

WATER QUALITY IN THE MONASAVU
RESERVOIR AND WAILOA RIVER
IN 1987

INR TECHNICAL REPORT NO 88/1

March, 1988

INSTITUTE OF NATURAL REOSURCES
UNIVERSITY OF THE SOUTH PACIFIC

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AND WAILOA RIVER IN 1987

S.D. Naidu

Report prepared for the Fiji Electricity Authority

March 1988

INTRODUCTION

At the request of Fiji Electricity Authority (FEA), the Institute of Natural Resources monitored the water quality of Monasavu reservoir and the Wailoa river again in 1987. The programme was carried out in accordance with the proposal submitted to the FEA at the beginning of 1987 (Appendix 1).

The Monitoring Programme

1) The Organisation

The monitoring of the Monasavu reservoir and the Wailoa river were carried out in July and December and the details of the parameters analyzed are shown in Table 1

TABLE 1

Monitoring Programme of Monasavu Reservoir and Wailoa River

| | No of sites monitored | Monitoring sequence | Parameters measured |
|--------------------|---------------------------------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Monasavu reservoir | 3 Stations each at 3 different depths | 13/7/87 16/12/87 | Temperature and dissolved oxygen profiles, pH, alkalinity, chlorophyll a, b and c, nutrients - total nitrogen, phosphorus and sulphur, ammonia, nitrate, nitrite, dissolved and total iron and manganese |
| Wailoa | 3 Stations | 13/7/87 16/12/87 | As for above |

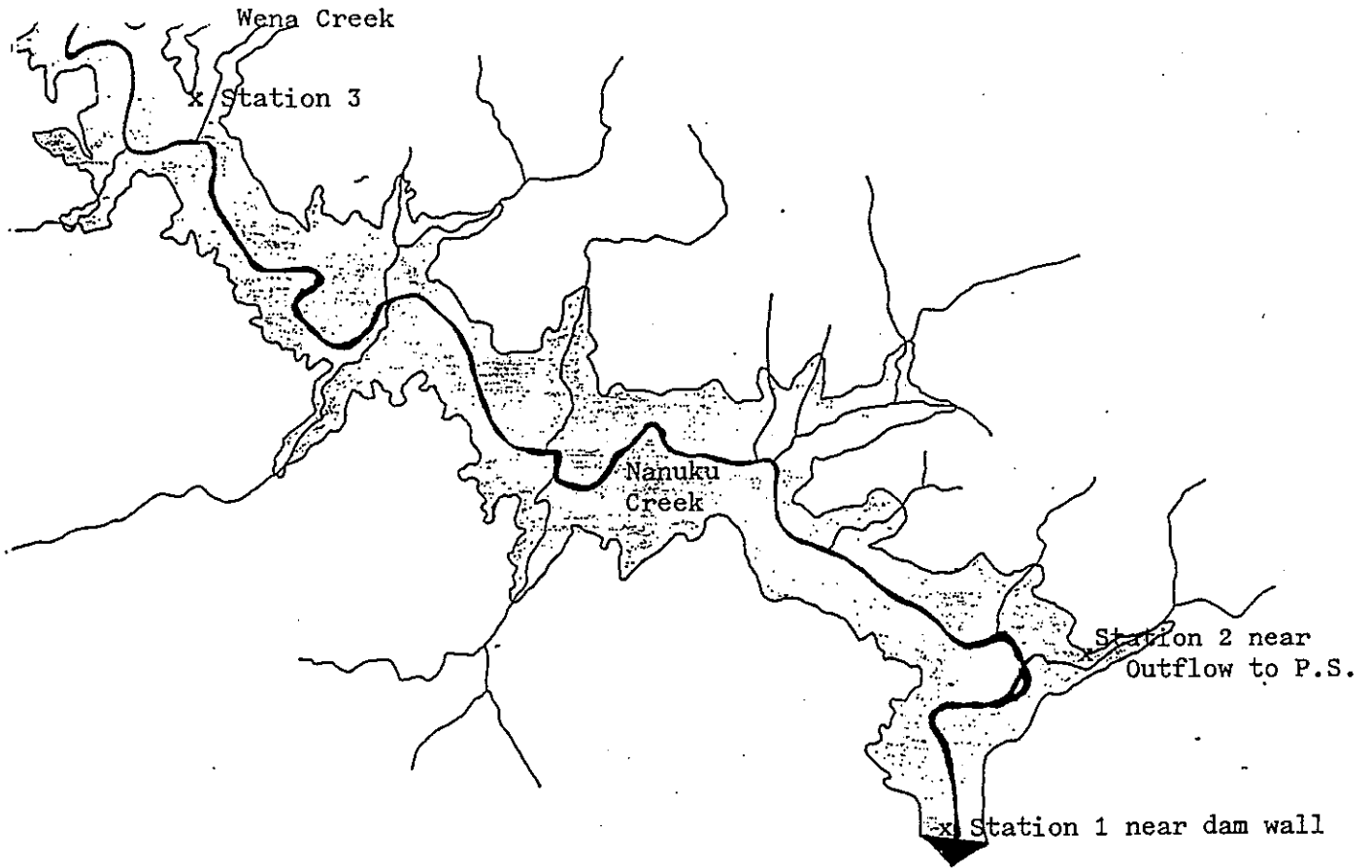


FIGURE 1: Location of the sampling stations in the Monasavu Reservoir

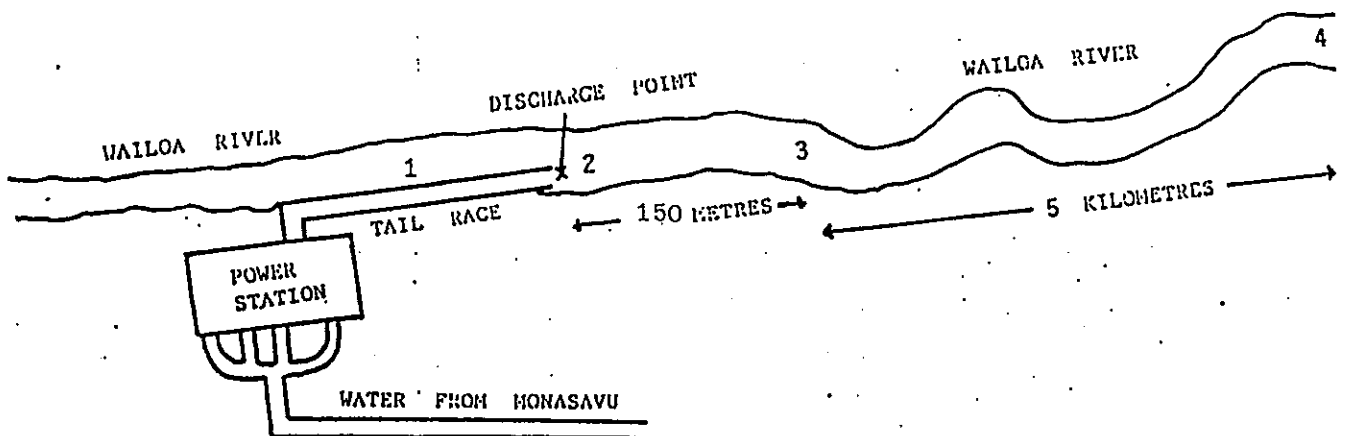


FIGURE 2: Sampling sites along the Wailoa River

- Site : 1 100 m above P.S. discharge
- 2 Tailrace
- 3 150 m below P.S. discharge
- 4 Wailoa at Laselevu

2) Sampling Sites

The sites chosen for sampling in 1987 remained the same as for previous years (1984, 1985, 1986) for comparison purpose. Figure 1 shows the location of the three sampling sites in the reservoir while Figure 2 shows the sampling stations along the Wailoa river. Station 4 is located at Laselevu village.

3) Record of Data

Apart from temperature and dissolved oxygen which were determined on site, rest of the chemical analyses were carried out at the INR laboratory. Tables 2 and 3 give the results of the analyses carried out on the samples.

4) Interpretation of Results for Water Quality

4.1 The Monasavu Reservoir

a) Temperature and Dissolved Oxygen profiles

The temperature and the dissolved oxygen profiles for the three reservoir stations for both sampling trips are given in Figure 3 and 4 respectively. As noted previously (1984, 1985, 1986), the profiles for the summer months can be characterised by a distinct temperature gradient with little oxygen below 30 m whereas during cooler months the reservoir is almost homothermal with oxygen at depth as well.

b) pH in the Monasavu Reservoir

The range in pH values for the Monasavu reservoir is in the acceptable range (6-9) for the reservoirs

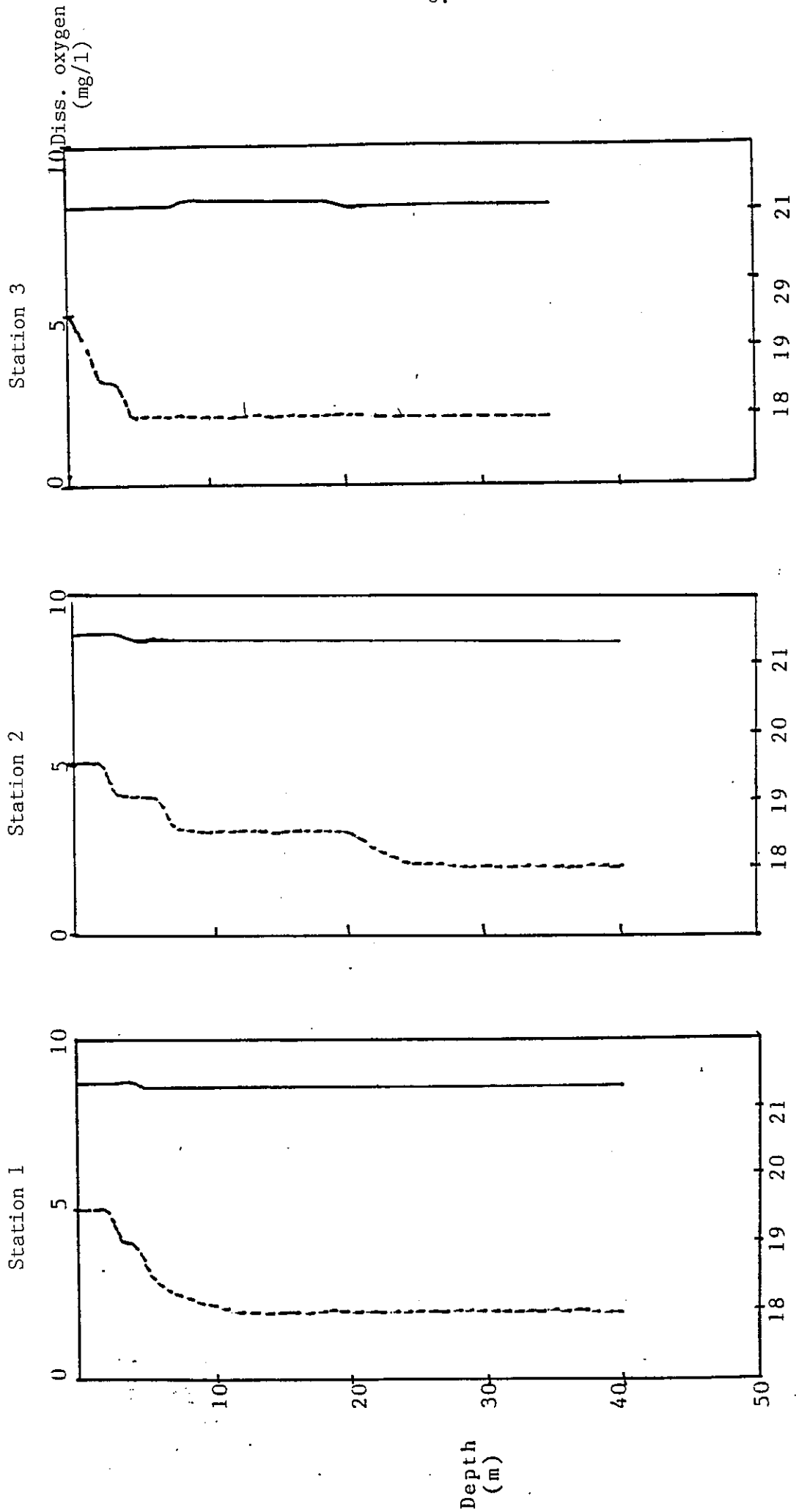
TABLE 2 : Results of July monitoring of the Monasavu reservoir and Wailoa river

| | Stn. 1 Surface | Stn. 1 Mid | Stn. 1 Bottom | Stn. 2 Surface | Stn. 2 Mid | Stn. 2 Bottom | Stn. 3 Surface | Stn. 3 Mid | Stn. 3 Bottom | Wailoa Above P.S. | Wailoa Tailrace | Wailoa at Laselevu |
|-----------------------------------------------|-------------------|---------------|------------------|-------------------|---------------|------------------|-------------------|---------------|------------------|----------------------|--------------------|-----------------------|
| | 21 | 21 | 19 | 19 | 12 | 16 | 21 | 19 | 21 | 31 | 45 | 21 |
| Total Alkalinity (mg/l CaCO ₃) | 21 | 21 | 19 | 19 | 12 | 16 | 21 | 19 | 21 | 31 | 45 | 21 |
| Turbidity | 2.5m | | | 2.5m | | | 2m | | | | | |
| pH on site lab | 6.41 | 6.26 | 6.20 | 6.58 | 6.29 | 6.28 | 6.33 | 6.32 | 6.20 | 7.58 | 7.13 | 7.55 |
| Total N (mg/l) | 0.76 | 0.76 | 0.82 | 0.62 | 0.66 | 0.95 | 0.66 | 0.72 | 0.76 | 0.72 | 0.62 | 0.82 |
| Total P (ug/l) | 12 | 12 | 54 | <6 | <6 | 54 | 12 | 12 | 40 | 24 | 12 | 24 |
| Total S (mg/l) | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| NO ₃ ⁻ (mg/l) | 18.6 | 142.6 | 111.6 | 49.6 | 124.0 | 130.2 | 68.2 | 18.6 | 18.6 | 179.8 | 223.2 | 223.2 |
| NH ₃ (ug/l) | 22 | <20 | 100 | <20 | <20 | 40 | <20 | <20 | 40 | <20 | <20 | <20 |
| Chlorophyll mg/m ³ | 9.1 | 3.8 | 0 | 4.9 | 4.2 | 9.4 | 8.6 | 16.0 | 10.8 | 0 | 0 | 5.4 |
| a | 4.1 | 2.0 | 0 | 4.5 | 0 | 1.0 | 0 | 4.6 | 1.3 | 0 | 0 | 8.2 |
| b | 43.8 | 7.8 | 0 | 12.0 | 11.1 | 5.0 | 0 | 0 | 0 | 0 | 0 | 60.0 |
| c | | | | | | | | | | | | |
| Dissolved Mn (mg/l) | <0.1 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | 0.1 | 0.3 | 0.2 | <0.1 | <0.1 | <0.1 |
| Total Mn (mg/l) | <0.1 | 0.3 | 0.6 | 0.3 | 0.1 | 0.1 | 0.4 | 0.4 | 0.3 | <0.1 | 0.3 | <0.3 |
| Dissolved Fe (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 Fe (mg/l) | 0.45 | 0.41 | 0.46 | 0.43 | 0.45 | 0.40 | 0.36 | 0.38 | 0.45 | 0.38 | 0.41 | 0.40 |
| Temperature (°C) | 19.5 | 18.0 | 18.0 | 19.5 | 18.0 | 18.0 | 19.5 | 18.0 | 18.0 | 18.5 | 18.0 | 19.0 |
| Dissolved O ₂ (mg/l) | 8.7 | 8.6 | 8.6 | 8.7 | 8.6 | 8.6 | 8.2 | 8.2 | 8.2 | 9.0 | 9.0 | 8.8 |
| Depth (m) | 0 | 32.5 | 65 | 0 | 21 | 42 | 0 | 17 | 35 | 0 | 0 | 0 |
| Dissolved PO ₄ (ug/l) | 73.4 | 73.4 | 146.8 | 24.4 | 24.4 | 146.8 | 24.4 | 73.4 | 110.1 | 73.4 | 73.4 | 73.4 |

TABLE 3 : Results of December monitoring of the Monasavu reservoir and Wailoa river

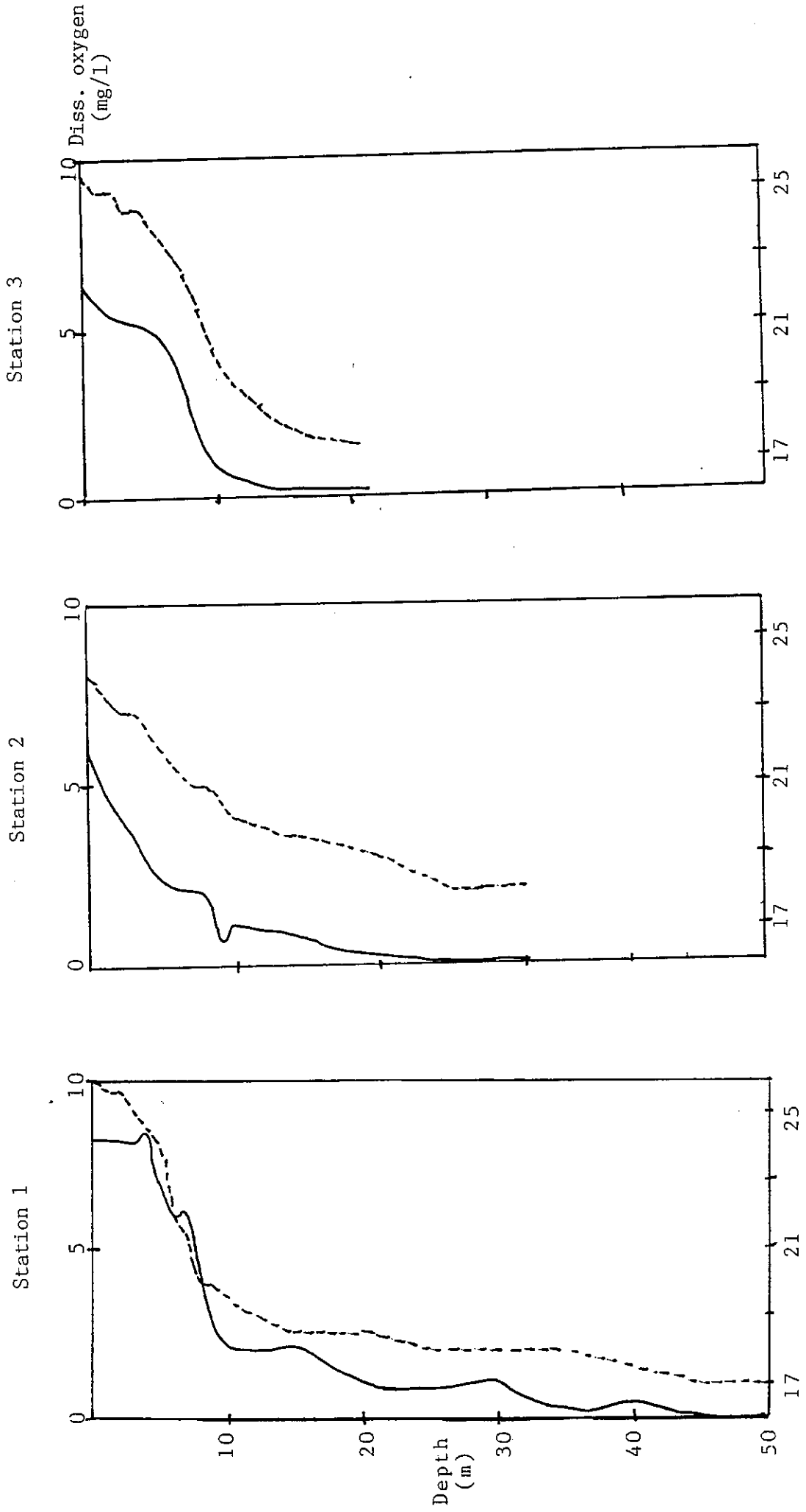
Date :15/16 December 1987

| | Stn. 1 Surface | Stn. 1 Mid | Stn. 1 Bottom | Stn. 2 Surface | Stn. 2 Mid | Stn. 2 Bottom | Stn. 3 Surface | Stn. 3 Mid | Stn. 3 Bottom | Wailoa Above P.S. | Wailoa Tailrace | Wailoa at Laselevu |
|-----------------------------------------------|-------------------|---------------|------------------|-------------------|---------------|------------------|-------------------|---------------|------------------|----------------------|--------------------|-----------------------|
| Total Alkalinity (mg/l CaCO ₃) | 14.9 | 16.3 | 27.8 | 14.3 | 15.0 | 15.0 | 15.3 | 13.8 | 14.8 | 30.5 | 18.0 | 21.9 |
| Turbidity | | 2m | | 1.5 | | | 3.5 | | | | | |
| pH on site lab | 8.05 | 7.00 | 6.90 | 8.70 | 6.95 | 7.00 | 7.70 | 7.20 | 7.05 | 7.80 | 7.30 | 7.50 |
| Total N (mg/l) | 3.87 | 4.41 | 7.60 | 7.91 | 6.28 | 6.34 | 5.23 | 3.91 | 4.16 | 7.00 | 4.16 | 10.46 |
| Total P (ug/l) | 17.5 | 8.8 | 342 | 21.3 | 17.5 | 52.5 | 17.5 | 21.3 | 77.5 | 43.8 | 26.3 | 26.3 |
| Total S (mg/l) | 3.2 | 6.2 | 17.2 | 3.2 | 4.4 | 3.2 | 3.2 | 6.0 | 0 | 0 | 0 | 0 |
| NO ₃ ⁻ (mg/l) | 0 | 151 | 124 | 0 | 7.4 | 14.9 | 62 | 24.8 | 42.3 | 42.2 | 24.8 | 33.5 |
| NH ₃ (ug/l) | 26 | 32 | 4220 | 92 | 10 | <10 | <10 | <10 | 232 | <10 | <<10 | 12 |
| Chlorophyll mg/m ³ | 0.62 | 0.83 | 4.85 | 1.69 | 0.23 | 1.42 | 1.76 | 0.26 | 0 | 4.57 | 0.29 | 0 |
| a | 1.16 | 0.95 | 0.48 | 6.76 | 1.28 | 5.25 | 2.51 | 2.23 | 0 | 2.55 | 0.98 | 0 |
| b | 7.59 | 39.1 | 1.08 | 31.9 | 4.59 | 20.5 | 16.6 | 4.46 | 25.8 | 7.36 | 1.58 | 0 |
| c | | | | | | | | | | | | |
| Dissolved Mn (mg/l) | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Total Mn (mg/l) | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Dissolved Fe (mg/l) | <0.1 | <0.1 | 3.7 | <0.1 | <0.1 | 0.25 | <0.1 | <0.1 | 0.90 | <0.1 | <0.1 | <0.1 |
| Total Fe (mg/l) | <0.1 | 0.14 | 4.1 | 0.1 | 0.12 | 0.25 | 0.12 | 0.10 | 1.25 | <0.1 | 0.18 | <0.1 |
| Temperature (°C) | 26.0 | 18.0 | 17.6 | 23.5 | 19.5 | 18.0 | 25.5 | 20.0 | 17.5 | 26.0 | 26.0 | 24.0 |
| Dissolved O ₂ (mg/l) | 8.2 | 0.8 | 0 | 6.0 | 0.7 | 0 | 6.2 | 0.8 | 0.2 | 9.0 | 9.0 | 8.3 |
| Depth (m) | 0 | 25.0 | 50 | 0 | 15 | 30 | 0 | 12.5 | 25.0 | | | |
| Dissolved PO ₄ (ug/l) | 37.5 | 10 | 680 | 27.5 | 37.5 | 97.5 | 37.5 | 50 | 156 | 77.5 | 77.5 | 97.5 |



Temperature (°C)
Key : — dissolved oxygen
----- temperature

FIGURE 3 : Dissolved oxygen and temperature profiles for station 1, 2 and 3 in July 1987



Temperature (°C)

Station 1 Station 2 Station 3

Key : — dissolved oxygen
----- temperature

FIGURE 4 : Dissolved oxygen and temperature profiles for station 1, 2 and 3 in December 1987

(Wetzel, 1975) as was also recorded during previous studies.

c) Nutrients

i) Nitrogen

With limited monitoring it is difficult to show details in the variations of the different forms of nitrogen in graphical forms. However, figures 5, 6 and 7 give some indications of the various forms of nitrogen during winter and summer periods for the three reservoir stations. These results are similar to those reported in previous years. The surface waters at all stations have low levels of nitrate (Figure 7) throughout the year because of higher photosynthetic activity in these areas and hence the consumption of nitrate within it. Sufficient oxygen in the surface waters prevent formation of ammonia while stratification in the summer months prevents reoxygenation at depths thus explaining the reduction in the nitrate content and increases in the ammonia content (Figure 6). As a result of higher levels of oxygen at all depths in winter, the production of organic forms of nitrogen increases. This explains the observed increases in total nitrogen (TN) at all depths from winter throughout into summer (Figure 4).

ii) Phosphorus

Total phosphorus concentration in the Monasavu reservoir continues to show similar pattern as in previous years. With limited monitoring it is difficult to show graphically variations in total phosphorus concentration with time of year. However, with the two results available it is apparent that TP

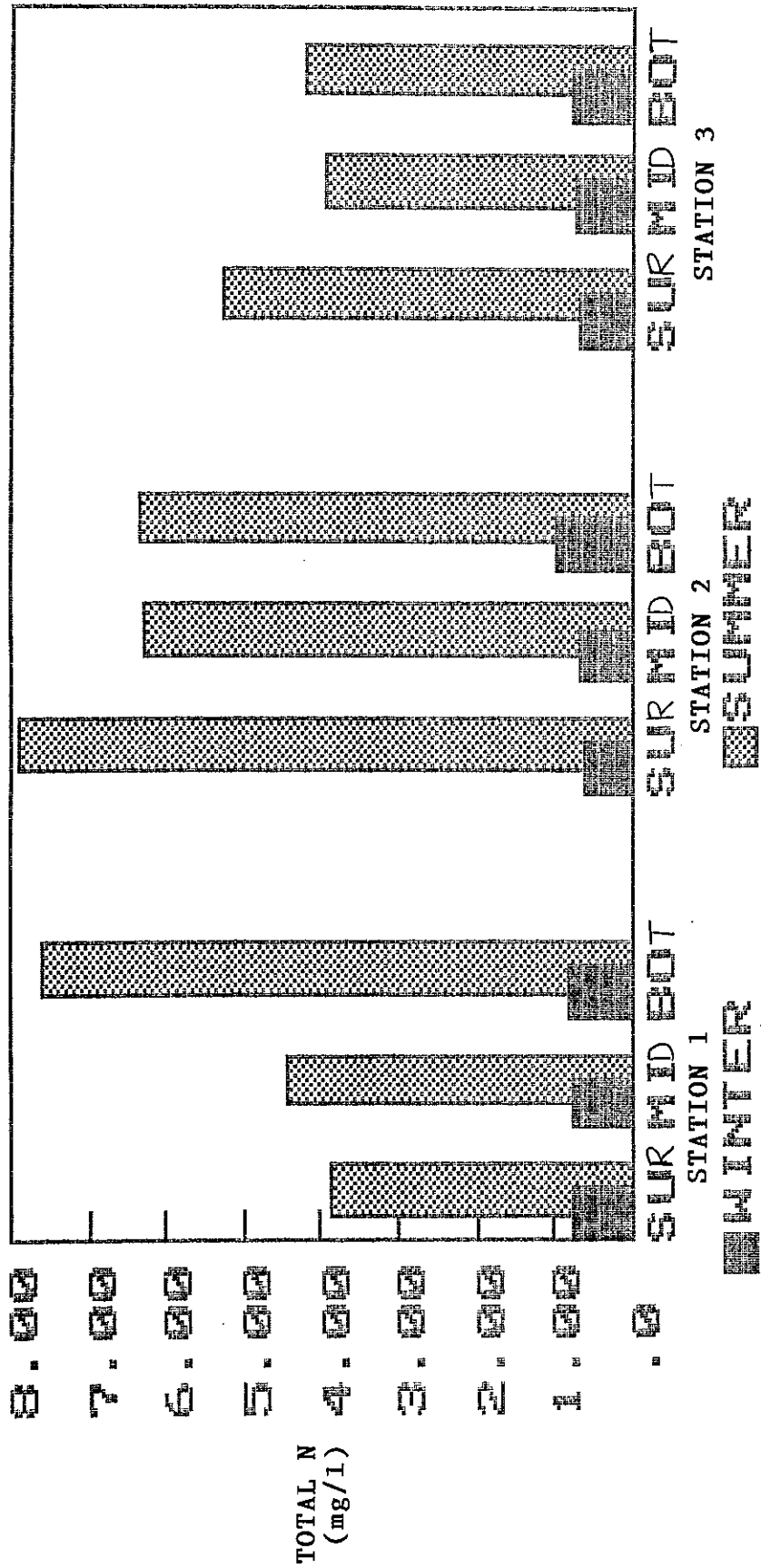


Figure 5 : Variation of total nitrogen (TN) content of the Monasavu reservoir with time of year in 1987

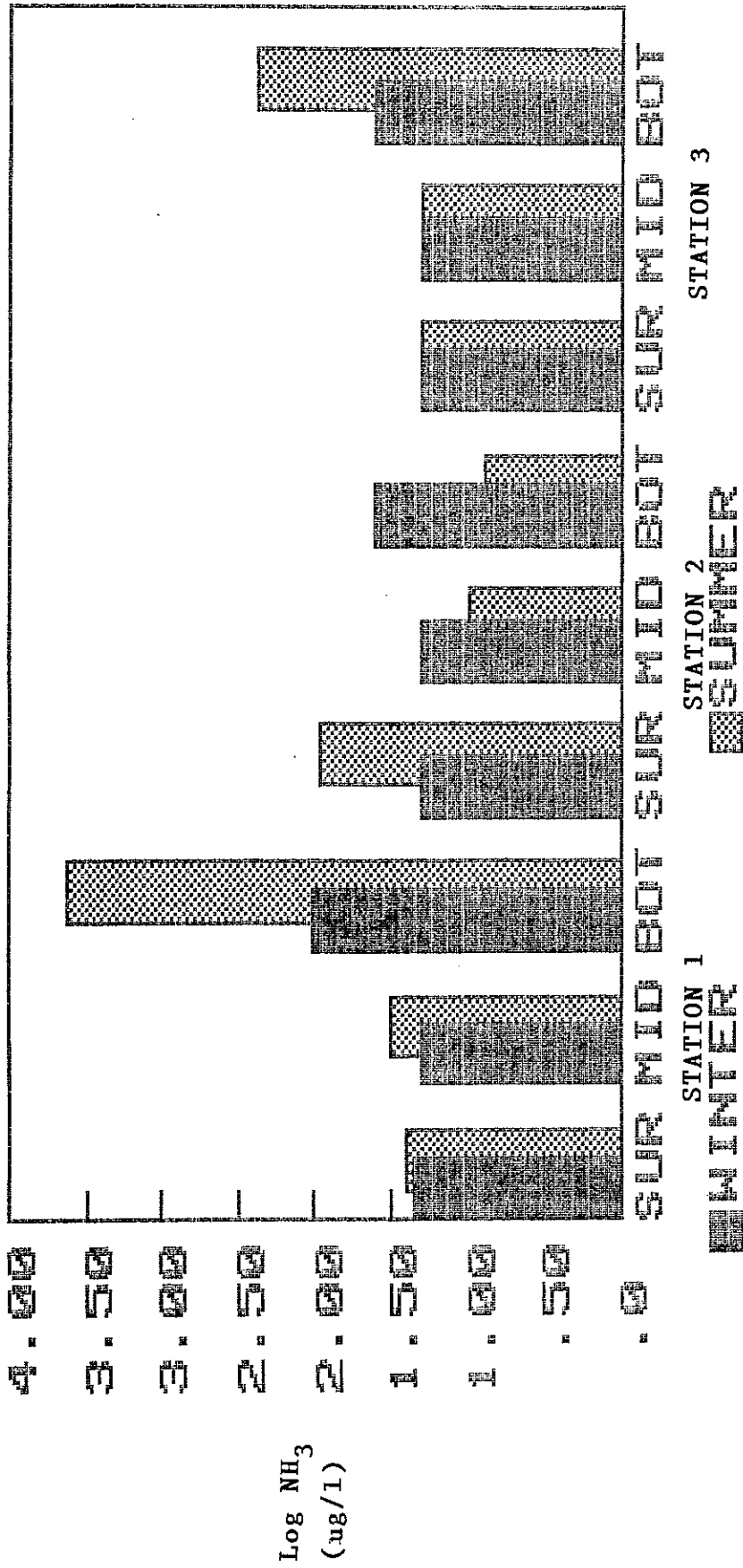


Figure 6 : Variation of ammonia content of the Monasavu reservoir with time of year in 1987

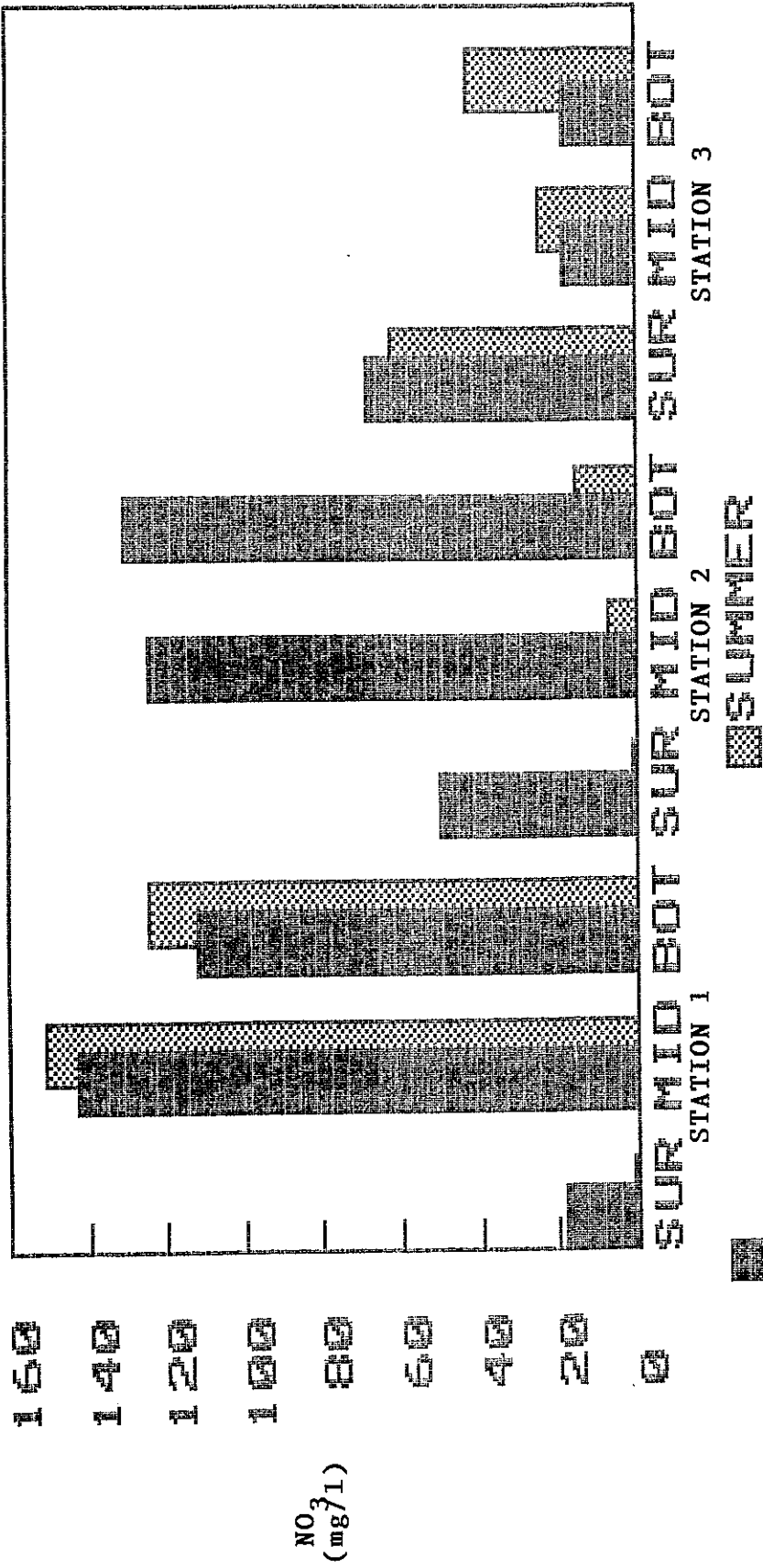


Figure 7 : Variation of nitrate content of the Monasavu reservoir with time of year in 1987

starts to build up at depths beginning in winter months because of greater decomposition of the underlying organic matter and this continues into early summer. The circulation of the entire water column in the winter months allow the movement of mobilized forms of phosphorus into the upper layers where they are used up for metabolic processes thus explaining the lower levels in surface and in middle waters.

iii) Sulphur

The surface sulphur content continues to be low because any release of sulphur from decomposition of organic matter is quickly oxidised under oxic conditions to sulphate which is reused by biota for protein synthesis.

iv) Total Iron and Manganese

Figure 8 shows the trends in total iron concentration during both sampling trips. The seasonal variations are not very apparent with only two monitoring. The cycling of iron and manganese is regulated to a large extent by the seasonal variation in dissolved oxygen content of the water. The surface and middle waters continue to have low levels of iron and manganese because in oxygenated waters these ions are oxidised and returned to the sediments as particulate matter. In the summer months with the formation of stable stratification these ions migrate back into water and an increase is observed at depth.

4.2 The Wailoa River

The point from which water is drawn to the Wailoa power station is located at the bottom of station 2 and

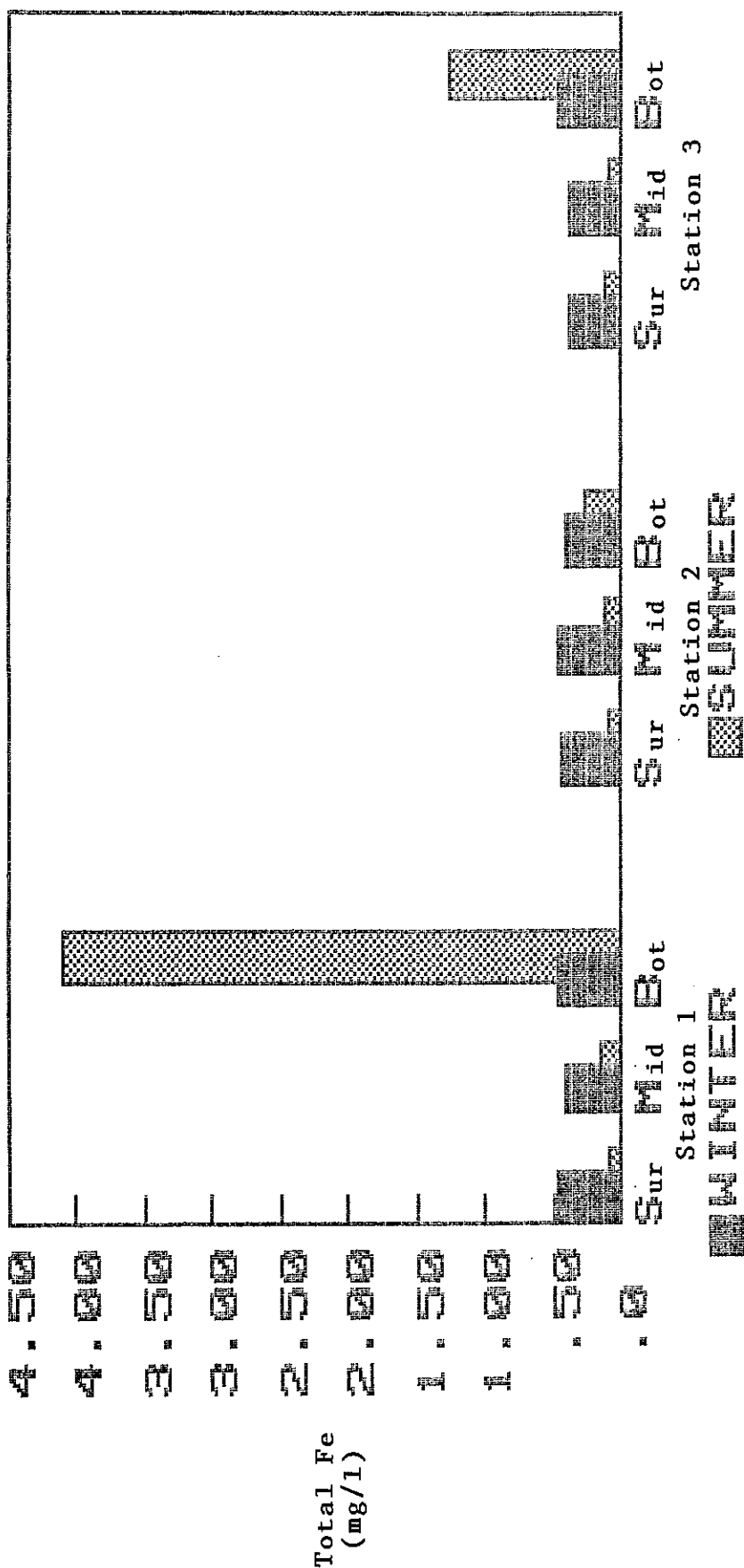


Figure 8 : Variation of total iron (T Fe) content of the Monasavu reservoir with time of year in 1987

according to the conditions prevalent in the reservoir, the power station would normally be receiving water of very low dissolved oxygen content throughout the year especially during the summer months. The oxygenation of the water at the power station however would oxidise any ammonia, hydrogen sulphide and the reduced forms of iron and manganese thus helping to prevent any major corrosion and deposition of material on machines.

TABLE 4

Comparison of Data from Station 2 Bottom Waters and Tailrace Water

| | Sampling Date | Station 2 | Tailrace |
|------------------------|---------------|-----------|----------|
| Total Nitrogen (mg/l) | July 87 | 0.95 | 0.62 |
| Total P (ug/l) | | 54 | 12 |
| NH ₃ (ug/l) | | 40 | <20 |
| NO ₃ (mg/l) | | 130.2 | 223.2 |
| Total Mn (mg/l) | | 0.1 | 0.3 |
| Total Fe (mg/l) | | 0.40 | 0.41 |
| pH | | 6.28 | 7.13 |
| D.O. (mg/l) | | 8.6 | 9.0 |
| TN (mg/l) | Dec. 87 | 6.34 | 4.61 |
| TP (ug/l) | | 52.5 | 26.3 |
| NH ₃ (ug/l) | | <10 | <10 |
| NO ₃ (mg/l) | | 14.9 | 24.8 |
| Total Mn (mg/l) | | <0.1 | <0.1 |
| Total Fe (mg/l) | | 0.25 | 0.18 |
| pH | | 7.00 | 7.30 |
| D.O. (mg/l) | | 0 | 9.0 |

Comparison of the data from station 2 bottom waters and the tailrace water (Table 4) shows that in the winter period there was no significant reduction in

concentration iron or manganese when water reached the tailrace. However, for the summer months the total iron content of the tailrace is slightly lower than that of the bottom waters of station 2. This loss probably occurs at the power station when reduced forms of iron get oxidised and precipitate out as insoluble particulates.

5) Vector-Borne Disease Survey

Dr Alison Haynes, a biologist from the School of Pure and Applied Sciences, USP carried out a survey on 13/14 July of the Monasavu area for possible disease hosts.

5.1 Gastropods in Lake Monasavu in July 1987

by Dr Alison Haynes

A second survey of gastropods in Lake Monasavu was made on 14 and 15 July 1987.

Two sites were visited (1) the end of the road (2) the dam edge. Gastropods are found in relatively shallow water on rocks and wood which become covered in a film of microscopic algae on which the snails feed.

The left-handed gastropod Physastra nasuta, which was very abundant when the reservoir was filling, was present in small numbers. They were examined for parasitic trematode worms but none were found. The P. nasuta population is probably kept in check by fish (Tilapia and carp), leeches, dragonfly and damselfly nymphs and caddisfly larvae, all of which were found around the edge of the lake. For the first time the gastropod Melanoides tuberculata was found. This snail was also examined for parasitic trematode worms, because in Egypt it is known as a host of the lungfluke

Paramonostomium aegyptiacum, but none were found. Two small nematode worms were found in the mantle of one M. tuberculata. These are unlikely to be any danger to humans but fish may act as a second host to these nematodes.

Another gastropod found for the first time in the lake was the small (3 mm high) endemic species Fluviopupa pupoidea. The lake contained a greater variety of invertebrate animals than have been present since 1982. The invertebrates present were:

| | |
|----------------------------|-------------------------------|
| GASTROPODA : | <u>Physastra nasuta</u> |
| | <u>Melanoides tuberculata</u> |
| | <u>Fluviopupa pupoidea</u> |
| HIRUDINEA : | <u>Vivabdella</u> sp. |
| (leeches) | |
| PLANARIA : | a small (1.0-1.5 mm) black |
| (flat worm) | white species |
| ODONATA : | dragonfly nymph |
| | damsel fly nymph |
| TRICHOPTERA: | caddis fly larvae |
| PORIFERA : | green sponge |
| Plankton trawl contained : | copepods (CRUSTACEA) |
| | mites (ARACHNIDAE) |

6) Water-weed Survey

The INR team carried out a water-weed survey on the reservoir during December. The team was concentrating on common weeds like Salvinia auriculata, Eichornia crassipes (water hyacinth) and Hydrilla verticillata. None of these were found in the reservoir.

7) Zooplankton Survey

Dr Satish Choy, a marine biologist from the SPAS, USP carried out a zooplankton survey on the reservoir.

7.1 Zooplankton Survey in Lake Monasavu, 1987 by Dr Satish Choy

No comprehensive study on the Fijian freshwater zooplankton has yet been carried out. This report provides, for the first time, a list of plankton collected from the Monasavu Dam between 1982 and 1987. For comparison, a list of species from various low-altitude lentic habitats is also given. Unfortunately, sampling at regular short-term intervals was not carried out and therefore no information can be provided regarding the temporal variations in the distribution and abundance of the zooplankton in any of the habitats.

The difference between high and low altitude zooplankton species is marked. Limnetic (open water) zooplankton is dominated by the genus Brachionus, Moina, Diaphanosoma, Ceriodaphnia and the cyclopoid copepod Mesocyclops. The others are essentially littoral species.

1. Monasavu Hydroelectric Dam

| | |
|----------------------------------------|-----|
| <u>15/7/82</u> - Littoral (65 um) | |
| <u>Diaphanosoma</u> cf. <u>sarsi</u>) | 94% |
| <u>D. modigliane</u>) | |
| <u>Mesocyclops albicans</u> Smith | 5% |
| <u>Chydorus eurynotus</u>) | |
| Herpacticoid copepods) | 1% |
| Ostracods (<u>Cypretta</u>) | |

- Open water (100 @ 2 knots)

Mesocyclops albicans 100%
19/8/82 - Littoral and open water
Mesocyclops albicans 37%
Diaphanosoma spp. 26%
Chydorus eurynotus 23%
Paracyclops chiltoni (Thomson) 14%
 plus numerous copepodites and nauplii

15/10/82 - Littoral and open water

Diaphanosoma cf. sarsi) open water 83%
D. modigliane)
Mesocyclops albicans 16%
Daphnia sp. (juveniles)
Ceriodaphnia cf. quadrangula (1 specimen)
 Floscularid rotifer)
 Bdelloid rotifer) Undertermined spp.

23/10/85 - Open water

Diaphanosoma spp.
Mesocyclops albicans
Daphnia sp.

22/7/86 - Open water

Diaphanosoma spp.
Mesocyclops albicans
Chydorus eurynotus

15/12/87 - Open water (just before end of drought)

Diaphanosoma spp.
Mesocyclops albicans
Daphnia sp.
Paracyclops chiltoni
 Herpacticoid copepods
 Ostracods
 Unident. water mite

2. Fish Pond - Government Buildings, Suva18/12/81Alona karuaTropacyclaps prasinusArcella

Oligochaetes

Chironomidae

3. Concrete Drainage Coll. Pond, USP, Suva18/12/81Alona karuaTropocyclops prasinusArcellaCentropyxisDiffflugis

Oligochaetes

4. Physics Fishpond, USP, Suva28/12/81Alona (Karua?)Microcyclops varicansTropocyclops prasinusArcellaDiffflugiaPlumutella repens (ectoprocta polyp)5. Ricefield adjacent to Navua River18/12/81Conochilus dossuariusPlatyias quadricornisBrachionus quadridentatusDiaphanosoma sarsi

Alona davidi
Moina micrura
Mesocyclops leuckarti
Tropocyclops prasinus
Arcella
Rhabdocoela
Oligochaetes
Chironomidae

8) Conclusions

The trends observed in the water quality of the Monasavu reservoir and Wailoa river in 1987 were similar to those of previous years. There are indications that the water at the bottom of the reservoir is improving in quality as evidenced by decreasing turbidity, ammonia levels and notable lack of smell of hydrogen sulphide at the power station. The survey of gastropods in lake Monasavu showed negative results for parasitic trematode.

References

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APPENDIX 1
The University of the South Pacific

Serving the Cook Islands, Fiji, Kiribati, Nauru, Vanuatu, Niue, Solomon Islands, Tokelau, Tonga, Tuvalu, Western Samoa

INSTITUTE OF NATURAL RESOURCES

Our Ref :

P.O. Box 1168, Suva, Fiji.

Your Ref :

Telephone: 313900.

Date : 12 March 1987

Cables: University Suva. Telex: FJ2276

The General Manager
Fiji Electricity Authority
Private Bag
LAUTOKA

Dear Sir

I write in response to your telephone conversation (Brodie/Hing Sue) of 11 March requesting for a quotation for water quality measurements in 1987. The quote is as follows for two sampling trips:

| | |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|
| 1. Wailoa monitoring for pH, oxygen, sulphide, iron, manganese, total P, S and N, nitrate, ammonia, phosphate and chlorophyll - laboratory charges | \$ 400.00 |
| 2. Reservoir monitoring for pH, oxygen, sulphide, iron, manganese, total P, S and N, nitrate, ammonia, phosphate, alkalinity, turbidity and chlorophyll - laboratory charges | \$ 900.00 |
| 3. Snail examination | \$ 300.00 |
| Staff sampling time (4 days) | \$ 860.00 |
| Transport | \$ 180.00 |
| Accommodation - FEA | |
| Meals | \$ 40.00 |
| Report Preparation | \$ 60.00 |
| | <hr/> |
| TOTAL | \$2,740.00 ===== |

I hope this is satisfactory.

Yours faithfully

Shamila Naidu
for DIRECTOR