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WATER QUALITY IN THE MONASAVU RESERVOIR AND WAILOA RIVER IN 1995

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by

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WATER QUALITY IN THE MONASAVU RESERVOIR,

THE FIVE WEIR SITES AND THE WAILOA RIVER

1. INTRODUCTION

The monitoring of water quality in the Monasavu dam and the Wailoa river, by the Institute of Applied Sciences, University of the South Pacific (USP) began in 1985 with funding from the Fiji Electricity Authority (FEA). Initially the water quality of the dam and the Wailoa river above the Power Station and at the Tailrace (discharge site) were the main areas studied but in 1990, the FEA requested IAS to include the five weir sites at Wainisavulevu, Wainabua, Wainikasou and Nabilabila in the monitoring program. Monitoring was carried out twice yearly during the Summer (December, January) and Winter (July) months. An invertebrate, plankton and water weed survey of the entire Monasavu project area was carried out in 1985. Further surveys were only at the dam and from 1990 an algae survey at the five weirs were included. This biological survey was carried out annually by the School of Pure and Applied Sciences (SPAS), USP. There was no biological survey in 1986 and 1993 due to the unavailability of the biologist in-charge.

2. BACKGROUND

Results obtained over the years show a gradual improvement in the quality of the water at the reservoir, as evident from the results of nutrient levels and the metals iron and manganese (Morrison *et al.*, 1990; Gangaiya, 1991; Lloyd *et al.*, 1993; Tamata *et al.*, 1995). Temperature in the reservoir rarely go below 17°C or exceed 26°C. Seasonal trends in water temperature and dissolved oxygen variation with depth at the reservoir remain clear. During the winter months surface waters get cooler and density approaches those of underlying waters resulting in a homothermal profile. In winter 1985 and 1989 some stratification existed resulting in a marked difference in dissolved oxygen (DO) levels between the surface and underlying waters. This was caused by the unusually high temperature of the surface waters during the winter months which was around 23.5°C for June, 1985 and 21.5°C for July, 1989. During the summer months there is definite stratification when warmer and less dense surface waters resist mixing with cooler underlying waters. From 1985 to 1990 the dissolved oxygen difference between the epilimnion and the hypolimnion was quite high, often around 8 mg/L and DO at depth was at 0 mg/L. In 1992 and 1993 the middle and bottom layers were more aerobic relative to previous years but DO levels returned to 0 mg/L in the bottom layer in 1994. The relative high levels of DO retained at the bottom layers during 1992 and 1993 could be due to low levels of water in the reservoir or to the decreasing amounts of decomposing organic matter at these depths.

The seasonal variation in iron and manganese are most pronounced in the bottom of the reservoir. In deoxygenated waters of the hypolimnium, Fe(II) and Mn(II) diffuse readily from the sediments and accumulate in the bottom waters. During the turnover of the winter months when oxygen is present at these depths the Fe(II) and Mn(II) ions are oxidised, subsequently precipitated and returned to the sediments in the form of particulate matter. The reintroduction of the summer stratification re-establishes the migration of these ions into solution and an increase is observed. However, there has been marked reduction in levels of iron and manganese over the years.

3. THE MONITORING PROGRAM

3.1 Organisation

The 1995 Water Quality monitoring at Monasavu was carried out at Monasavu on July 4th and 5th (winter monitoring) and on December 5th and 6th 1995 (summer monitoring). The invertebrate survey and plankton sampling was carried out during the July monitoring.

3.2 Methodology, Parameters and Sampling Stations

Reservoir

As in previous monitoring, the Monasavu reservoir was assessed and sampled at three (3) stations : Station 1 was near the float near the dam wall, station 2 near the outflow to the Wailoa Power Station and station 3 was at the other end of the dam, near the Wena Creek junction. Fig. 1 shows the location of the three stations in the reservoir.

At each station, on-site measurements of depth of water, clarity, pH and profiles of water depth/temperature/dissolved oxygen were carried out. Water samples were collected from the three depths: near the surface, mid-depth and near the bottom and analysed in the IAS laboratory for various characteristics (see Table 1 below).

Water clarity was measured with a secchi disc as done previously (Tamata *et al.*, 1995). The pH of the samples were measured using the ORION model 250A pH meter. The temperature/dissolved oxygen profiles were measured at 1 meter depth intervals using a YSI Model 51B DO Meter. The DO meter was calibrated on site for altitude (set at 2,500 feet).

Also during the winter monitoring on 4 and 5 July 1995, a biological survey of invertebrates, plankton and algae was carried out. The findings of the survey are discussed separately under item 5 below.

Wailoa River Monitoring

The Wailoa River receives water channelled from the reservoir to the Power Station. To assess the impact of the Power Station on the Wailoa river, three monitoring stations have been established and studied over the last ten years.

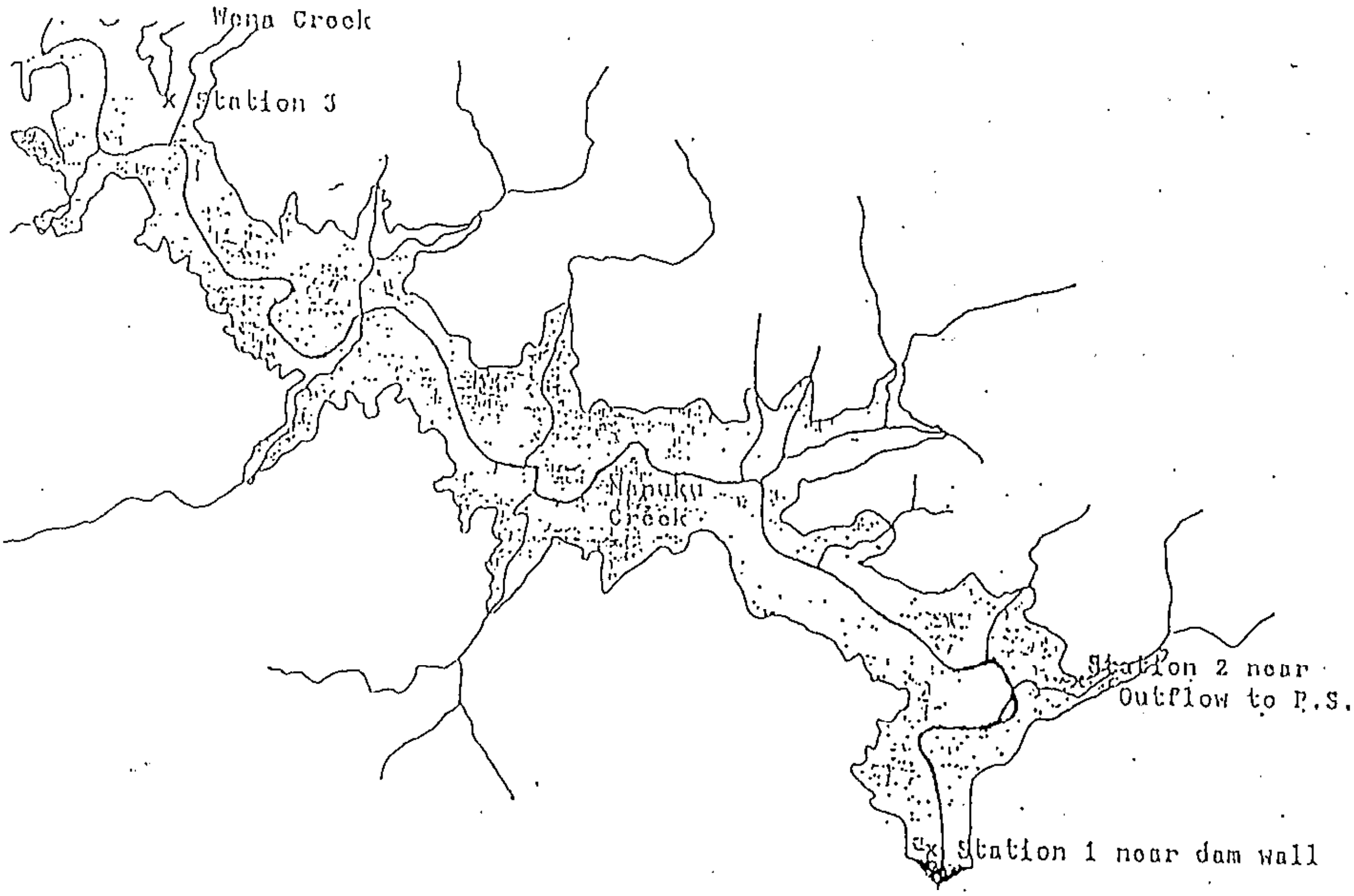


FIGURE 1 : Location of the sampling stations in the Monasavu Reservoir

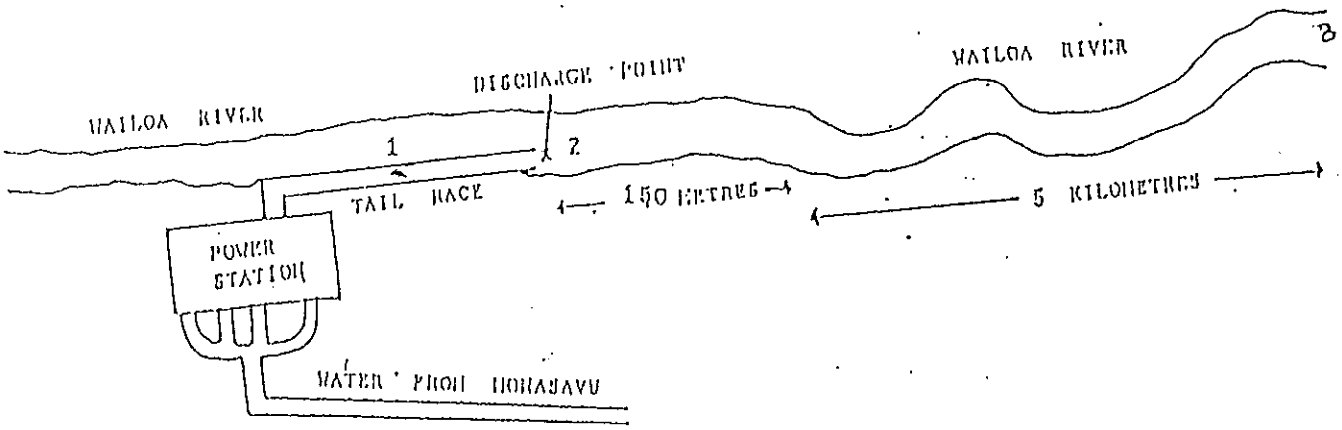


FIGURE 2 : Sampling sites along the Wailoa River

Site 1 : 100 m above Power Station discharge
Site 2 : Tailrace
Site 3 : Wailoa at Laselevu village

Wailoa station 1 is located upstream from the Power Station; station 2 is just below the tailrace and station 3 is at Laselevu village further downstream. At the stations, on-site measurements of temperature, dissolved oxygen and pH were measured and water samples following routine techniques and equipment (see above). Water samples were collected from just below the surface, and analysed in the IAS laboratory. Fig. 2 shows the location of the three stations along the Wailoa river.

The Weir Sites

The five weir sites assessed as in previous occasions were Wainabua, Nabilabila, Wainikasou North, Wainikasou South and Wainisavulevu. At the weir sites, measurements of pH, temperature and dissolved oxygen were taken. Water samples were collected and analysed in the IAS laboratory for iron and manganese (total and dissolved), total dissolved solids (TDS) and total suspended solids (TSS).

Details of the entire 1995 Monitoring program are summarised in Table 1 below.

Table 1 : Summary of 1995 Water Quality Monitoring Program

Location	No. of sites Monitored	Monitoring Sequence	Parameters measured
Reservoir	3 stations each at 3 depths	July 4 & 5 Dec. 5 & 6	pH, clarity, Temp./DO profiles, alkalinity, nutrients, chlorophyll a, iron & manganese (bottom)
Wailoa River	3 stations	As above	As above except for depth profiles
Weirs	5 stations	As above	Temp., pH, DO. Total and dissolved Fe and Mn, TDS, TSS.

4. WATER CHEMISTRY AT MONASAVU

4.1 Results

The data on water chemistry for the reservoir, weirs and Wailoa river for the winter and summer monitoring are given in Tables 2 and 3 respectively. The data on depth/temperature/dissolved oxygen for the three stations in the dam are given in Tables 4-8.

4.2 Interpretation of Results

4.2.1 The Reservoir

(a) Temperature and dissolved oxygen profiles

The profiles for the three stations in July are shown in figures 3, 4 and 5. Temperature range at the three stations was 21.5 - 19.0°C at station 1, 21.5 - 20.0°C at station 2 and 22.0 - 20.5°C at station 3. Station 1 has the greatest depth, relative to the other two stations, thus it has the lowest temperature in the bottom waters.

At all three stations dissolved oxygen (DO) is high at around 8 mg/L in the surface waters.

At stations 1 and 2 DO decreases rapidly to a depth of about 10m and to levels of about 3 mg/L. This could be explained by the temperature profile which shows a thin thermocline layer (decreasing temperature) to depths of about 10m and below this the hypolimnion where temperatures become uniform with depth. A difference of only a few degrees is sufficient to prevent complete circulation of the entire water column (Wetzel, 1975). Surface temperature at all three stations is higher relative to previous years (Morrison *et al.*, 1990; Gangaiya, 1991; Lloyd *et al.*, 1993; Tamata *et al.*, 1995).

Very little mixing occurs in the thermocline layer thus the rapid decrease in DO levels with increasing depth. From 10m to the bottom of the reservoir DO is fairly constant since this is in the hypolimnion where temperature is almost uniform and mixing results in distribution of DO. At station 1 only does DO levels reach 0 mg/L at the bottom (55m). Station 3 is very shallow, reaching a depth of only 16m, and heat therefore penetrates deeper. There is a thick epilimnion existing (warm surface layer) where temperature is uniform (isothermal). This thick layer could be explained by the unusually high surface temperature relative to previous years during this time (winter). This isothermal layer is up to a depth of 8m and results in DO levels being constant at about 7.7 mg/L. From 8m to 10m there is a weak thermocline where there is a drop in temperature. In this layer DO levels decrease to 2 mg/L. Below 10m temperatures again become uniform with depth and DO remains relatively constant to the bottom with levels of about 2 mg/L.

Summer profiles (Figures 6, 7 and 8) show a thicker epilimnion compared to the winter profile. The underlying thermocline however is the thickest layer and extends from 7m to the bottom. DO levels decrease steadily from about 8 mg/L to 0.03 mg/L from the surface to the bottom.

In winter the temperature difference (variation) for all stations was only 1.5°C but in summer the temperature difference for all stations was about 5°C.

TABLE 2 - WATER QUALITY RESULTS FOR MOANASAVU AND WAILOA RIVER - JULY 1995

	Station 1 Surface	Station 1 Mid	Station 1 Bottom	Station 2 Surface	Station 2 Mid	Station 2 Bottom	Station 3 Surface	Station 3 Mid	Station 3 Bottom	Wailoa Above PS	Wailoa at Tailrace	Wailoa at Laselevu
Lab No.	95/994	95/995	95/996	95/997	95/998	95/999	95/1000	95/1001	95/1002	95/992	95/993	95/991
Total alkalinity (mg/L CaCO3)	24	20	53	22	24	24	23	23	23	34	26	33
Clarity (m)	2.3			2.2			1.8					
pH on site	7.4	7.0	6.3	8.1	7.6	7.4	7.5	7.0	6.7	7.8	7.1	7.4
Total N (mg/L)	0.11	0.09	0.99	0.07	0.16	0.10	0.14	<0.01	0.88	0.23	0.11	0.028
Total P (µg/L)	15.7	6.3	88.2	15.6	49.0	903	22.9	13.6	13.0	100.6	16.0	23.9
NO2 (µg/L)	<34	46.4	35.0	<34	<34	83.1	<34	<34	54.4	152.5	119.8	96.8
NH3 (µg/L)	<12.2	<12.2	899	<12.2	<12.2	<12.2	<12.2	<12.2	<12.2	<12.2	<12.2	<12.2
Chlorophyll a (µg/L)	38.1	5.0	0.5	36.3	9.7	2.6	40.8	24.5	8.2	0.8	4.2	4.3
Dissolved Mn (mg/L)			3.8			<0.2			<0.2	<0.2	<0.2	<0.2
Total Mn (mg/L)			4.2			0.6			<0.2	<0.2	<0.2	<0.2
Dissolved Fe (mg/L)			7.0			<0.3			<0.3	<0.3	<0.3	<0.3
Total Fe (mg/L)			7.0			6.9			<0.3	<0.3	<0.3	<0.3
Temperature (°C)	21.5	20.1	19.0	21.5	20.1	20.1	22.0	21.9	20.5	23.1	21.1	22.0
Dissolved O2 (mg/L)	8.0	3.8	0.0	9.1	3.4	3.0	7.8	7.5	1.8	7.8	9.0	8.8
Depth (m)	0	27	55	0	19	38	0	8	16			
Dissolved PO4 (µg/L)	<20	<20	165	<20	<20	<20	<20	<20	<20	126	<20	45

TABLE 2 (Contd.)

Monasavu Water Samples (Weirs)

	Wainabua	Nabilabila	Wainisavulevu	Wainakasou Sth	Wainakasou Nth
Lab No.	95/1003	95/1004	95/1005	95/1006	95/1007
pH on site	7.2	7.3	7.5	7.0	7.6
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	<0.3	<0.3
Total Fe (mg/L)	<0.3	<0.3	0.4	<0.3	<0.3
Temperature (°C)	17.7	18.0	18.2	18.4	18.3
Dissolved O2 (mg/L)	8.2	9.2	8.0	8.4	8.8
Total Dissolved Solids (mg/L)	90	90	93	115	89
Total Suspended Solids (mg/L)	4	7	13	4	12

TABLE 3 - WATER QUALITY RESULTS FOR MONASAVU DAM AND WAILOA RIVER - DECEMBER 1995

	Station 1 Surface	Station 1 Mid	Station 1 Bottom	Station 2 Surface	Station 2 Mid	Station 2 Bottom	Station 3 Surface	Station 3 Mid	Station 3 Bottom	Wailoa Above PS	Wailoa at Tailrace	Wailoa at Laselevu
Lab No.	95/1786	95/1787	95/788	95/1789	95/1790	95/1791	95/1792	95/1793	95/1794	95/1779	95/1780	95/1778
Total alkalinity (mg/L CaCO3)	19	15	14	22	16	-	17	21	23	34	15	23
Clarity (m)	1.8m			2.0m			1.7m					
pH on site	9.43	7.49	7.30	9.44	7.52	7.33	9.27	7.50	7.60	8.75	7.52	7.96
Total N (mg/L)	0.41	0.32	0.26	0.24	0.44	-	0.37	0.32	0.40	0.24	0.21	0.11
NO2 (µg/L)	<34	<34	728.7	155.0	46.6	103.7	52.2	<34	37.0	96.7	<34	122.1
NH3 (µg/L)	<12.2	<12.2	42.4	<12.2	<12.2	59.0	<12.2	22.0	142	<12.2	15.8	<12.2
Chlorophyll a (µg/L)	12.4	5.19	2.02	9.84	2.29	<1.0	10.7	7.69	2.63	1.62	<1.0	3.37
Dissolved Mn (mg/L)			0.3			0.2			0.3	<0.2	<0.2	<0.2
Total Mn (mg/L)			0.3			0.2			0.4	<0.2	<0.2	<0.2
Dissolved Fe (mg/L)			<0.3			<0.3			0.4	<0.3	<0.3	<0.3
Total Fe (mg/L)			0.3			0.4			4.0	<0.3	<0.3	<0.3
Temperature (°C)	24.0			24.0			25.0			25.5	21.5	23.6
Dissolved O2 (mg/L)	8.2			8.2			8.0			8.1	8.2	8.0
Depth (m)	52m			30m			18m					
Dissolved PO4 (µg/L)	<20	<20	<20	<20	<20	<20	<20	<20	<20	292.6	286.0	41.4

TABLE 3 (Contd.)

Monasavu Water Samples (Weirs)

	Wainabua	Nabilabila	Wainakasou Nt	Wainakasou Sth	Wainisavulevu
Lab No.	95/1781	95/1782	95/1783	95/1784	95/1785
pH on site	8.49	8.69	8.45	8.59	7.89
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	<0.3	<0.3
Total Fe (mg/L)	<0.3	<0.3	<0.3	<0.3	<0.3
Temperature (°C)	21.0	21.7	22.7	23.2	22.7
Dissolved O2 (mg/L)	8.6	9.5	9.9	11.2	8.3
Total Dissolved Solids (mg/L)	96	118	73	133	60
Total Suspended Solids (mg/L)	8	25	15	20	21

TABLE 4 - WINTER RESULTS

DATA FOR MONASAVU DAM - STATION 1, JULY 1995

DEPTH (m)	TEMP. (°C)	D.O. (mg/L)	DEPTH (m)	TEMP. (°C)	D.O. (mg/L)
0	21.5	8.0	25	20.1	4.0
1	21.2	8.0	26	20.1	4.0
2	21.1	7.8	27	20.1	3.8
3	21.1	8.0	28	20.1	3.6
4	21.0	7.0	29	20.0	3.6
5	21.0	6.6	30	20.0	3.4
6	21.0	6.0	31	20.0	3.4
7	20.9	5.1	32	20.0	3.2
8	20.8	4.2	33	20.0	3.0
9	20.8	3.4	34	20.0	2.4
10	20.5	3.0	35	20.0	2.0
11	20.5	3.0	36	20.0	2.4
12	20.2	3.0	37	20.0	2.4
13	20.1	3.0	38	20.0	2.4
14	20.2	3.2	39	20.0	2.6
15	20.2	3.1	40	20.6	3.0
16	20.1	3.2	42	20.0	3.0
17	20.1	3.2	44	20.0	2.6
18	20.1	3.2	46	20.0	2.0
19	20.1	3.4	48	20.0	1.4
20	20.1	3.4	50	20.0	1.0
21	20.1	3.6	52	19.0	0.4
22	20.1	3.6	53	19.8	0.2
23	20.1	3.6	54	19.2	0.1
24	20.1	4.0	55	19.0	0.0

FIGURE 3 - TEMPERATURE/DO PROFILE FOR STATION 1 - JULY 1995

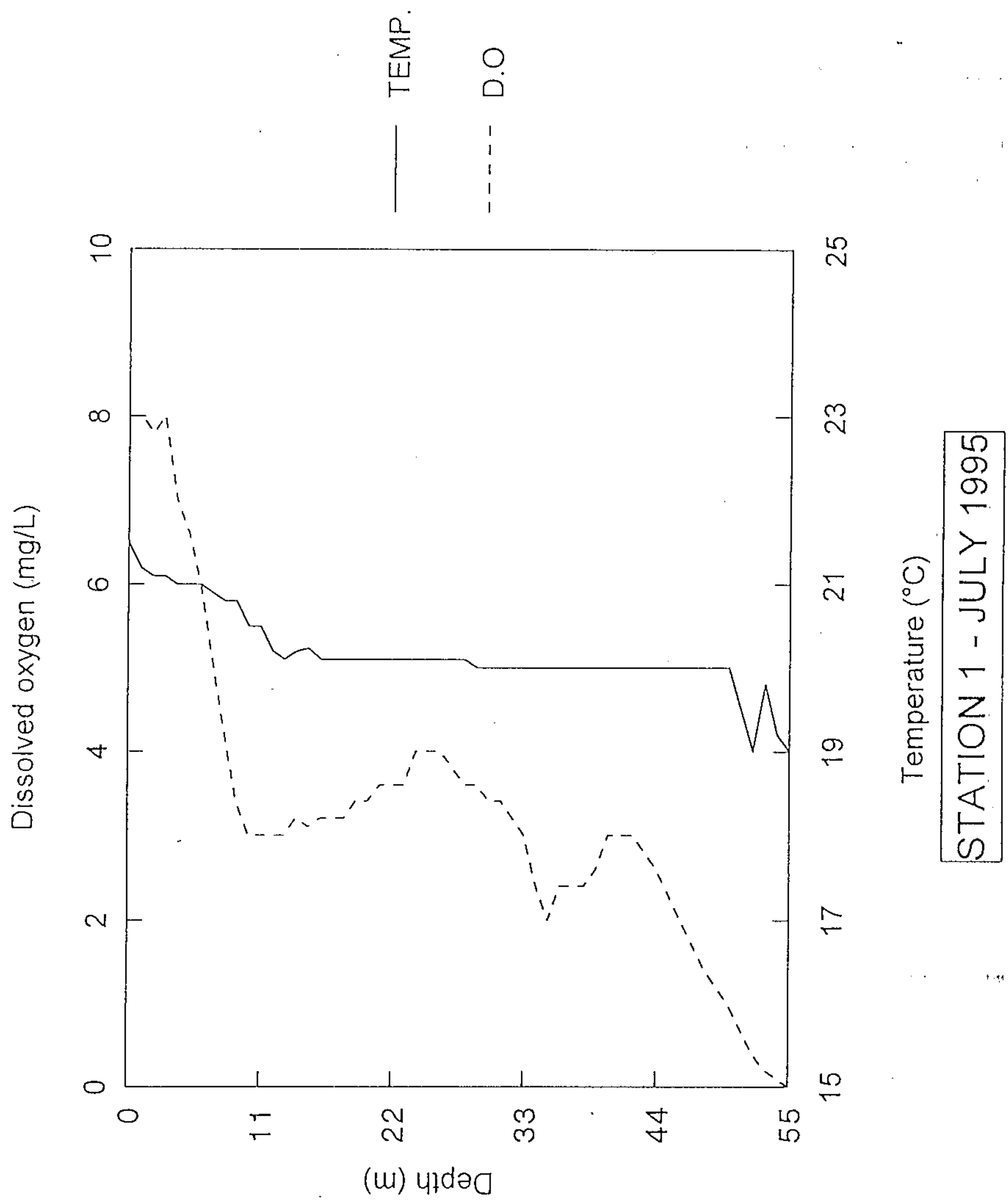


TABLE 5 - WINTER RESULTS

DATA FOR MONASAVU DAM STATION 2, JULY 1955

DEPTH (m)	TEMP. (°C)	D.O (mg/L)	DEPTH (m)	TEMP. (°C)	D.O. (mg/L)
0	21.5	9.1	20	20.1	3.4
1	21.5	8.8	21	20.1	3.4
2	21.5	8.4	22	20.1	3.3
3	21.5	9.8	23	20.1	3.3
4	21.3	9.5	24	20.1	3.3
5	21.3	8.8	25	20.1	3.4
6	21.0	6.6	26	20.1	3.4
7	20.9	5.4	27	20.1	3.4
8	20.8	4.6	28	20.1	3.4
9	20.5	4.0	29	20.1	3.4
10	20.3	3.3	30	20.1	3.4
11	20.1	3.2	31	20.1	3.6
12	20.1	3.1	32	20.0	3.6
13	20.1	3.0	33	20.0	3.6
14	20.1	3.2	34	20.0	4.0
15	20.1	3.2	35	20.0	3.8
16	20.1	3.2	36	20.0	3.4
17	20.1	3.2	37	20.0	3.0
18	20.1	3.3	38	20.1	3.0
19	20.1	3.4			

FIGURE 4 - TEMPERATURE/DO PROFILE FOR STATION 2 - JULY 1955

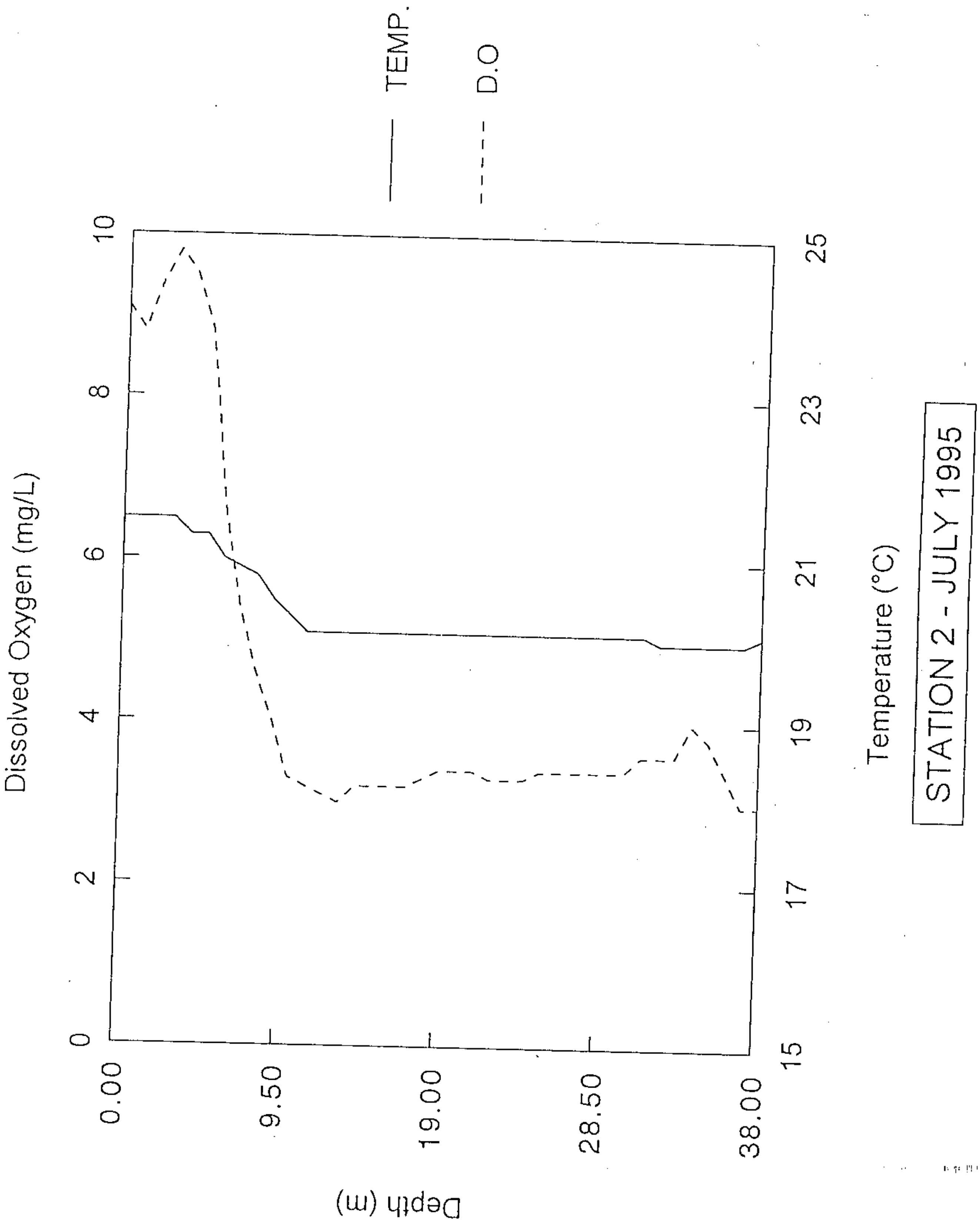


TABLE 6 - WINTER RESULTS

DATA FOR MONASAVU DAM STATION 3 - JULY 1995

DEPTH (m)	TEMPERATURE (°C)	DISSOLVED O_2 (mg/L)
0	22	7.8
1	22	7.6
2	22	7.5
3	22	8.0
4	22	7.7
5	21.8	7.7
6	21.9	7.7
7	21.9	7.6
8	21.9	7.5
9	21.5	5.6
10	21.0	2.8
11	20.9	2.4
12	20.8	2.0
13	20.8	2.0
14	20.5	1.9
15	20.5	1.8
16	20.5	1.8

FIGURE 5 - TEMPERATURE/DO PROFILE FOR STATION 3 - JULY 1995

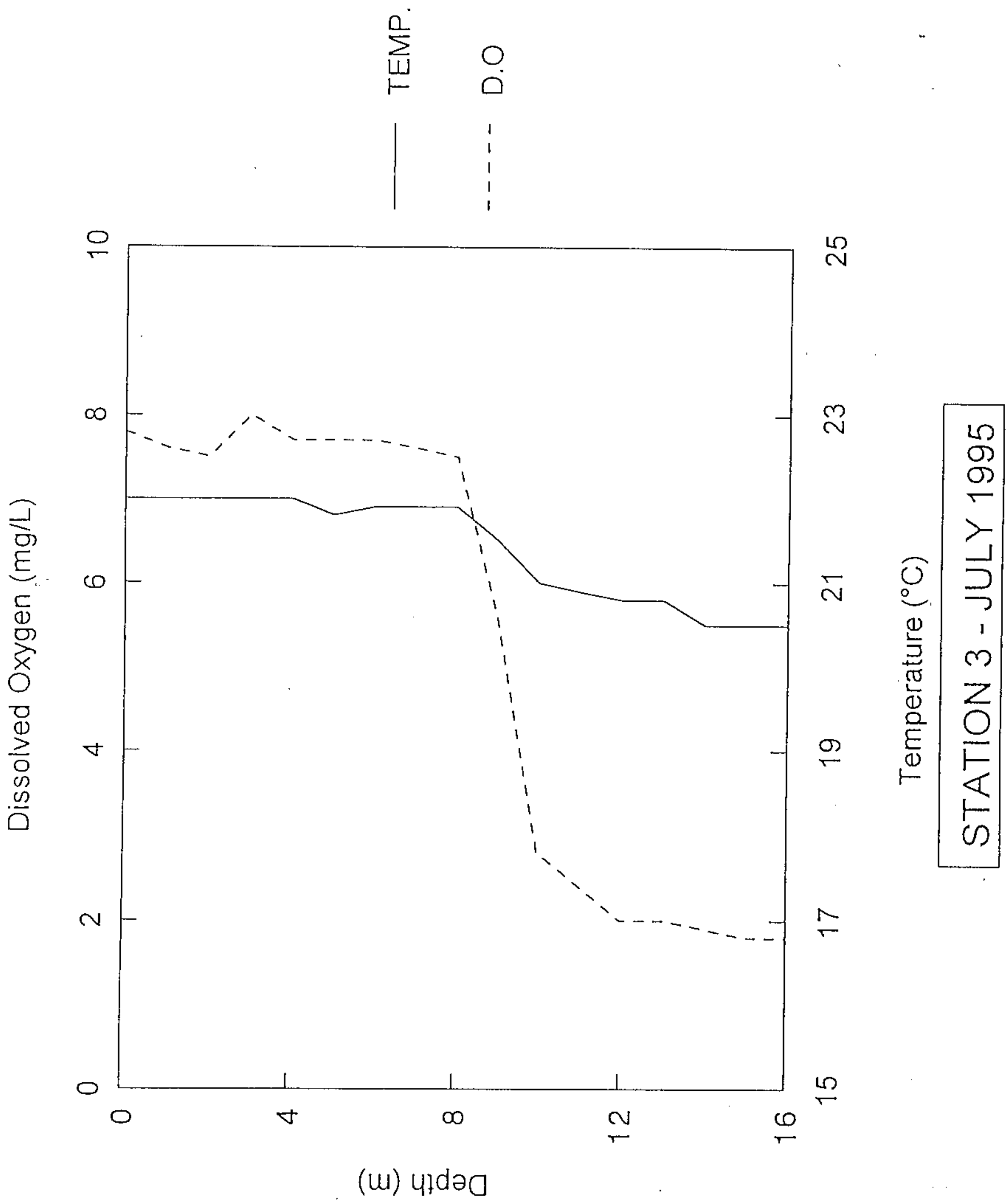


TABLE 7 - SUMMER RESULTS

DATA FOR MONASAVU DAM STATION 1 - DECEMBER 1995

DEPTH (m)	TEMP. (°C)	D.O (mg/L)	DEPTH (m)	TEMP. (°C)	D.O (mg/L)
0	24.0	8.2	23	20.8	1.6
1	24.1	8.2	24	20.6	1.4
2	24.1	8.0	25	20.5	1.2
3	24.1	8.05	26	20.3	1.2
4	24.1	8.3	27	20.2	1.4
5	24.0	7.8	28	20.1	1.6
6	23.7	7.1	29	20.1	2.0
7	23.1	5.0	30	20.0	2.3
8	22.8	5.1	31	19.9	2.2
9	22.5	5.2	32	19.8	2.0
10	22.4	4.8	33	19.7	2.0
11	22.2	4.4	34	19.6	2.2
12	22.1	5.0	35	19.5	2.4
13	22.0	4.6	36	19.4	2.1
14	21.9	4.2	37	19.5	2.0
15	21.8	3.7	38	19.5	2.2
16	21.6	3.6	39	19.4	1.9
17	21.5	3.2	40	19.3	1.4
18	21.4	2.8	41	19.3	1.1
19	21.2	2.4	42	19.3	0.9
20	21.1	2.4	43	19.3	0.6
21	21.0	2.2	44	19.3	0.5
22	20.9	1.8			

FIGURE 6 - TEMPERATURE/DO PROFILE FOR STATION 1 - DECEMBER 1995

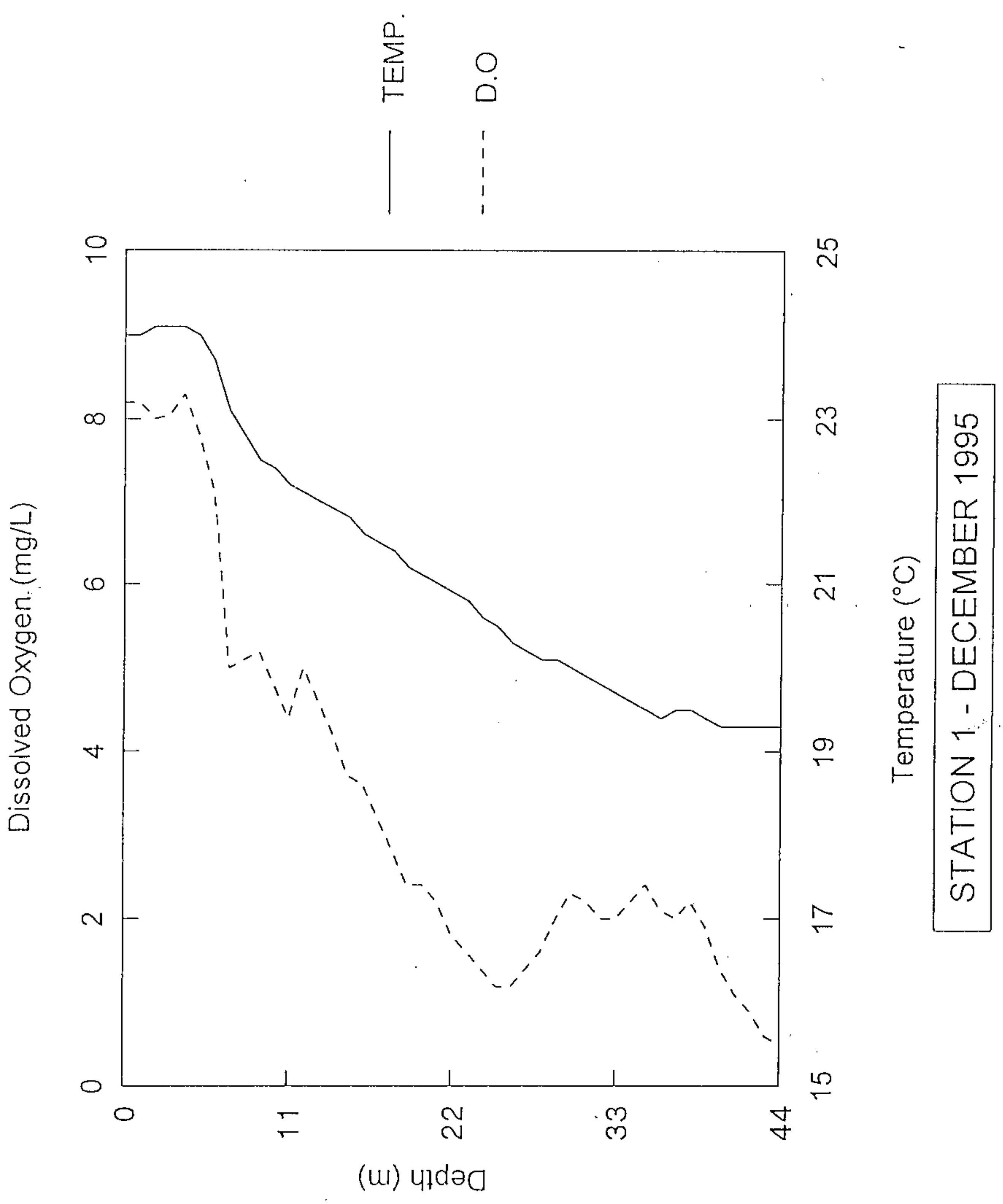


TABLE 8 - SUMMER RESULTS

DATA FOR MONASAVU DAM STATION 2 - DECEMBER 1995

DEPTH (m)	TEMP. (°C)	D.O (mg/L)	DEPTH (m)	TEMP. (°C)	D.O (mg/L)
0	24.0	8.2	20	21.2	2.5
1	24.1	8.2	21	21.1	2.1
2	24.0	8.3	22	21.0	1.8
3	24.0	8.2	23	20.9	1.4
4	23.6	7.9	24	20.7	1.0
5	23.0	7.8	25	20.5	0.4
6	22.9	7.1	26	20.3	0.4
7	22.7	6.1	27	20.1	0.3
8	22.5	5.6	28	20.1	0.4
9	22.2	5.2	29	20.0	0.4
10	22.1	4.8	30	19.9	0.3
11	22.0	4.8	31	19.8	0.3
12	21.9	4.2	32	19.7	0.2
13	21.8	4.0	33	19.7	0.3
14	21.6	3.9	34	19.6	0.3
15	21.5	3.6	35	19.6	0.2
16	21.4	3.3	36	19.6	0.2
17	21.3	3.1	37	19.6	0.2
18	21.2	2.3	38	19.6	0.2
19	21.3	2.3	37	19.6	0.2

FIGURE 7 - TEMPERATURE/DO PROFILE FOR STATION 2 - DECEMBER 1995

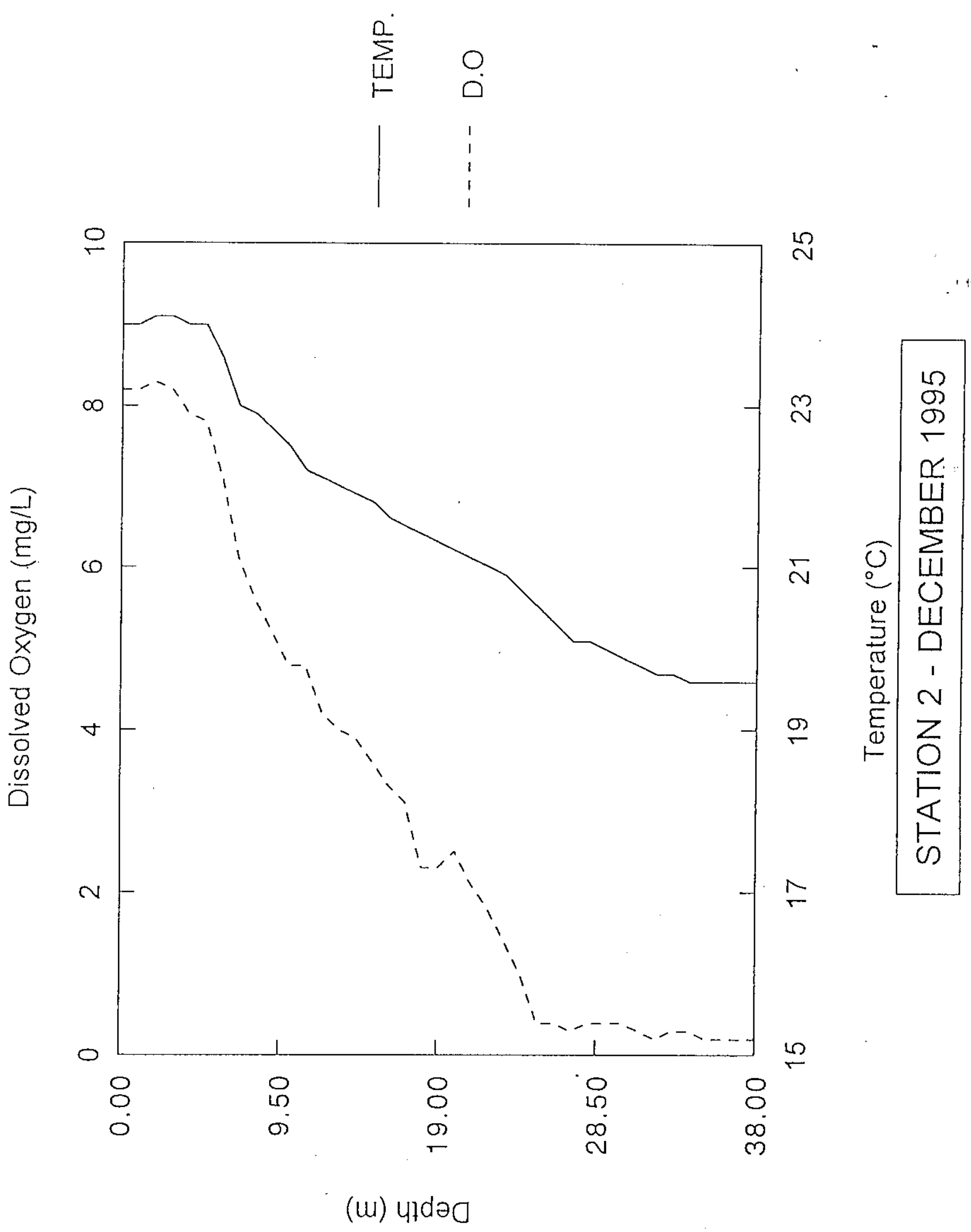
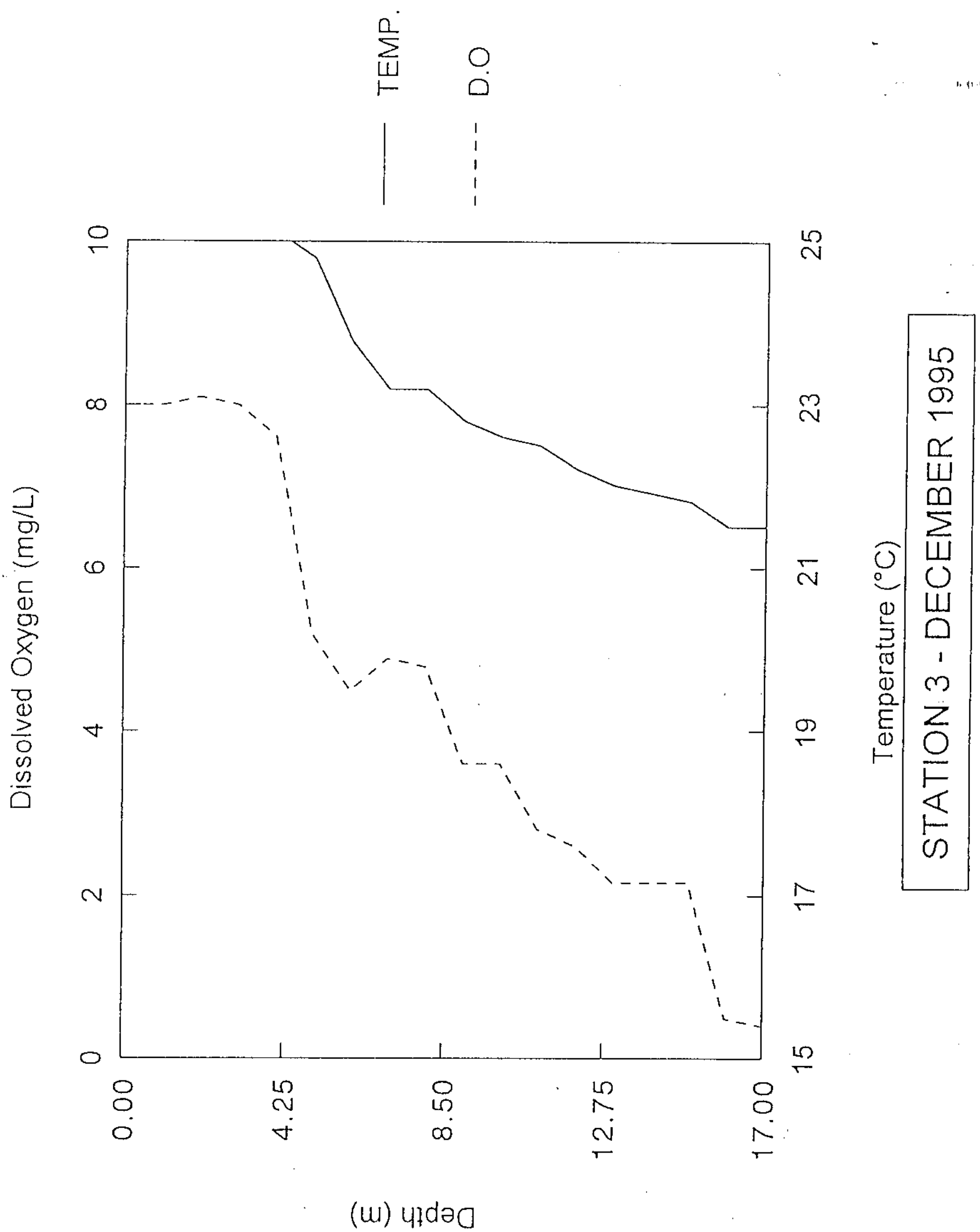


TABLE 9 - SUMMER RESULTS

DATA FOR MONASAVU DAM STATION 3 - DECEMBER 1995

DEPTH (m)	TEMPERATURE (°C)	DISSOLVED O_2 (mg/L)
0	25	8.0
1	25	8.0
2	25	8.1
3	25.1	8.0
4	24.8	7.6
5	23.8	5.2
6	23.2	4.5
7	23.2	4.9
8	23.2	4.8
9	28	3.6
10	26	3.6
11	25	2.8
12	22.2	2.6
13	22.0	2.15
14	21.9	2.15
15	21.8	2.15
16	21.5	0.5
17	21.5	0.4

FIGURE 8 - TEMPERATURE/DO PROFILE FOR STATION 3 - DECEMBER 1995



b) pH

The Monasavu lake is a bicarbonate type lake with a pH range between 6 and 9.

The pH values for all the sites during the winter sampling was in the range 6.3 - 8.1 which is the expected range for dams (Wetzel, 1975) and also for recreational waters for Fiji which is 5.0 - 9.0 (NEMP 6, 1992). The summer sampling range was 7.30 - 9.44 and this was generally higher than values obtained in the past. At all three stations, surface waters had a pH above 9.0 which is caused by greater utilisation of carbon dioxide for photosynthesis in the upper layers relative to carbon dioxide output by respiration. This is confirmed by the high surface temperatures during both the winter and summer visit relative to previous years. The lethal effects of most acids begin to appear near pH 4.5.

(c) Total Alkalinity

The alkalinity was in the range of 19 - 53 mg/L $CaCO_3$ during winter and a narrower range from 14 to 34 mg/L $CaCO_3$ during summer. These values are fairly consistent with values obtained over the previous years (Gangaiya, 1991; Lloyd *et al.*, 1993; Tamata *et al.*, 1995).

(d) Nutrients

Nitrate concentrations ranged from values <34 to 152.5 μg/L in the winter visit and values <34.0 to 729.7 μg/L during summer with surface waters having the least concentrations due to the consumption of nitrates as a result of photosynthetic activity.

Very low ammonia concentration (<12.2 μg/L) is present throughout the water column during winter except at the bottom of station 1 where it is high at 899 μg/L. The high ammonia content is due to the anoxic conditions existing at this depth which causes the bacterial decomposition of organic matter and reduction in nitrate. Ammonia concentration was seen to increase with depth during the summer visit as was the trend over the previous years. This results from the steady decrease in DO levels with depth. Total nitrogen ranged from 0.01 to 0.99 mg/L during winter and for summer values ranged from 0.11 to 0.44 mg/L. These ranges were consistent with that obtained over previous years. There was no obvious pattern in the distribution of the substance with depth.

Total phosphorus during winter ranged from 6.3 to 903 μg/L but no analysis was done for the summer visit. Total phosphorus levels were unusually very high this year compared to previous years. The release of phosphorus into the surrounding water as a result of decomposition of organic matter may have caused the high levels in total phosphorus at the bottom of stations 1 and 2. However, the levels at the bottom of these stations are still too high despite this reasoning. There was no obvious pattern in the levels of total phosphorus at station 3.

Dissolved phosphates during summer was found to be uniform at <20 μg/L throughout the water column at all three stations except at the bottom of station 1 where it was much higher at 165 μg/L. The summer visit showed dissolved phosphates to be <20 μg/L throughout the water column at all 3 stations.

(e) Chlorophyll

Only chlorophyll *a* was determined during the 1995 monitoring of the reservoir. Winter results showed chlorophyll *a* to be concentrated in the surface waters and decreasing significantly with depth. Range for the winter visit was 0.5 - 40.8 μg/L. High levels in the surface waters corresponded to the presence of algae and phytoplankton.

The summer visit also displayed the same chlorophyll *a* distribution with depth as the winter visit but the surface waters contained lesser chlorophyll *a* compared to the winter visit. Range for the summer visit was <1 - 12.4 μg/L.

(f) Total and dissolved iron and manganese

Water samples from only the bottom of all 3 stations were analysed. In winter, both total iron and dissolved iron ranged from <0.3 to 7 mg/L. The highest levels of total iron and dissolved iron came from the bottom of station 1 where conditions are most anoxic. This results in the reduction of iron oxides and hydroxides which releases iron ions into the water column. In summer dissolved iron ranged from <0.3 to 0.4 mg/L and total iron ranged from 0.3 to 4.0 mg/L. Station 3 had the highest dissolved and total iron concentration during the summer visit.

Dissolved manganese during winter ranged from <0.2 - 3.8 mg/L and total manganese ranged from <0.2 to 4.2 mg/L. Station 1 had the highest levels of both dissolved and total manganese. Summer sampling showed dissolved manganese ranging from 0.2-0.3 mg/L and total manganese varied from 0.2 - 0.4 mg/L.

The low concentrations of the total and dissolved iron and manganese in the dam in general, with the exception of the deeper waters at the bottom of station 1 during winter, has been the trend over the previous years since 1985 (Gangaiya, 1986; Naidu and Brodie, 1987; Naidu *et al.*,1989; Morrison *et al.*, 1990; Gangaiya, 1991; Lloyd *et al.*, 1993; Tamata *et al.*, 1994; Tamata *et al.*, 1995).

4.2.2 The Weirs

The pH, temperature and dissolved oxygen concentrations were all within acceptable ranges for fresh water creeks during the winter and summer visits. Generally all three parameters were slightly higher during summer compared to winter.

The total dissolved solids (TDS) concentrations were in the range 89-115 mg/L and 60-133 mg/L during summer. These TDS levels were slightly but not significantly higher as compared to previous years, excluding summer 1994 (Lloyd *et al.*, 1993; Tamata *et al.*, 1994; Tamata *et al.*, 1995).

The total suspended solids (TSS) concentrations were low as usual during the July sampling (4-13 mg/L) and the December values were slightly higher (8-25 mg/L). These low TSS concentrations are expected for fresh water.

The concentrations of total and dissolved irons were all low. In winter all values were below 0.3 mg/L except Wainisavulevu which was 0.4 mg/L and in summer all values were below 0.3 mg/L. Such low occurrence of iron at the weir sites have been the trend for many years now (Gangaiya, 1991; Lloyd *et al.*, 1993; Tamata *et al.*, 1994; Tamata *et al.*, 1995).

The concentrations of total and dissolved manganese were also low with all values being below the detection limit of 0.2 mg/L in both winter and summer.

4.2.3 The Wailoa River

The three sites along the Wailoa River (Fig. 2) are compared to see if the Power station was having an impact on the quality of the water. Also by comparing the status of iron and manganese at the bottom of station 2 in the dam and the tailrace below the Power station, the possibility of deposition of these metals on the machinery in the power station can be indirectly addressed.

As far as pH, temperature and dissolved oxygen are concerned, there were on significant difference in the values for the three sites along Wailoa river and the dam sites.

The nutrient levels are generally similar for the three sites along Wailoa river except for total phosphorus which was high above the power station (100.6 μg/L) but then decreased to levels of about 20 μg/L at the tailrace and at Laselevu.

As has been the trend so far, the level of ammonia is greatly reduced from when the water leaves the dam (bottom, station 2) until it is discharged at the tailrace and this is a consequence of the oxygenation process of the water in the power station. This is only true however for the summer visit. During winter however ammonia levels were below the detection limit of 12.2 μg/L from the bottom of station 2 and all along the river.

All values of total and dissolved manganese along the Wailoa river were below detection limit (<0.2 mg/L). At the bottom of station 2 total and dissolved manganese was 0.2 mg/L during summer and during winter total manganese was 0.6 mg/L and dissolved manganese was <0.2 mg/L.

The total and dissolved iron levels along the Wailoa river during both the July and December visit were all below 0.3 mg/L. At the bottom of station 2, dissolved iron was also below 0.3 mg/L on both visits but total iron was 6.9 mg/L during winter and 0.4 mg/L during summer. This difference in total iron levels between the bottom of station 2 and the discharge site at the tailrace also occurred in 1994 (Tamata *et al.*, 1995).

5. REPORT ON BIOLOGICAL SURVEY, 4 AND 5 JULY 1995

Sites visited were:

1. The end of the road, below the FEA administration buildings, where the yellow brown sponge Spongilla sp. was found on the under side of rocks.

2. The rocks of the dam

Porifera	: Spongilla sp.	sponge
Hirudenia	: Vivabdella sp.	predatory leech
Anisoptera	: dameslfly nymphs	
Gastropoda	: Melanoides turbuculata Physastra nasuta	

PLANKTON TRAWL:

Crustacea	: cocepods (abundant) colonial yellow green algae (abundant)

WEIRS:

All weirs except the Wainikasou North were free of water weed.

Wainkasou North:

Large green alga Chara excelsa on the bottom - living on it were beetle larvae and case caddisfly larvae. Chara excelsa was very abundant in four of the weirs in 1990 when it obstructed the outflows after heavy rain.

6. CONCLUSIONS

As in the previous year, the water quality in the Monasavu reservoir and the Wailoa river was generally good. Dissolved oxygen, pH, temperature, the nutrients and the concentrations of total and dissolved iron and manganese were within acceptable ranges for fresh water lakes and rivers. The depth of the reservoir has a major effect on the dissolved oxygen levels for both the winter and summer seasons and this affects other parameters such as dissolved metals and nutrients. Though dissolved oxygen levels were low at the bottom of the deepest station of the reservoir during summer, mixing during winter replenished oxygen supply at these depths. The concentrations of total and dissolved iron and manganese were all very low thus the risk of deposition of these metals on the machinery in the power station at Wailoa is very low. These low metal concentrations indicate relatively well oxygenated waters.

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