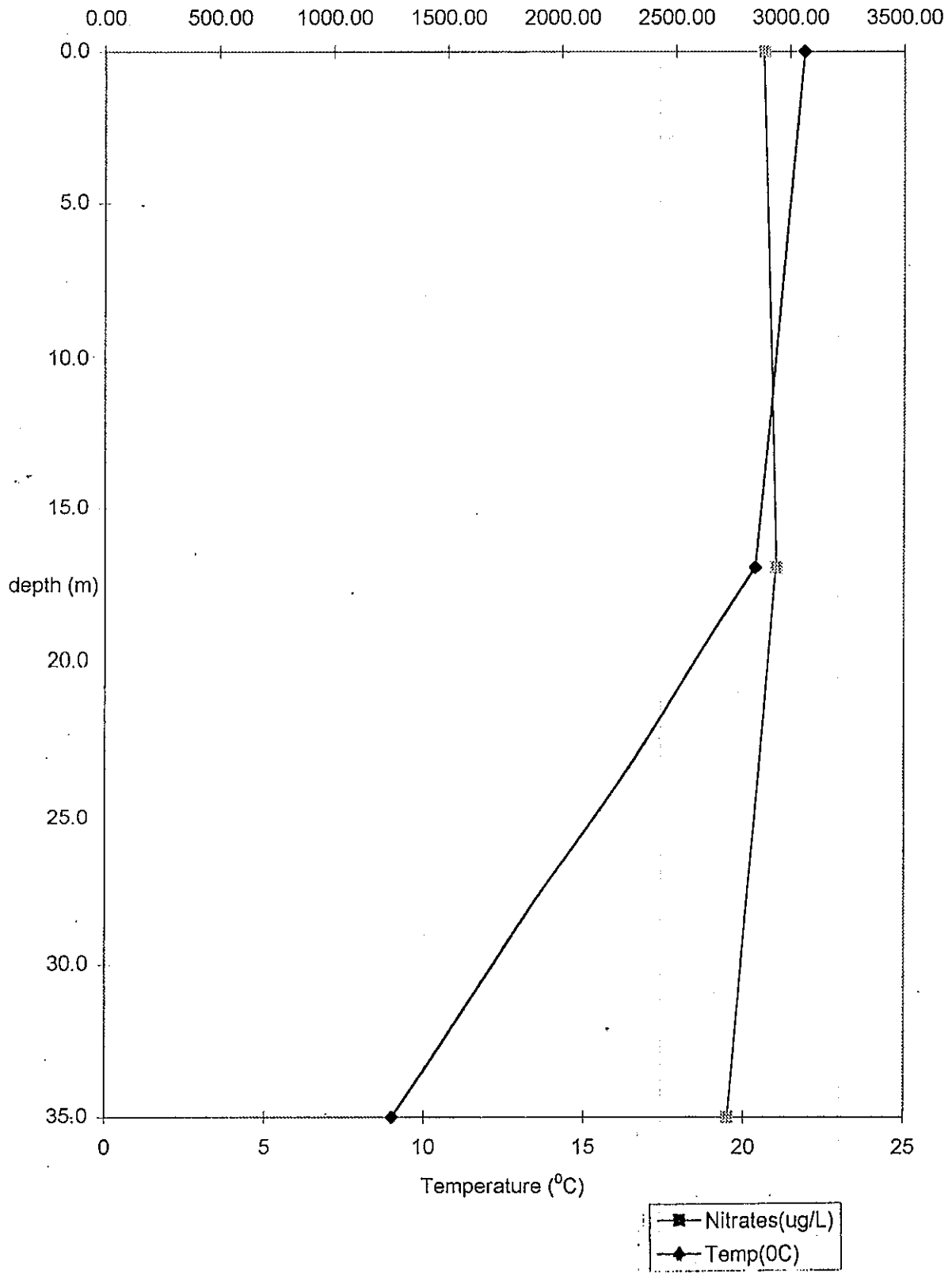
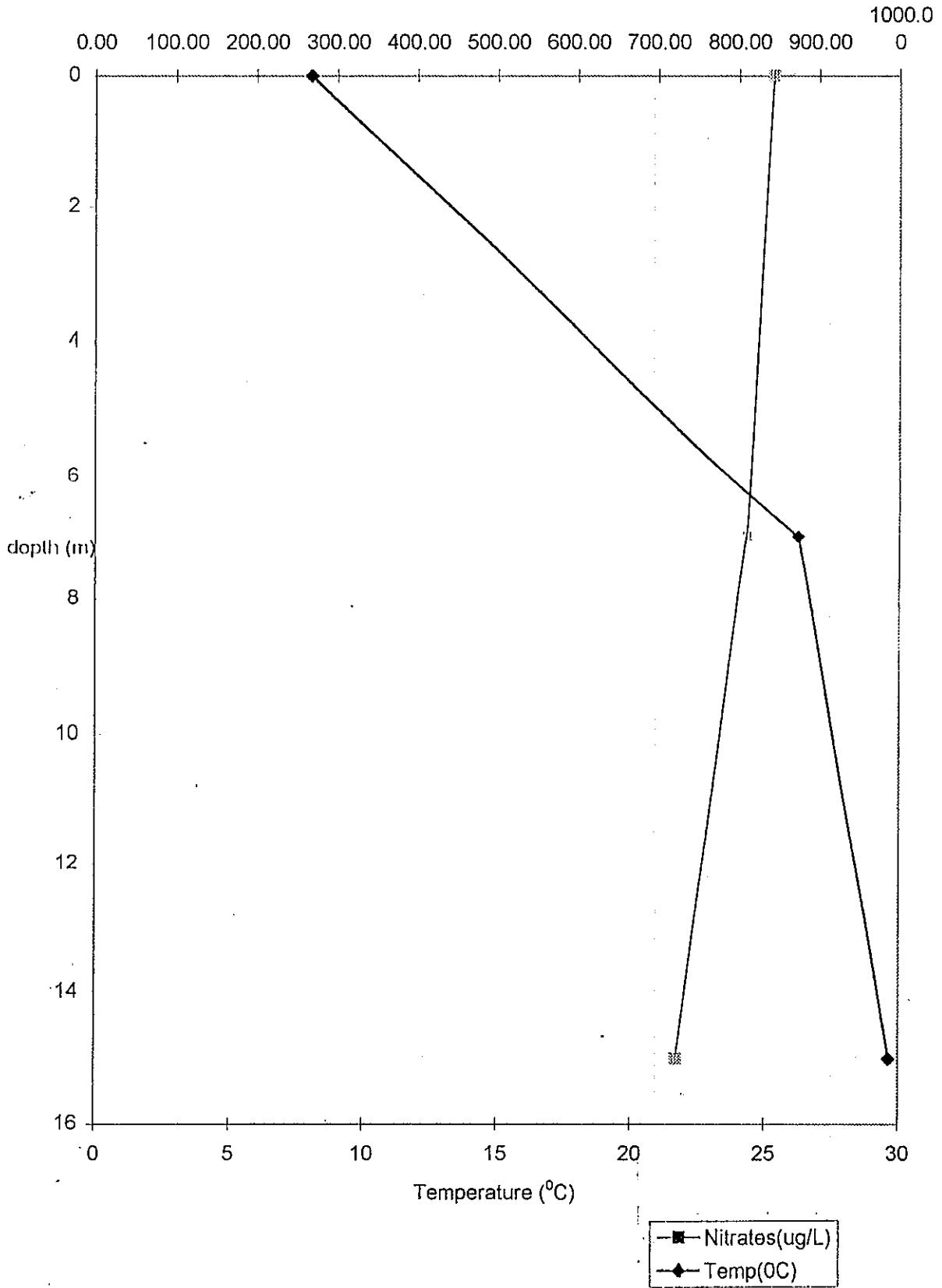


Figure 16 Station 3 - Nitrate/Temperature Profile for
 Monasavu - December 1997 Nitrates (ug/L)



in the hypolimnion. (Compare with fig 1.1) Standard values are usually 3.0mg/L (NEMP 1992) This pattern is fairly typical, and is similar to previous years results, and indicates that there is some thermally related stratification occurring in the reservoir lake during the summer (November - April).

(b) Clarity

Clarity of water in the reservoir during the winter was generally much higher than in previous years, with depths of up to 3.3 meters being visible, compared to a maximum depth of 1.9 m recorded in 1996. For recreational waters, the recommended the minimum visibility is 1.2m (NEMP 1992). The measurements taken in December, however, were lower than the past figures, and it was only possible to see to a depth of 1 m. The increased turbidity in the summer could be due to increased runoff, sedimentation or higher levels of algal biomass in the water.

(c) pH

The Monasavu reservoir forms a typical bicarbonate-type lake, with average pH values ranging from 6 to 9. According to NEMP 6 (1992), the recommended pH levels for recreational waters in Fiji is 5 to 9, which are similar to the expected range for dams (Wetzel, 1975).

Values from the winter sampling ranged from between 6.91 and 7.30, which are similar to previous results, and well within the recommended levels. The summer results showed greater variation, ranging from 6.37 to 9.39, which are generally higher than the 1996 values, but similar to 1995 values. The higher pH levels noted at the surface, could be due to a greater utilisation of carbon dioxide for photosynthesis (by autotrophic algae), relative to that used in respiration by these organisms.

(d) Total Alkalinity

The total alkalinity values measured during the winter were between 12.9 and 15.7 mg/l CaCO₃ in the reservoir. Results for the summer were in the range of 11.7 to 13.6 mg/l CaCO₃. The upper Wailoa River had a value of 32.1 mg/l CaCO₃. There is less variation in these results compared to 1994 and 1995 results. Generally speaking, alkalinity has in fact decreased over the years (1994 - 1995 - 1997). This may indicate that chemically, the reservoir is stabilising. Ideally, alkalinity levels should not decrease by more than 20% within the threshold of its environment.

(e) Nutrients

For Total Nitrogen in the reservoir, winter values ranged from 0.7 mg/L to 3.0 mg/L. Summer values ranged from 100.4 mg/L to 357 mg/L. These summer values contrast sharply with the 1.36 mg/L - 5.14 mg/L range obtained in the summer of 1994, or the 4.58 mg/L i.e. more than 100 fold increase. The large increase noted in 1997 will be closely monitored in 1998.

Ammonia levels ranged from <12.2 - 81.1 ugh/L in winter, and from 9.7 - 70.3 ug/L in summer of 1997. As in previous studies, levels of ammonia tend to increase with depth, the highest values being recorded for the deepest part of the reservoir - bottom of station 1.

For nitrates, winter values range from 225 µg/L to 548 µg/L. Summer values ranged from 267.6 to 3000 µg/L. The summer values obtained this time are the highest ever recorded since the first study in 1985. This sharp increase in nitrate levels is cause for some concern and will be monitored closely in 1998. Such a high nitrate level could be attributed to a number of factors such as heavy rainfall prior to sampling, clearing of vegetation in the area, increased organic matter input into the reservoir and variability arising from the analysis itself (technician's level of experience etc.) Nevertheless, the pattern of nitrate distribution within the

water column remains as before, with surface waters having less nitrates than the cooler, deeper waters (Tamata *et al.*, 1995, 1996).

Total phosphates and dissolved phosphates have remained relatively low in winter at values less than 20µg/L . An exception is noted at bottom depth of station 2 for Total P at 131µg/L. In summer there has been an overall but slight increase in these two parameters. Values are higher at the bottom of the lake, as is the pattern for nitrates.

(f) Total and Dissolved Manganese and Iron

The levels of total and dissolved manganese and iron are fairly constant throughout the reservoir, with values being very similar to those recorded in previous years.

In the winter, Dissolved manganese concentration was less than 0.07 mg/l for all reservoir samples. On the other hand, Total manganese varied around 0.03 mg/l, with very little difference between stations and between depths, except for the bottom of stations 1 and 2 which had much higher Total Manganese concentration of 0.09 mg/L and 0.74 mg/L respectively.

Dissolved iron concentrations varied from around 0.03 to 0.05 mg/l, on both sampling occasions, and for all three depths (surface, mid-depth and bottom). Total iron concentrations were generally higher in summer than in winter, but again with no significant variation between stations, between sampling depths and between seasons. However, the bottom of station 2 recorded the highest Total iron, as was seen for Total Manganese.

4.2 The Wailoa River

The Wailoa River was sampled at three points to assess any impact of the Power Station on the river water quality.

a) Temperature, Dissolved oxygen, Alkalinity, pH

Again there is no significant difference in temperatures for the three stations in the river during the winter and summer monitoring. The values are no different either from those recorded for the reservoir during any one sampling.

Dissolved oxygen levels indicated well saturated water at all three points along the Wailoa River, for both winter and summer monitoring. DO levels varied from 8.0 - 8.3 mg/L in winter, and 7.2 - 8.4 mg/L in summer.

Alkalinity values for all three points are within the usual range for the river and are very similar to the 1995 results (Tamata et al., 1996).

pH values are similar for all three stations in any one sampling occasion. The 1997 pH values are similar to those of previous years.

b) Nutrients

A sharp increase in Total N, nitrates and ammonia is seen in the summer values compared to the winter values for 1997. The increased nitrates levels has occurred for the reservoir samples as well in December 1997. Possible reasons for such sharp increase have been discussed above (section 4.1.e). However, Dissolved phosphate and Total phosphorus values have decreased for each site.

c) Total and Dissolved Manganese and Iron

Levels of Total and Dissolved manganese at all three sections of the river are no different from those recorded for the reservoir and all are low (below detection limits of IAS instruments). Tables 2A and 3A show this clearly.

Levels of dissolved iron has stabilised over the years (1994-1995-1996) to around 0.3 mg/L. For 1997, the results are also within this range. Total iron levels in summer are no different from the rest of the reservoir being <0.3 mg/L. The winter values also fall within the same range, all being below 0.3 mg/L.

4.3 Weirs

a) Temperature and Dissolved Oxygen

Temperatures have varied appropriately with the seasons, with no significant difference between the different weirs, and between the weirs and the reservoir. DO levels are quite high in the winter ranging from 8.2 to 9.4. In the Summer range was 7.2 to 9.1 mg/L. During sampling, only surface measurements are taken because of accessibility problems.

b) Metals- Iron and Manganese

For the metals - Iron and Manganese, all weirs have in the past shown acceptable levels (< 1 mg/L) as recommended under NEMP. However there has been an increase in the 1997 results compared to previous years. In the summer of 1997 Wainikasou North showed values of 2.15mg/L in total iron and 0.77mg/L in dissolved iron whereas in winter it showed < 0.12 in total iron and 0.05 in dissolved iron.

(c) Total Dissolved and Total Suspended Solids

The Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) levels were recorded at the five weirs. TDS values ranged from 38-57 mg/l in the winter, and 18-47 mg/l in the summer. TDS values have varied over the years. The 1997 winter values are similar to those of July 1994, but much lower than those for July 1995.

TSS levels were slightly lower than previously. The winter values ranged between 1 and 3 mg/l, and the summer values ranged between 4 and 26 mg/l. TSS values have also varied a great deal from season to season, and from year to year. The levels of TSS are influenced by a number of factors including amount of rainfall, stability of parent material in the area, organic matter input etc. An additional source of organic matter input in the creeks and reservoir is livestock such as cattle.

(d) Aquatic Weeds and fauna

Species of tilapia were introduced by the Fisheries Division in collaboration with the weed control unit of MAFF. According to the dam caretaker, the fisheries department, had reported as follows : Wainisavulevu and Wainikasou North had no weed growth. In Wainikasou South, there was some weed growth but less than before. (John : pers comm.)

None of the fish released earlier of the same size were observed. A possible explanation for this could be predation by eels in the weirs. Consequently greater care will be taken when a second lot of grasscarp is to be released in March of 1998. The caretakers reported two large tilapias in the dam that were about 26 cm in size (showing growth) and a large number of eels.

5.0 SUMMARY

From the discussion above a number of major observations may be summarised as follows :

5.1 The Monasavu Dam Reservoir

- A major point of concern was the significant increase in the levels of nitrates found in the reservoir in the summer of 1997. This increase was noted in all the stations. This prompted a closer examination of rainfall patterns and dam levels for 1996 and 1997. Daily rainfall data, and levels of the Monasavu reservoir for the months of June, July, November and December were compared graphically (Appendix A). These months were selected because they coincided with the monitoring periods by the IAS. The increased nitrate levels may well be explained by the following :
- As already explained above, 1996 was a very dry year with dam levels falling below the critical level (725 m) on some occasions. In sharp contrast to this was the 1997 situation with water spilling over the spillway on several occasions (dam level exceeding 745 meters).
- Total rainfall for 1997 was 6493.6 mm and the total rainfall for 1996 was 4224.8 mm. The height of the water level in the dam verified such difference. The average water levels in the dam was much higher in 1997 (Appendix A).
- A day before the 1997 December Monitoring; rainfall was recorded at a high as 34.1 mm. Nitrates retention in soils is very difficult due to their high soluble nature and therefore get easily leached out during heavy rain and lost as runoff.
- Apart from the unusually high nitrate levels, the other parameters have remained relatively unchanged from the last monitoring, indeed for the last five years.

5.2 Wailoa River

- While the concentrations of the metals iron and manganese have stabilised at levels that satisfy recommended guidelines (NEMP, 1992), the nutrients particularly nitrates have fluctuated with rainfall. The levels of nitrates have also increased sharply during December 1997 in the Wailoa River.

5.3 Weirs

- The weirs were not assessed for nitrate content during the 1997 monitoring. The other parameters including the metals iron and manganese are stable at levels considered normal for these environments (no different from 1996).
- Another important point to note was that during the December monitoring, much of the environment at Wainikasou (North and South) was disturbed due to a massive clean up operation at the weirs. Waters were very turbid and muddy and access to these places was difficult. This is another possible explanation for the high nitrate levels in the reservoir.
- There is some indication that the control of the weeds by using biological control methods of releasing *Tilapia sp.* in the affected weirs is having some success. It is also possible that some of the fish that are released in the weir could find their way to the dam when the weir gates are opened. The status of these weirs seems to be otherwise fairly stable and well flushed.

6.0 Invertebrate Study in Lake Monasavu

The last invertebrate survey was done on 5th July, 1995. This years survey was carried out on the 9th of December at two sites along the shores of the lake.

6.1 Results and Discussion

Site 1. At the end of the road, below the FEA administration buildings.

Spongilla sp., a bright green sponge was abundant on the rocks and stones.

Site 2. The rocks and stones adjacent to the dam.

PORIFERA : Spongilla sp. freshwater sponge

HIRUDINEA : Vivabdella sp. predatory leech

ANISOPTERA : damselfly nymphs

GASTROPODA : Melanoides tuberculata

Melanoides lutosa

Physastra nasuta

The sponge Spongilla was the most abundant invertebrate organism.

The six species found in December 1997 were the same as those found in July 1995. This suggested that the invertebrate fauna had stabilised to these six species indicating that the reservoir had matured. Spongilla sp. was first observed in the lake in January 1994.

7.0 CONCLUSION

For the 1997 monitoring, the quality of the water has been generally good in the reservoir, the weirs and the Wailoa River. Conditions are similar to what they have been for the last five years or so. The exception to the normal is the dramatic increase in nitrate levels at all stations. Possible explanations for this have been discussed above. The most important factor for the changes observed has to be the increased rainfall during the year 1997, following very dry 1996. The latter effect could be attributed to a global effect of the El Nino cycle which has caused extreme weather conditions around the mid latitudes. Other anthropogenic factors such as land clearing and livestock grazing need to be monitored carefully.

BIBLIOGRAPHY

Fung, C., and Chand, K., 1997. Water Quality in the Monasavu Reservoir and Wailoa River in 1996. IAS Technical Report No. 97/01,

Gangaiya, P. 1992. Water Quality in the Monasavu Reservoir and Wailoa Dam. INR Technical Report No. 91/3, 6p

JØrgensen, S.E. and Johnson, I. 1989. PRINCIPLES OF ENVIRONMENTAL SCIENCE AND TECHNOLOGY. Studies in Environmental Science 33. Elsevier Science Publishing Company INC., New York.

Naidu, S.D., and Brodie, J.E. 1987. Water Quality in the Monasavu Reservoir and Wailoa River in 1986. INR Technical Report No. 87/6, 14p

Nagatalevu.M .1996. Ministry of Agriculture, Fisheries and Forests. Koronivia Research Station. Aquatic weeds in Monasavu Hydro Scheme ,15TH - 16TH August Survey Report.

NEMP. NATIONAL ENVIRONMENT MANAGEMENT PROJECT, TA No. 1206 - Fiji recommended National Environmental quality Criteria, Final Report, Oct. 1992. 92p

Tamata, B., Anderson, E., and Peter, W., 1995. Water Quality in the Monasavu Reservoir and Wailoa River in 1994. IAS Technical Report No. 95/01 24p

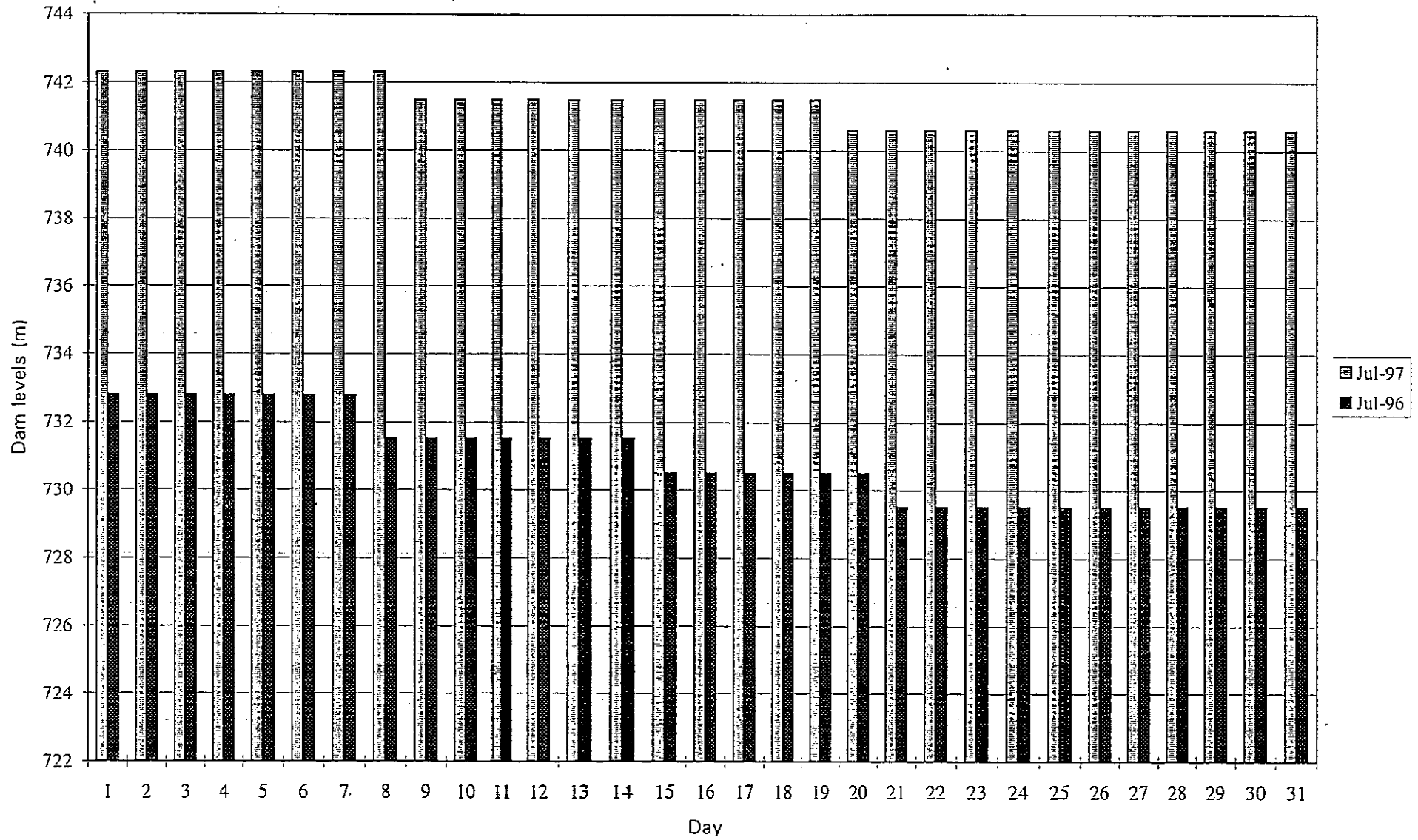
Tamata, B. and Peter. W., 1995. Water Quality in the Monasavu Reservoir and Wailoa River in 1993. IAS Technical Report No. 94/08, 25p

Tamata, B., Haynes, A., Chand, K. and Fung, C., 1996. Water Quality in the Monasavu Reservoir and Wailoa River in 1995. IAS Technical Report No. 96/01,

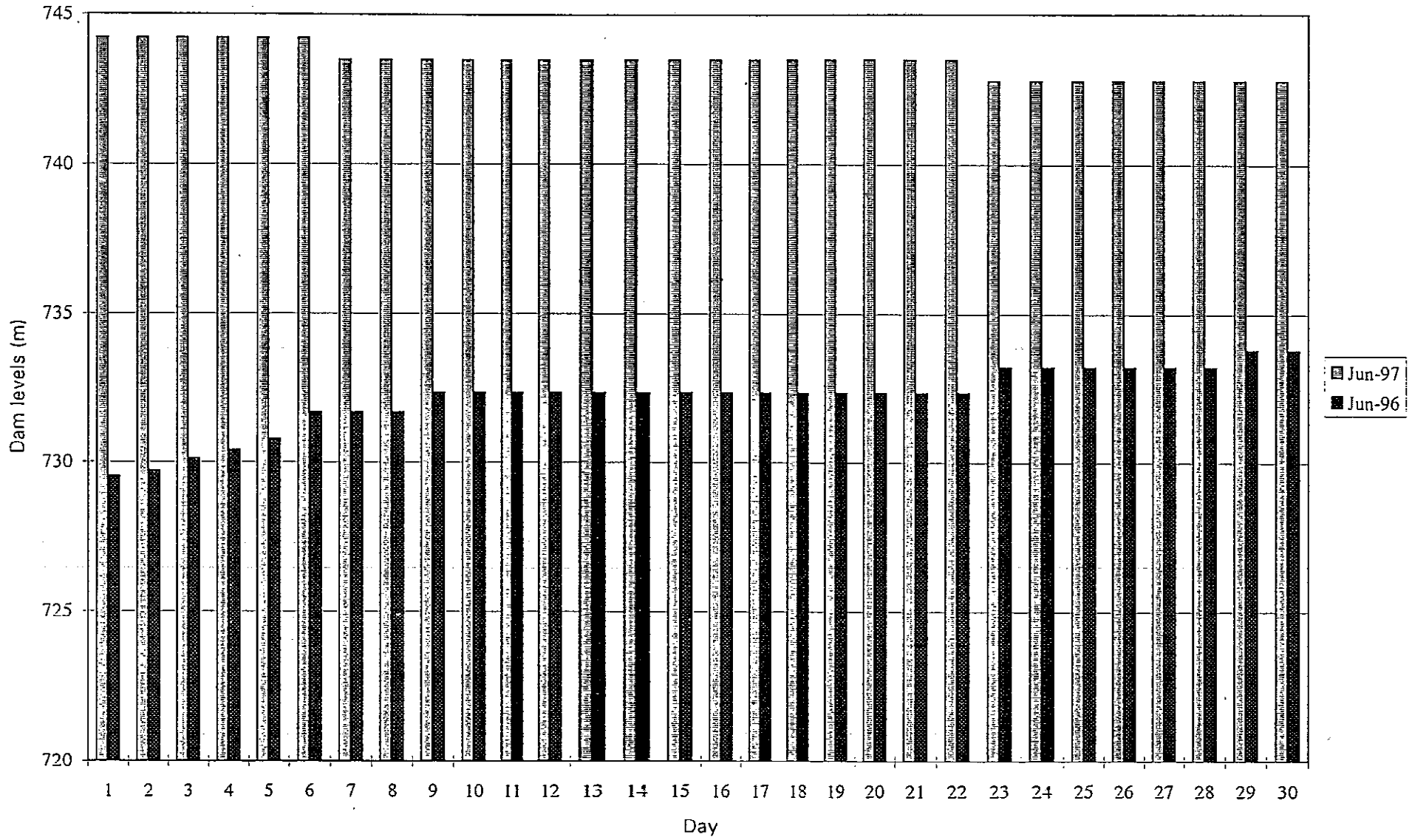
APPENDIX A - Figures showing :

- I. Changes in dam levels for the months of June and July for the year 1996 and 1997.
- II. Changes in dam levels for the months of November and December for the year 1996 and 1997.

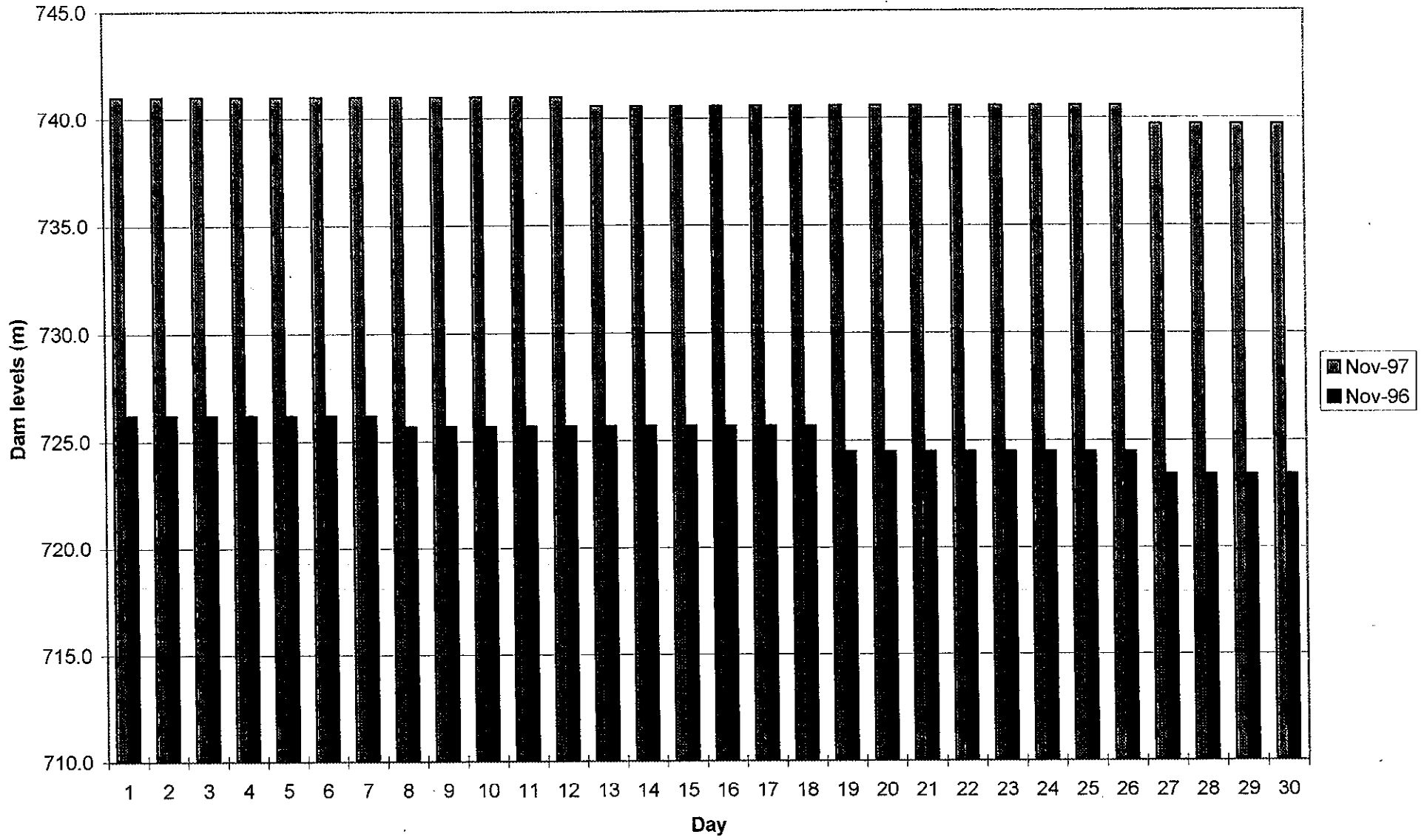
Change in Dam levels for July 1996 and 1997 (supplied by FEA)



Change in Dam levels for June 1996 and 1997 (supplied by FEA)



Change in Dam levels for November 1996 and 1997 (supplied by FEA)



Change in Dam levels for December 1996 and 1997 (supplied by FEA)

