6.2 Statistical Analysis and Discussion of Malpas Dam Water Quality

Data collected at Site 1 included single measurements of some parameters such as temperature, pH, DO, algal cell counts, turbidity, TSS and colour whilst repeated measurements of DRP, TON, Fe, Cu and Mn were performed at varying depths in an effort to identify regions within the water which may be chemically, physically and biologically distinct and to identify possible causes for the variation over time.

Given this situation correlation and regression analysis between parameters utilised the mean of repeated measurements over the entire water column for each parameter. In this fashion it became possible to compare single measurement results with other parameters which had replicates. When assessing trends over time only the data which had replicates were used. The data sub-set comprised the period from October 1998 – July 1999. All statistical analysis were undertaken using STATISTICS (Student Statistic 7).

6.2.1 Wilks-Shapiro Test for Normality

Initial tests indicated that temperature (0.93), secchi depth (0.95), pH (0.96), dissolved oxygen (0.97) and TON (0.93) were normally distributed, although log transformation of TON increased the normality to 0.96. All other parameters required transformation after which all data was normally distributed. These results are shown in Table 6.1.

Table 6.1 Wilk-Shappiro normality test for Site 1[26].

	Natural	Log	$x^{-1/2}$	x^{-1}
Colour	0.44	0.87	0.95	**0.97**
Turbidity	0.35	0.85	**0.96**	0.95
Temperature	**0.93**	0.90	0.88	0.85
TSS	0.82	0.93	0.96	**0.97**
Algal Counts	0.31	**0.97**	0.23	0.11
DRP	0.51	**0.95**	0.82	0.64
TON	0.93	**0.96**		
Chl a	0.65	**0.95**		
Cu	0.56	**0.90**	0.62	
Fe	0.68	**0.94**		
Mn	0.67	**0.91**	0.65	

---

[26] Numbers which appear in bold were used for correlation analysis

6.2.2 Pearson Correlation Coefficients

The correlation between parameters was assessed using the Pearson Correlation Statistic on STATISTICS[27]. There were 16 moderate to strong correlations identified (Figure 6.17).

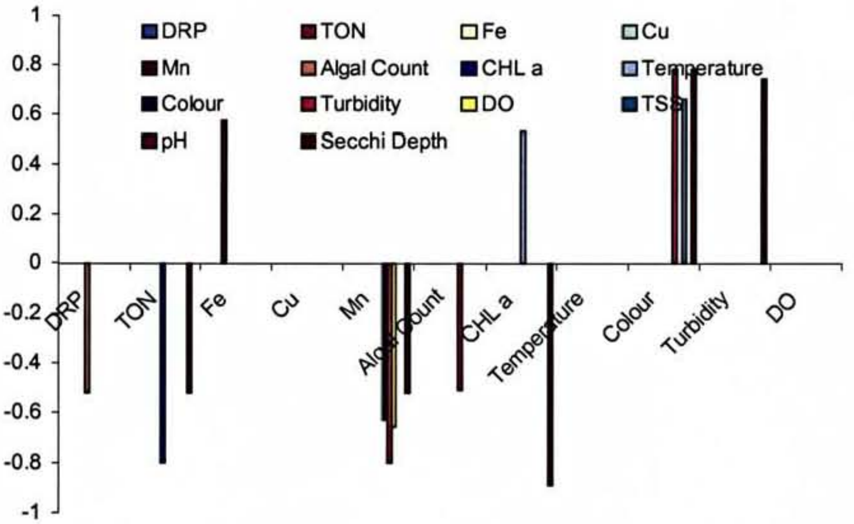

Figure 6.17 Site 1 moderate-strong Pearson correlation values for parameters measured.

There were strongest correlations between Chl-*a* and TON (-0.80) (Figure 6.18), Secchi Depth and Chl-*a* (-0.89) (Figure 6.19) and Turbidity and Mn (-0.80).

The negative relationships with Chl-*a* reflect the nutritional requirements of both aquatic plants and algae within the water column and the influence of increased biomass (as indicated by Chl-*a*) on transparency. The presence of algae also explains the mild correlation (-0.52) between TON and pH. As algae biomass increases TON would be utilised and become less prevalent whilst pH would increase as a result of the removal of carbon from the water column for photosynthesis.

---

[27] All correlations were performed with P=0.05.

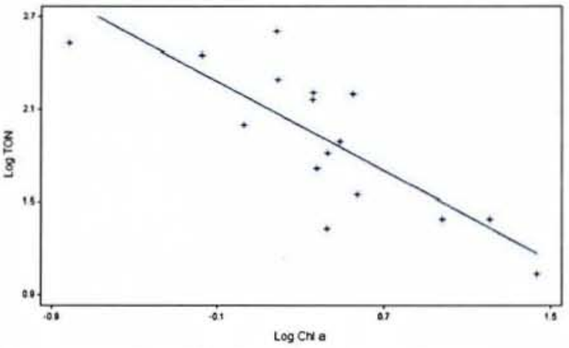

Figure 6.18 Scatter plot of Chl-*a* Vs Log TON at Site 1.

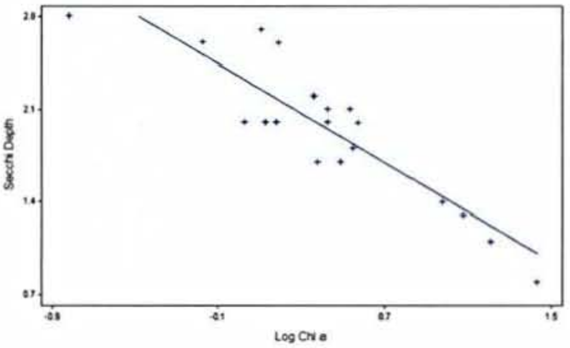

Figure 6.19 Scatter plot of Chl-*a* Vs secchi depth at Site 1.

Both algae and plants require nitrogen in order to facilitate life cycle functions and thus will exert a negative influence on TON concentrations during growth (and Chlorophyll-*a* production). However, during times of decay the nitrogen stored within both plants and algae will be released into the water column. In this situation most of this nitrogen will be in the organic form and not immediately biologically available. The time required for this organic nitrogen pulse to become available will depend largely on the bacterial community present in the water column and those physical factors such as water temperature and pH, which regulates their metabolic activity. The results show (Figure 6.10) that TON fluctuates around a similar median and mean which may be an indication that nutrient recycling at this site is in a steady state in which loss of TON is equivalent to re-supply[28].

---

[28] Also an indication that the data is normally distributed.

Chlorophyll-*a* increased with temperature (0.53). However there was no correlation between algal cell counts (cyanobacteria) and Chl-*a* which indicates that significant other sources of Chl-*a* were present during the sampling period. Possible sources may include unidentified algae and plant material.

Transparency, represented by secchi depth, was adversely impacted by Chl-*a*. There was also mild negative correlations between cyanobacteria cell counts and secchi depth (-0.32) and cyanobacteria cell counts and turbidity (-0.51). Taken together these results indicate that the presence of cyanobacteria within the water column may adversely impact on transparency. However, strong correlation was achieved between secchi depth and colour (0.78), turbidity (0.74) and TSS (-0.69). This indicates that the major influences on transparency are physical in nature and not biological. Although this may also reflect the sporadic infrequent nature of algal blooms

Colour and TSS were moderately correlated (0.66) (Figure 6.20) whilst colour and turbidity were significantly positively correlated (0.78) (Figure 6.21). Possible sources of colour in the water column are cyanobacteria and other algae as well as material such leaf matter and fine sediment. Sediments are the main cause of inorganic turbidity. Given that TSS was correlated with colour it is likely that most of the turbidity was due to colour producing sources already mentioned which prevailed on occasions when the sediment load within the water column was comparatively minor.

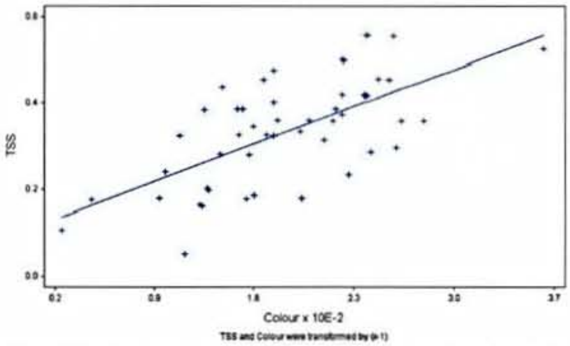

Figure 6.20 Relationship between transformed TSS and colour data at Site 1.

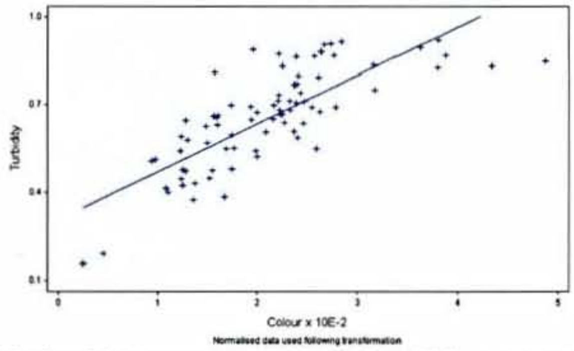

Figure 6.21 Relationship between transformed turbidity and colour data at Site 1.

Manganese was correlated in varying degrees to many parameters monitored at Site 1. These included Fe (0.57), Colour (-0.63), Turbidity (-0.80), DO (-0.66) and secchi depth (-0.52). From redox theory and the coexistence of Mn and Fe within the dam sediments (Boulton et al. 1995) it is likely that both these metals occur as a result of internal loading under reducing conditions. The lack of correlation between these metals and pH can be explained by the inability to obtain pH measurements at the micro-environment above the sediments where pH would be significantly less than that measured at even a few centimetres higher. This was evident on some occasions when the pH probe was inadvertently lowered to the dam floor (Woods unpublished, Appendix D). On most of these occasions the sediments were disturbed which affected the accuracy of other measurements such as turbidity and TSS. For this reason sampling from this micro-environment was avoided whenever possible. Likewise the relationship between DO and Mn and Fe may also be underestimated by the same inability. Increased turbidity and colour would accompany the release of these metals and if circulated result in reduced transparency (secchi depth) due to the formation of oxides.

6.2.3 Regression Analysis and Threshold Levels[29]

Linear regression analysis of all data revealed that with the exception of Chl-*a* and secchi depth (R^2=0.8) there was little evidence of controlling parameters. These results reveal that there is a high degree of independence amongst the

---

[29] All data used in threshold identification were raw i.e. were not transformed to normality.

parameters measured such that linear modeling of this data set is inappropriate (Table 6.2).

Table 6.2 Site 1 moderate regression values

	Colour	Turbidity	Chl a	TON	Secchi	Mn
Secchi Depth	0.57	0.54	0.80	NA	NA	NA
Chl a	NA	NA	NA	0.65	0.80	NA
Turbidity	0.62	NA	NA	NA	0.54	0.64

There were, however possible threshold levels, which heralded a change in cyanobacteria growth within the water column. It appears that the establishment of Anabaena *circinalis* at Site 1 occurs almost exclusively when the mean water column turbidity does not exceed approximately 6NTU (Figure 6.22). During this study period this condition was not met on 5 occasions (Table 6.3).

Table 6.3 Occasions of high mean water column turbidity within Malpas Dam.

Date Measurement Taken	Mean Water Column Turbidity (NTU)
7th August 1998	40.43
18 August 1998	40.18
11 September 1998	26.67
9 October 19998	7.16
13 October 1998	6.78

Likewise excessive growth occurred predominately between the temperature range of 14.5°C and 20°C (Figure 6.23).

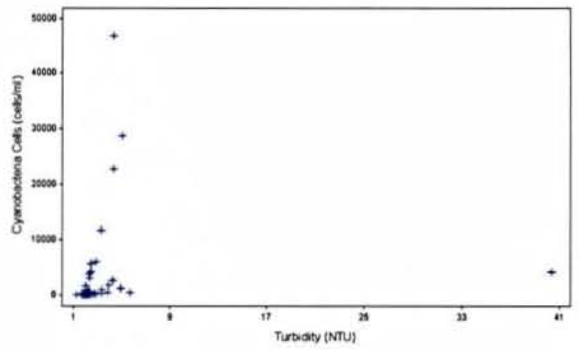

Figure 6.22 Site 1 turbidity threshold for Anabaena *circinalis.*

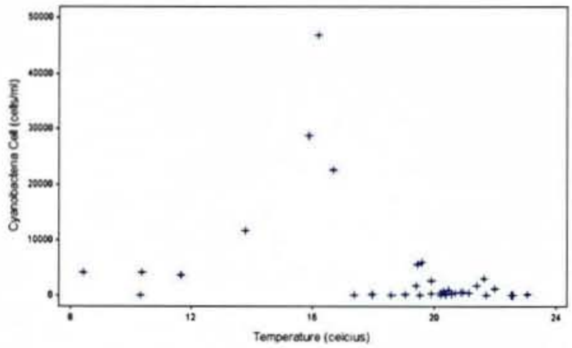

Figure 6.23 Site 1 temperature threshold for Anabaena *circinalis.*

Cyanobacteria were present throughout the range of DRP and TON concentrations which occurred at Site 1. However, it is evident that excessive growth generally occurs at nutrient levels significantly less than the maximum levels (approximately 80μg/L TON and 10μg/L DRP). This can be seen in Figures 6.24 and 6.25, which show that blooms were common at times when nutrient levels were relatively low.

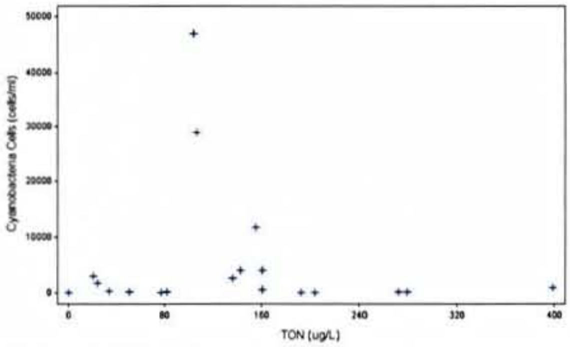

Figure 6.24 Site 1 threshold TON levels for Anabeana *circinalis* growth.

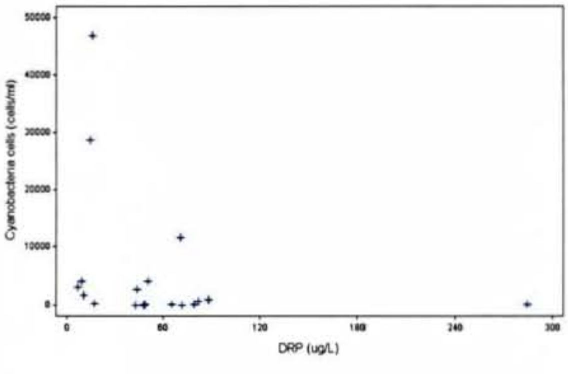

Figure 6.25 Site 1 threshold DRP levels for Anabaena *circinalis* growth.

6.2.4 Analysis of Variance

Data for variance analysis comprised only that subset of the sampling period in which replicates were taken at depths 0m, 6m and 20m below the water surface. These depths were selected so as to represent the possible regions within the water column: epilimnion, metalimnion and hypolimnion. Dissolved reactive phosphorus, total oxidized nitrogen and the filterable metals were assessed for variance however in the case of filterable copper zero values and variances made it impossible to compare.

6.2.4.1 Dissolved Reactive Phosphorus

A two-way analysis of variance revealed that DRP varies over time as well as depth with variation over time being most pronounced. There were 11, 10 and 12 distinct groups identified as having similar means. These were at 0m, 6m and 20m below the water surface respectively. Variation over depth was limited to two groups, the epilimnion (0-6m) and the rest of the water column (6-20m). Figures 6.26 and 6.27 show this variation of DRP over the period of the sampling period[30].

---

[30] Data appears in 2 graphs with different axis scale in order to achieve a clearer appreciation of the data.

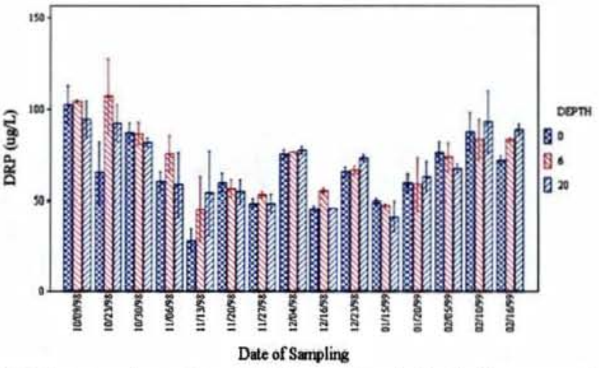

Figure 6.26 DRP error bar chart with standard deviation over time and depth.

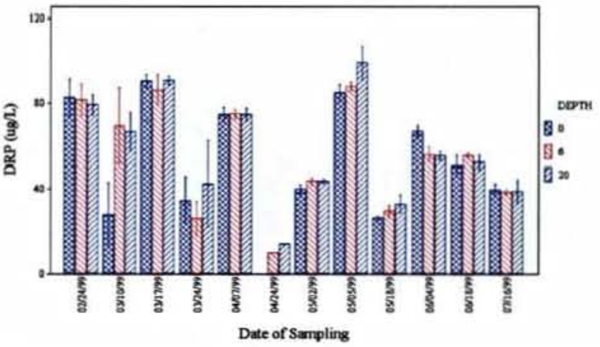

Figure 6.27 DRP error bar chart with standard deviation over time and depth.

The highest mean concentration of DRP occurred on August 17th of 1998 at 20m below the water surface (111.5μg/L). The minimum mean value (24μg/L) occurred on the 24th of March 1999 at 6m below the water surface following a period (one month) of little precipitation and unstable water conditions (i.e. no thermal stratification and DO>5mg/l).

Influence of Environmental Variables

Closer inspection of the data revealed that DRP concentration may be affected by the presence of algae, temperature and DO gradients as well as inflow events.

Presence of Algae

On three notable occasions when algae were present in the water column there was a subsequent significant difference between depths in DRP concentration. This occurred on 13th November and 16th of December 1998 (Volvox) and 10th March 1999 (Anabaena *circinalis*). On the 13th of November there were 0-6 cells of Volvox, over 2-12 metres below the water surface whilst on the 16th of December there were 930 cells of Anabaena *circinalis* from the surface to 2m below the water surface. A surface bloom of 10,000 Anabaena *circinalis* cells/ml characterised the period surrounding the 10th of March 1999. The significant variation between the 10th of March and the 17th of March of 1999 may be attributed to the decay of the algal bloom and release of intracellular stores of DRP into the water column.

The slight negative correlation observed in the previous section (6.1.12) between Chlorophyll-*a* and DRP concentration strengthens the belief that even relatively small numbers of algal cells can impact on localized DRP levels.

Major Inflows

On the 23rd Oct 1998 the hypolimnion contained significantly higher concentration of DRP than either the metalimnion or the epilimnion. On this occasion a large inflow event had raised turbidity levels to 40NTU in September. Turbidity was gradually settling to 6NTU on Oct 23rd however this was still above the base level of approximately 3NTU.

Other impacts of inflow were felt on the levels of metals in the water column. There was a moderate correlation between filterable iron and DRP suggesting that DRP in association with iron (and manganese) containing sediment particles may enter the dam during some rainfall events and exert significant changes over the chemical nature of the water column. In addition the large inflow would have agitated the benthic sediments possibly causing re-suspension due to the intrusion of the colder inflow water into the hypolimnion. This would have led to a concurrent increase in both turbidity and DRP levels in the metalimnion as seen on the 6 Nov 1998.

Changes in the Chemical Conditions at the Hypolimnion.

During the same period there was also evident thermal stratification with a strong oxycline. The temperature difference on both occasions was greater then 3.5°C with a dissolved oxygen difference between the surface and the hypolimnion of more than 4mg/L. The presence of both of gradients may have acted to promote internal loading whilst limiting mixing between the hypolimnion and the epilimnion leading to a build up in the hypolimnion of DRP.

6.2.4.2 Total Oxidised Nitrogen

There was a significant variation of TON over time but not depth over the sampling period. This lack of variation over depth may be due in part to the large standard deviations for this total data set. However specific days did display variability between depths. The period from the 13th of November to the 16th of December 1998 had numerous occasions where significant variation existed (Figures 6.28 & 6.29)[31]. As in the case of DRP the causes for this included the presence of algae, specific DO and temperature conditions as well as inflow characteristics.

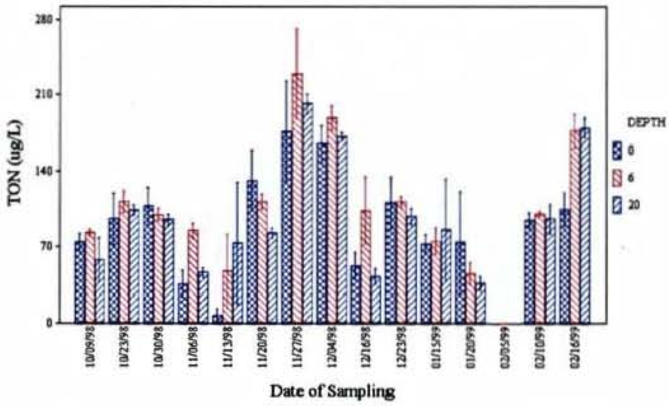

Figure 6.28 Mean TON concentration over depth and time at Site 1.

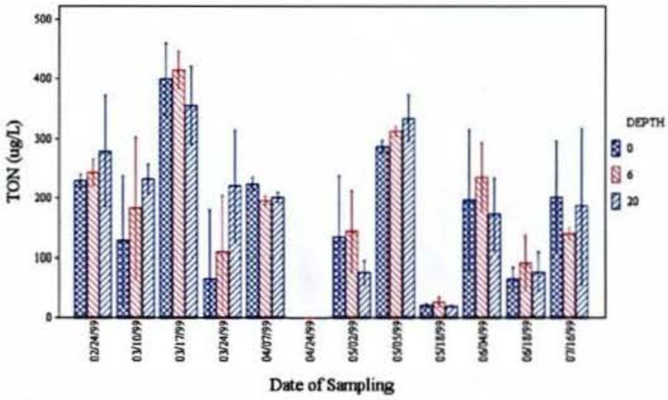

Figure 6.29 Mean TON concentration over depth and time at Site 1.

---

[31] Data appears in 2 graphs with different axis scale in order to achieve a clearer appreciation of the data.

During the late spring-early summer period of 1998 the green algae Volvox and the cyanobacterium Anabaena *circinalis* were present to varying degrees which placed some demand on TON stores.

In October of 1998 a large volume of water entered the dam from a single rainfall event. In addition to readily available TON present in this inflow there would also have been other organic material which after biological breakdown and mixing would also have contributed to the store of TON. The relatively high levels of TON recorded in November and December of 1998 may be a result of such a series of events.

Another period of variation occurred from late summer to early autumn of 1999. A bloom of cyanobacteria on the 12th of March was preceded by increased TON concentrations with depth. Although not significant[32] this may be a reflection of the nutrient requirements of the algae on its migration to the surface. Following the bloom on the 12th of March the TON concentration peaked at approximately 410μg/L at 6m below the water surface on the 17th of March 1999, the highest level recorded for the sampling period. The possible cause of this may be due to the release of TON from lysed algal cells which could have occurred as a result of over-exposure to sunlight (photo-oxidation) (Nienow et al. 1988 cited in Wynn-Williams 2000). The low DO levels for this period may also be explained as the result of biological oxygen demand increased with the breakdown of cell material.

6.2.4.3 Filterable Metals

There were four distinct homogenous groups for filterable iron and manganese The highest concentration occurred on the 30th October 1998 and reached levels of 440μg/L (Figure 6.30). This followed a major rainfall and inflow event[33]. During the period from 9th October to 13th November 1998 there was also substantial temperature and oxygen stratification as well as high turbidity levels.

---

[32] Probably due to the large variances between depths.

[33] See Section 7.3 for details regarding inflow events.

On the 23rd of October the hypolimnion was 14.2°C, 3.5°C less than the epilimnion at the same time the dissolved oxygen concentration was only 4.8mg/l, 5.1mg/l less than the epilimnion. On the 30th of October the temperature gradient was similar however the hypolimnic dissolved oxygen concentration was 2.85mg/l. At these levels of dissolved oxygen concentration reduction of ferric iron to ferrous iron at the sediment surface may occur resulting in increased levels of filterable Fe which is reflected in the results. Likewise on the 22nd of December 1998 low DO (2.8mg/L) would also facilitate reductive release of metals.

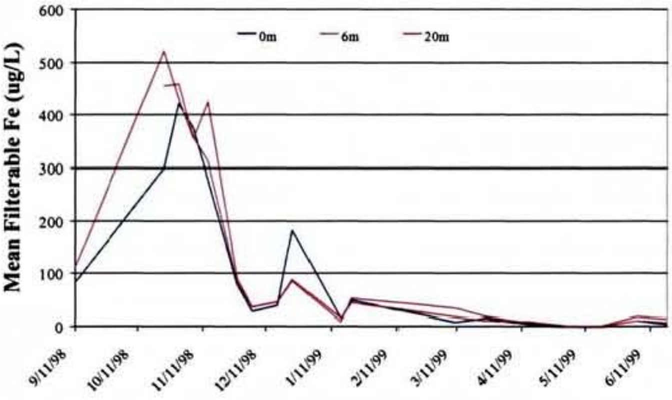

Figure 6.30 Mean filterable Fe concentration over time and depth.

The high filterable Fe concentrations for the period October to late November could also be related to the inflow event which raised turbidity levels to a maximum of 40 NTU in October. Following this period a gradual decline in turbidity was mirrored in a decrease in filterable metals. Internal loading of metals from the resuspension of dam sediments may also have occurred due to turbulence created in the hypolimnion due to the large volume of inflow. The solids contributing to this high turbidity would include catchment clay particles and humic substances, both of which readily carry Fe and Mn in their structures or sorbed to their surfaces and thus would effectively remove some of the metals from the water column when settling out.

6.3 Malpas Dam Water Quality Summary

All parameters measured were normally distributed or required a single standard transformation to achieve this state. Parametric statistical analysis of the data identified a number of strong correlations between variables including;

- Chl-*a* – TON (-0.80)
- Chl-*a* – Secchi Depth (-0.84)
- Turbidity – Mn (-0.80)

In addition there were many moderate correlations between the remaining parameters. In spite of the high number of correlations the data showed very little tendency towards linear regression analysis and modelling. There were, however threshold levels of some parameters identified which heralded a change in the water quality of the dam water and specifically cyanobacteria growth. Excessive cyanobacteria growth occurred almost exclusively when:

- Mean water temperature of the water column was 14.5°C - 20°C,
- Mean water column turbidity < 6NTU.

Blooms of cyanobacteria (predominately Anabaena *spp.*) appeared at variable levels of nutrients within the dam (greater than 10μg/L for DRP and 20μg/L for TON). These levels were consistently present and exceeded within the dam (median DRP and TON were 55 and 100.9μg/L respectively). This suggests nitrogen or phosphorus limitation within the dam is not a regulatory factor in the growth and proliferation of cyanobacteria in the dam.

Analysis of variance of selected data showed that DRP and filterable metals varied over time and depth in response to the presence of algae, temperature and DO gradients and the magnitude of inflow events. TON likewise varied in response to these factors but showed less variation over depth probably due to the large standard deviation of the results obtained.

Most parameters measured exceeded the health or aesthetic guidelines for drinking water in Australia on several occasions during the sampling period (Table 6.4). Most notable was the occurrence of cyanobacteria blooms and the high concentrations of filterable Fe and Mn. Turbidity, colour and pH all ranged beyond what is acceptable for drinking whilst TON and DRP concentration posed no health or aesthetic concern. Levels of TON and DRP however did exceed what is considered the threshold values at which algae may flourish.

Table 6.4 Australian guideline values for common water quality parameters (adapted from NHMRC/ARMCANZ 2000).

Parameter	Range	Mean Water Column	Health	Aesthetic
Dissolved Oxygen (mg/L)	0.07-17.75	7.2		>85%
pH	7.34 - 9.48	8.22		6.5 - 8.5
Turbidity (NTU)	0.82 - 42	4.05		5
Colour (HU)	16 - 446	61.7		15
DRP (µg/L)	0 - 1570	71		
TON (µg /L)	0 - 855	132.7	50000	
Filterable Fe (µg /L)	0 - 858	93.7		300
Cyanobacteria (cells/ml)	0 - 448000	NA	>6500	>2000

7.0 Catchment Results

7.1 Rainfall Review

7.1.1 Rainfall Temporal Pattern

In the four years that rainfall was recorded for this investigation it was shown to be highly variable in both amount and intensity. As both of these have been shown to be important when estimating runoff they were measured. The wettest year in the five year study period was 1998 where a total of 867mm of rainfall for the year (Table 7.1). The driest year was 2000 which had only 553mm spread over 145 wet days. Most rainfall occurred in spring and summer whilst winter months received significantly less (Figure 7.1).

Table 7.1 Malpas Catchment rainfall during the period 1997-2001.

	Total Rainfall (mm)	Daily Mean (mm)	Daily Max. (mm)	Monthly Max. (mm)	Wet Days
1997	730.4	2.2	45.1	184.0	127
1998	867.0	2.4	60.2	126.0	165
1999	592.0	1.6	38.4	117.0	169
2000	553.0	1.5	39.2	89.4	145
2001	862.0	2.4	72.0	173.4	164

1997 was dominated by summer rainfall culminating in the maximum monthly rainfall recorded for the 5 year period of 184mm in February (Figure 7.2). In February of 1997 123mm of rain fell between the 12th and 15th of that month

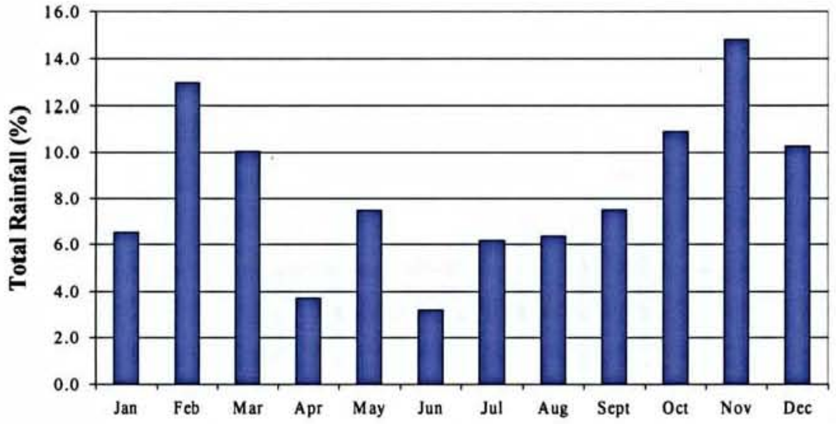

Figure 7.1 Rainfall temporal distribution during the period 1997-2001 (Appendix D).

including the maximum recorded in one day for the year (45.08mm). This event also exhibited a very high 20 minute intensity of 60.6mm/hr.

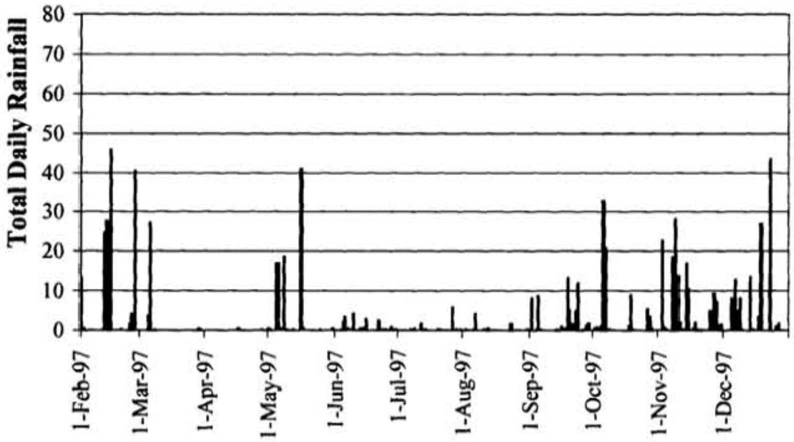

Figure 7.2 1997 rainfall records as measured at Willow Glen Station

On the 27th of the same month a further 40.4mm of rain fell. November and December of the same year had 139mm and 123mm respectively. Extended periods of continual wet days occurred in September (9 days), October (8 days) and November (8 days) however November contained the most total wet days for any month (20) followed by June (17 days). The driest month for 1997 was April, which had 1mm of rainfall.

1998 was dominated by late winter/early spring rainfall, which accounted for 40% of the years total rainfall with the wettest month being September (126mm) (Figure 7.3). On the 27th of July 60.2mm of rain fell in a 24hr period but had only a moderate 20minute intensity of 22.8mm/hr and a 6minute intensity of 38.0mm/hr. Both July and August recorded 111mm of rainfall with 23 and 17 wet days respectively including 2 days of 26mm on the 15th and 16th of August. February delivered 114mm of rainfall which represented 58% of total summer rainfall. During this month there were 13 consecutive wet days which ranged from 0.2-33.6mm/day. The driest month was March (11mm) followed by November (34mm) and December (40mm).

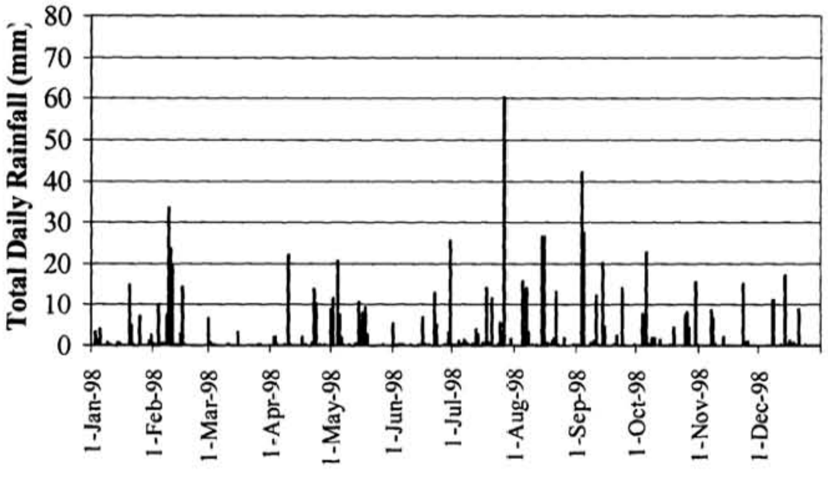

Figure 7.3 1998 rainfall records as measured at Willow Glen Station.

In contrast to the previous year, rainfall in 1999 was dominated by late spring early summer rainfall (Figure 7.4). The maximum monthly total was 117mm in October, which fell in three distinct periods within the month and comprised 18 wet days. The largest single day of rainfall was 38.4mm on the 4th of October which had a 20minute and 6minute intensity of 23.4mm/hr and 40.0 mm/hr respectively. November contributed 103mm with 13 wet days (8 consecutive) whilst December added 84mm over a total of 13 wet days also. The driest period was April-June which contributed a total of 41mm in the three months. 1999 was the second driest year during the study period behind 2000.

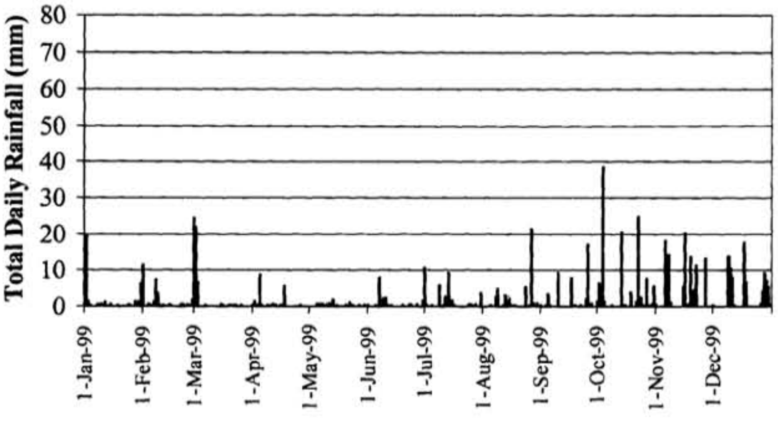

Figure 7.4 1999 rainfall records as measured at Willow Glen Station.

The year 2000 was significantly drier than all years in the study period characterised by a very dry autumn and winter (Figure 7.5). A total of 150.4mm

(27%) of rainfall fell in the 6 months between April and September of 2000. The largest fall for this period was 22mm on the 26th of May. The wettest month was March (89.4mm) followed by October (85.8mm), November (84.6mm) and December (64.8mm). October 14th was the wettest day with 39.2mm of rain recorded in the 24 hour period.

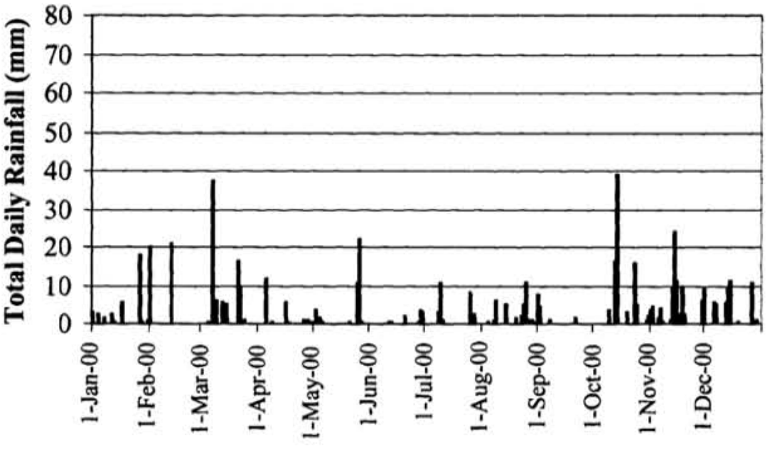

Figure 7.5 2000 rainfall records as measured at Willow Glen Station.

2001 was a wet year with 862mm of rainfall and 162 wet days (Figure 7.6). It was also dominated by Late summer/autumn and spring rainfall with the maximum total monthly rainfall of 175mm and daily rainfall of 72.0mm in March making it the second wettest month in the 5 year period. November was also extremely wet with 173.4mm and 15 wet days at an average daily rainfall of 5.8mm. The driest month was June (7.6mm).

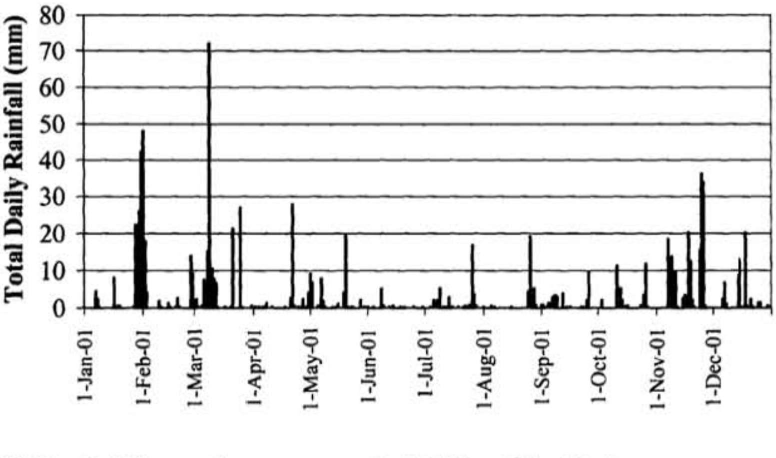

Figure 7.6 2001 rainfall records as measured at Willow Glen Station

7.1.2 *Rainfall Intensities*

During the period February 1997 and December 2001 there were a total of 221 events which produced more than 5 mm of rainfall. Approximately 50% had 20 min rainfall intensities of less than 8.4 mm/hr (Figure 7.7). For 6 min rainfall intensity approximately 32% of events were 8mm/hr or less (Figure 7.8).

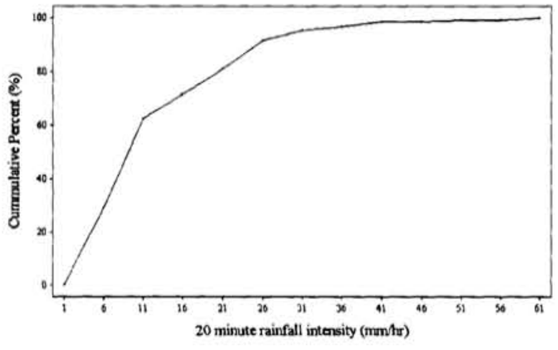

Figure 7.7 Commulative distribution of 20 minute rainfall intensity for all events greater than 5mm measured at Willow Glen Station for 1997-2001.

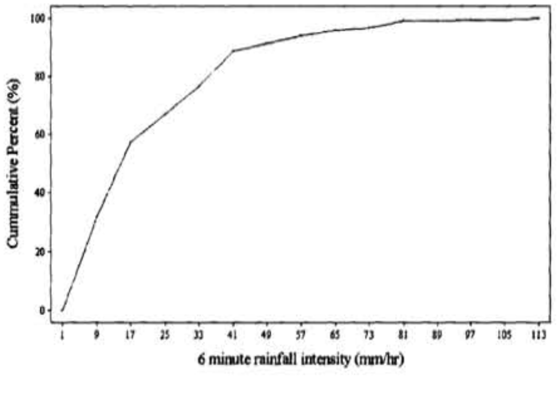

Figure 7.8 Commulative distribution of 6 minute rainfall intensity for all events greater than 5mm measured at Willow Glen Station for 1997-2001.

7.2 Gara River Discharge

Total discharge varied markedly between all years of the study period (Figure 7.9) 2001 yielded the most runoff from Gara catchment with total discharge reaching 30,608 ML for the year. This was marginally higher than that for 1998 (26,557 ML) and significantly larger than 1997, 1999 and 2000.

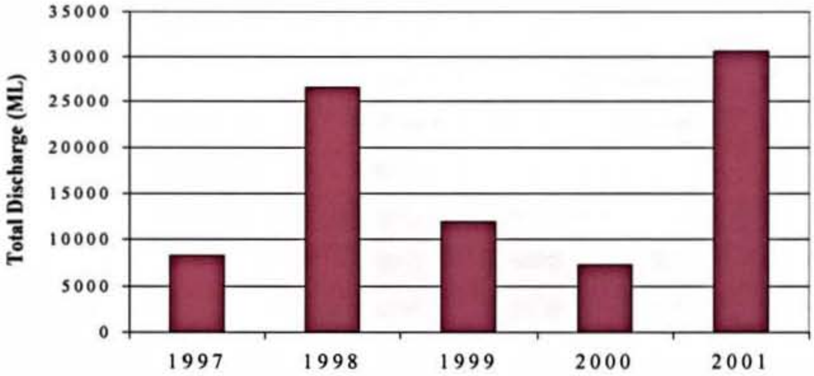

Figure 7.9 Total yearly discharge from Gara River

With the exception of 1998 most discharge occurred from October to March (Figure 7.10). The largest daily flows[34] were recorded in July of 1998 (4535ML) and March of 2001 (4102ML). Zero flow occurred at various times during 1998, 1999, 2000 and 2001. The median flow for the period 1997 to 2001 was 5.86ML/Day whereas the 95% figure corresponded to 164.5ML/day.

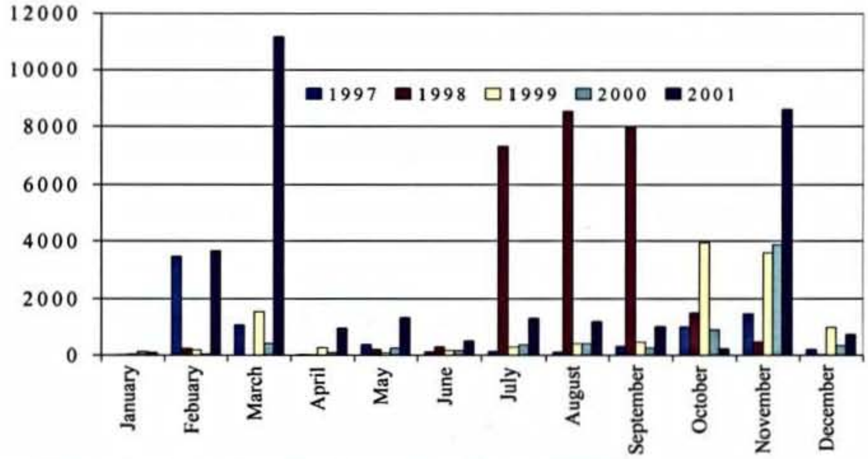

Figure 7.10 Total monthly flow from Gara River 1997-2001.

7.3 Water Quality

Anecdotal evidence and short term visual monitoring of the site at 'Willow Glen' revealed marked variation in the physical characteristics of the various possible sites. As a result a number of sites were chosen for a preliminary study in order to identify the site which would provide the optimum opportunity for sampling under all flow conditions. It was revealed that there was chemical and physical

---

[34] Daily flow measured from 0000 hours to 2400 hours.

variability between sites which also varied in degrees in response to discharge. All variables measured were averaged and the site which most closely agreed with these was chosen as the site of sampling. The complete results of this study appear in Appendix C.

7.3.1 *Manual Sampling of Gara River Water Quality*

Nutrient concentrations varied dramatically over the sampling period (1998-999) depending largely upon the discharge flowing past Willow Glen station. Manual sampling[35] (Figure 7.11) revealed that TON ranged between 0µg/L and 2100µg/L with a median value of 60.54µg/L. Ortho-phosphate varied between 0 and 256µg/L with a median of 12µg/L whilst turbidity recorded readings of 85, 4, and 9.8NTU for the maximum, minimum and median respectively for the same period.

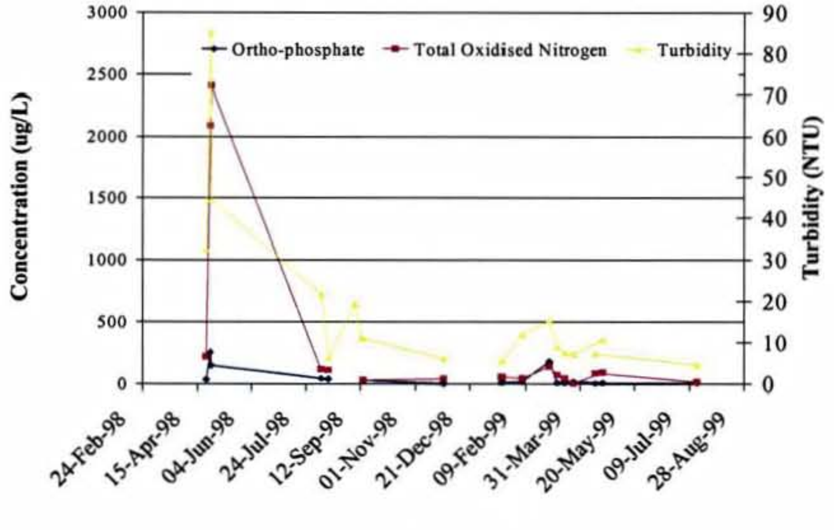

Figure 7.11 Mean nutrient and turbidity variation during zero-moderate flow measured manually at Willow Glen Station.

7.3.1.1 Statistical Analysis of Manual Water Samples

Catchment discharge measured over the sampling period was shown to be normally distributed (0.821) by the Wilks-Shapiro method whilst mean ortho-phosphate, total oxidised nitrogen and turbidity required Log transformation to

---

[35] Manual samples were collected from low-moderate flows (0-105ML/day). High flows were captured using the gammit autosampler.

achieve normality (0.93, 0.88, 0.92 and 0.821 respectively). Correlations between each varied from moderate to high (Figure 7.12).

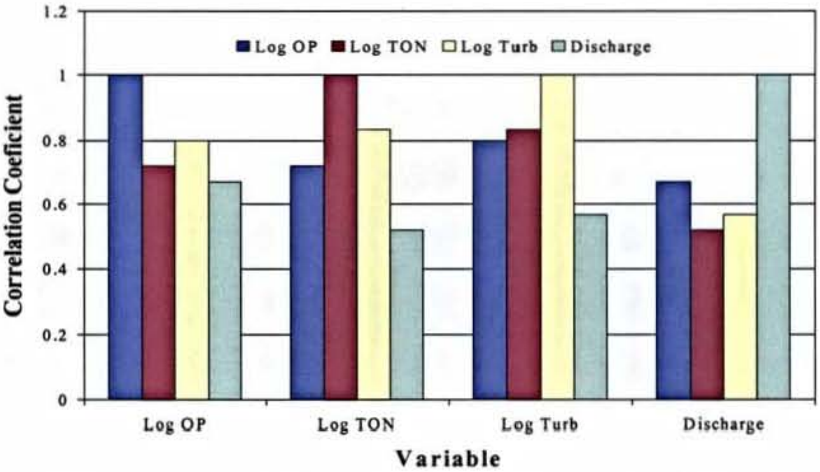

Figure 7.12 Correlation Matrix of Variables Monitored at Willow Glen Station (1998 - 1999).

7.3.1.2 Gara River Water Temperature

1998 recorded the overall warmest mean water temperature at 16.5°C over the year (Figure 7.13). It also had the warmest day for the period February 1998 to January 2002. During February the maximum temperature was 26.16°C. There was a gradual decrease in water temperature from the beginning of the study to the end typified by significant variation in water temperature on short temporal scales. The warmest water temperatures were recorded for all years in January whereas the coldest water occurred in July with the exception of 1998 which had unusually high winter water temperatures and a minimum of 8.8°C in August.

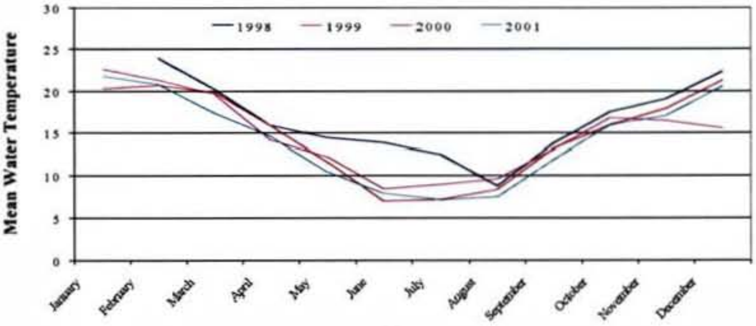

Figure 7.13 Mean Daily Water Temperature[36].

---

[36] Temperature was not measured in 1997.