Dolomedes Species Recovery Programme: Analysis of water chemistry from Lopham Fen

Introduction

The population of *Dolomedes plantarius* at Lopham Fen is being studied and monitored by Dr E. Duffey for the English Nature Species Recovery Programme. A number of pools in both Middle Fen and in Little Fen are being monitored. To compliment this work samples of water chemistry were taken from each of these pools.

Pools differ in history and location. Within Middle Fen pools on the 'Spider Pit Path' were dug in 1977, the remaining pools in Middle Fen were dug in 1986, while the pools sampled in Little Fen were all dug in 1989 (A.Rivet *pers comm*).

Samples were also taken from Worbys Drain, which runs through Little Fen and is suspected to be contaminated by agricultural runoff, and from three locations on the RiverWaveny. For location of these sampling points see map.

Sampling was carried out on one date in July and on one date in August. On each occassion pH, dissolved oxygen concentration, biological oxygen demand, concentrations of soluble reactive phosphorous (SRP) and of total phosphorous (total P) were determined.

After the July samples were collected the Suffolk Wildlife Trust began to pump water into most of the pools in Little Fen and Middle Fen, with the exception of the Spider Pit Path pools. Pumping commenced on the 2nd of August, with a rate of supply of approximately 6,500 litres an hour to each of the Fens (total 13,000 l hr^{-1} A.Rivet *pers comm*). Water came from the adjacent Anglian Water borehole, and was chlorinated and then de-chlorinated before delivery.

Methods used

Water samples from pools were collected from each of the pools being monitored by Dr Duffey (29 in Middle Fen and 28 in Little Fen), and from a random sample of 6 of the pools along the Spider Pit Path. Water samples were collected from 5-10 cm below the surface, transported to the laboratory in polythene storage bottles and stored at 4^0C.

Sampling was carried out on the 16th of July and the 28th of August.

pH

pH was measured on return to the laboratory using a glass electrode pH meter.

Oxygen
In July no oxygen meter was available. The concentration of dissolved oxygen was therefore determined using the Winklers reagent method (Allen 1974). In August dissolved oxygen was measured using a portable field oxygen meter.

Biological oxygen demand
BOD was determined by saturation of aliquots of water samples and distilled water controls with dissolved oxygen, incubation at 20°C for 5 days and determination of residual dissolved oxygen by the Winkler reagent method.

Soluble reactive phosphorøus
SRP was determined by the molybdenum blue colorimetric method (Allen 1974), on aliquots filtered through glass-fibre (GF/C) filters.

Total phosphorøus
Samples were acid digested (with sulphuric acid and potassium persulphate) for 1 hour at 15 p.s.i. in an autoclave. Total phosphorøus was then determined by the molybdenum blue colorimetric method.

Results

General comments
In a few July samples clearly erroneously high values of dissolved oxygen concentration were obtained; in both the determination of initial dissolved oxygen and of oxygen remaining after incubation (endpoint of BOD Detrmination). This is thought to result from unavoidable contamination with suspended organic matter during sampling, leading to significant oxidation of $Mn(OH)_2$ within the Winklers procedure (Allen 1974). These results (3 out of 67 oxygen and 5 out of 67 BOD samples) were not included in the analysis.

Before results were analysed the distribution of each of the chemistry variables was tested for normality using a Kolmogorov-Smirnov goodness of fit test. The results showed that a number of variables are not normally distributed (particularly SRP, $p=0.009$ and Total P, $p=0.014$). Consequently mainly nonparametric tests have been used.

Comparision of different areas
The different areas were compared to see if there were any clear differences in water chemistry between them, which could contribute to the distribution of *Dolomedes*.

The three main areas which differ in both location and the age of pools are:

Little Fen (LF), Spider Pit Path (SPP) and Middle Fen (MF). In addition, within Middle Fen, pools occur in two spatially discontinuous groups (MFa: pools 1-20, N=21 and MFb: pools 21-28, N=8).

Before comparisions were made at the level of the three major areas (LF, SPP, MF) the two subgroups MFa and MFb were compared to see if they should be treated as one block or two. The results of this comparision are given in table 1. This shows some significant differences between the two subgroups, consequently they have been treated seperately.

Table 2 shows the results of a non-parametric analysis of variance (Kruskal-Wallis) comparing LF/SPP/MFa/MFb for each of the water chemistry variables. The only variable which differed significantly between areas is pH. Table 3 gives the results of a further investigation of pH, this shows that the pH of MFb is significantly lower than that of MFa and LF.

Changes from July to August and the effect of pumping

Only 19 of the pools sampled in July were left untreated in August and of these only 9 had not dried up by the second sample date. Therfore few untreated pools were available to assess both the natural changes in water chemistry between July and August, and the effect of pumping.

Of these 9 untreated pools, nearly half (4) are situated in MFb. Due to the difference between MFb and other areas (Tables 1 and 3) it is inadvisable to look at the effect of pumping by a direct comparision of the August results for treated and untreated pools, as this may reflect position effects.

As an alternative, the results from July and August were compared for each individual pool. The trends for both treated and untreated pools were then determined using a Wilcoxon matched-pairs signed-ranks test. The results of this analysis are shown in table 4. For both treated and untreated pools there is no consistent change in BOD. For both treated and untreated pools dissolved oxygen and SRP are lower in August than in July. Treated pools differ from untreated pools for both pH and total P. In August compared with July, treated pools have higher pH and lower total P, while pH and total P appear unchanged in untreated pools.

Results for Worbys Drain and River Waveny

Worbys Drain has clearly been contaminated by agricultural run-off (from a pig farm). In both July and August the total P recorded in Worbys drain was the highest of all 67 sampling points (see Appendices 1 and 2). In July the BOD was the highest, and the dissolved oxygen nearly the lowest, recorded from all samples. In August the dissolved oxygen was the lowest of all samples.

Negligible flow was noted in Worbys Drain in July, and the drain had no inflow in August. It is therefore not clear to what extent the high phosphorous levels of the water result from recycling of phosphorous from the eutrophic sediment, or from recent inflow down the drain.

Within the reserve the water quality of the River Waveny appears reasonable. The data (Appendices 1 and 2) suggests that in July, when river and presumbly groundwater flow was more significant, the water quality was poorer downstream from the area of agricultural fields and drains (Waveny 3) than above these (Waveney 1 and 2).

Discussion

There is a general lack of clear differences in water chemistry between the different areas of the fen. The lack of differences between SPP pools (which have lost their population of *Dolomedes*) and other areas would suggest that water chemistry is not an important factor in explaining either the distribution of *Dolomedes* at Lopham or changes in it's population. However this conclusion would be based on a single set of water samples taken on one date, which may not be representative of conditions at other times. In view of the large variation between pools within an area, it may be valuable to correlate measures of the spider population with the July water quality data, at the level of the individual pools.

The data show that a number of pools have a very low pH. This may exclude the spider, in addition to many of its prey species. It is unclear wether this is a result of changes in hydrology resulting from the lowering of the water table, or wether it reflects the natural variation in pH in the fen.

In addition to the clearly beneficial effects of pumping on water levels, pumping has beneficial effects on water chemistry, reducing total phosphorous and increasing pH.

Summary

Very few differences were found between the major areas of pools (Little Fen, Middle Fen pools 1-20: MFa, Middle Fen pools 21-28: MFb, Spider Pit Path:SPP). MFb had significantly lower pH than most other areas, and higher biological oxygen demand than MFa. Despite the loss of *Dolomedes* from the Spider Pit Path pools, SPP did not show any significant differences in water chemistry from other areas.

Pumping water into pools significantly reduced the level of total phosphorous and increased pH, relative to July (before pumping started), compared to untreated pools which showed no consistent difference

between July and August for total phosphorous and pH.

Worbys Drain shows clear evidence of contamination by heavy inputs of phosphorous, resulting in a high biological oxygen demand and low levels of dissolved oxygen.

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Reference

Allen, S.E. ed. (1974). Chemical analysis of ecological materials. Blackwell Scientific Publications, Oxford.

Table 1. Comparision between MFa and MFb. Results of Mann Whitney test.

Chemistry Variable	Mann Whitney for MFa v MFb Z	p	
pH	-3.550	0.00039	*****
Oxygen	0.879	0.37918	N.S.
BOD	2.230	0.02577	*
SRP	-1.207	0.22742	N.S.
Total P	-1.031	0.30269	N.S.

N.S. not significant.* p<0.05; ** p<0.01; *** p<0.005; **** p<0.001; ***** p<0005; ****** p<0.0001;

Table 2. Comparision between each area of pools. Results of single factor non-parametric analysis of variance. Area means and standard errors given.

Chemistry Variable	MFa (N=21)	MFb (N=8)	SPP (N=6)	LF (N=28)	Kruskal Wallis	p
pH	6.31 ±0.16	3.80 ±0.59	5.38 ±0.52	5.75 ±0.28	16.70	0.00081 ****
Oxygen mgl^{-1}	7.09 ±0.35	7.70 ±0.73	6.97 ±0.99	7.22 ±0.44	0.75	0.86123 N.S.
BOD mgl^{-1}	1.91 ±0.16	2.78 ±0.24	2.38 ±0.27	1.99 ±0.21	4.73	0.19234 N.S.
SRP μgl^{-1}	22.67 ±4.48	23.25 ±15.28	22.60 ±9.63	12.71 ±1.53	3.04	0.38547 N.S.
Total P μgl^{-1}	61.48 ±7.38	70.50 ±32.58	69.33 ±20.17	55.18 ±7.00	1.28	0.73409 N.S.

N.S. not significant.* p<0.05; ** p<0.01; *** p<0.005; **** p<0.001; ***** p<0005; ****** p<0.0001;

Table 3. Further comparision of pH in each area of pools. Results of a single factor analysis of variance. Area means with different superscripts differ significantly (Tukey multiple range test, p=0.05).

	MFa (N=21)	MFb (N=8)	SPP (N=6)	LF (N=28)	ANOVA F	p
pH	6.31^{a} ±0.16	3.80^{b} ±0.59	$5.38^{a/b}$ ±0.52	5.75^{a} ±0.28	7.46	0.0003 *****

N.S. not significant.* p<0.05; ** p<0.01; *** p<0.005; **** p<0.001; ***** p<0005; ****** p<0.0001;

Table 4. Trends of changes in individual pools between July and August analysed seperately for untreated pools and pools with pumped water. Trends from July to August tested for using a Wilcoxon matched-pairs signed-ranks test. For each sample date and treatment, means and standard errors are presented.

	Pumped water				Untreated			
Chemistry Variable	July	August	Test	p	July	August	Test	p
pH	5.93 ±0.19	6.90 ±0.03	4.89	<0.00001 ******	4.87 ±0.53	4.71 ±0.53	0.59	0.55361 N.S.
Oxygen mgl^{-1}	7.15 ±0.31	5.91 ±0.25	2.95	0.00317 ***	7.60 ±0.70	5.54 ±0.72	1.89	0.05802 N.S.
BOD mgl^{-1}	1.87 ±0.13	1.74 ±0.15	0.90	0.36798 N.S.	2.44 ±0.29	2.19 ±0.43	0.77	0.44121 N.S.
SRP μgl^{-1}	17.27 ±2.37	5.40 ±0.76	4.52	<0.00001 ******	15.89 ±6.38	1.94 ±0.99	2.49	0.01285 *
Total P μgl^{-1}	56.75 ±5.15	20.74 ±1.44	5.31	<0.00001 ******	63.89 ±14.25	40.60 ±11.00	1.30	0.19252 N.S.

N.S. not significant.* p<0.05; ** p<0.01; *** p<0.005; **** p<0.001; ***** p<0005; ****** p<0.0001;

Appendix 1. July results.

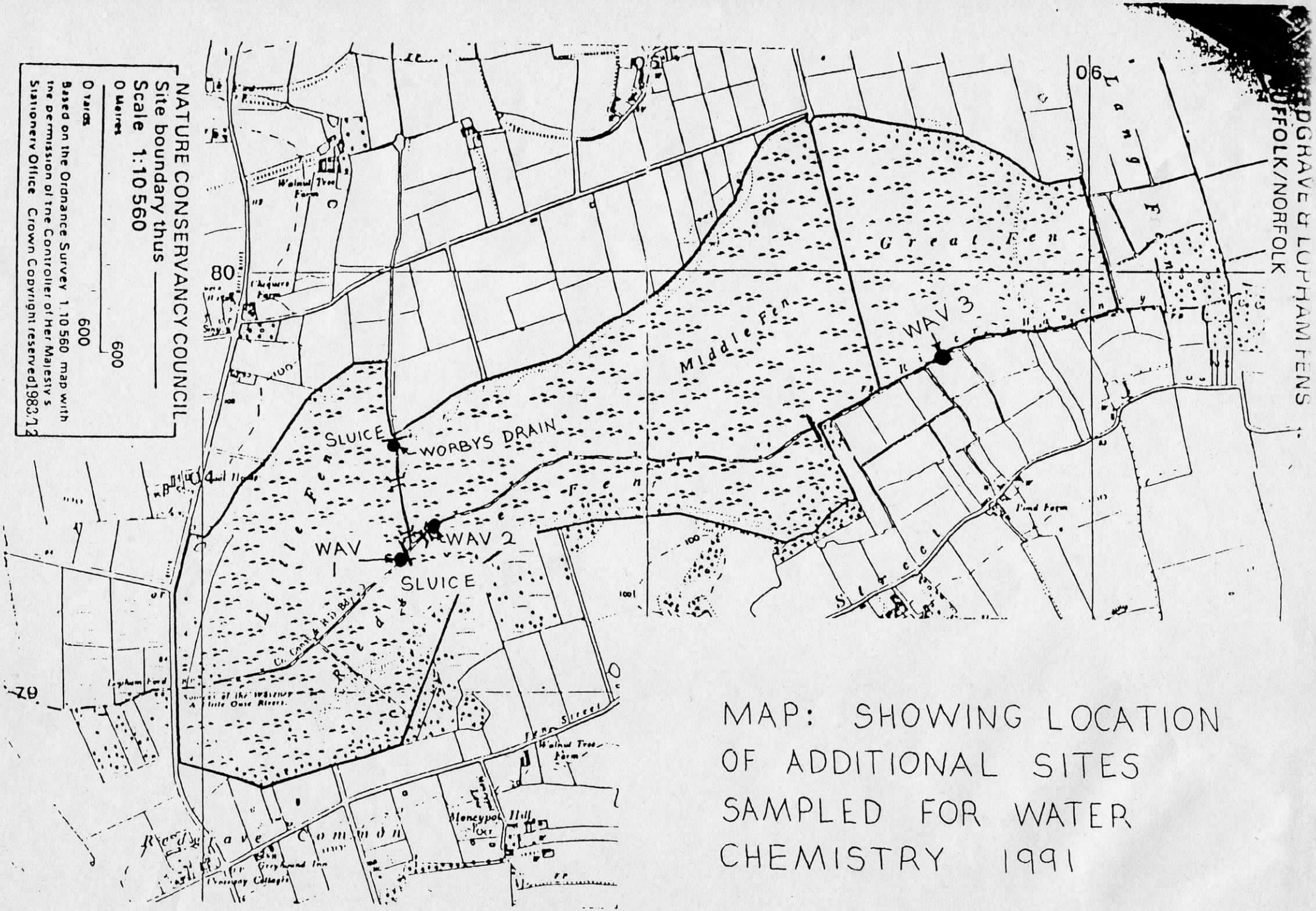
Pool	pH	O mgl^{-1}	BOD mgl^{-1}	SRP μgl^{-1}	Total P μgl^{-1}	Pool	pH	O mgl^{-1}	BOD mgl^{-1}	SRP μgl^{-1}	Total P μgl^{-1}
MF1	6.3	6.7	0.8	7	24	LF1	6.0	5.7	3.5	29	39
2	6.7	7.3	2.8	29	58	2	7.0	8.1	3.1	7	34
3	6.7	7.7	1.5	7	58	3	6.0	5.7	1.3	7	116
4	6.8	6.3	2.5	22	58	4	6.9	8.7	2.3	14	34
5	6.8	7.3	2.1	7	39	5	6.7	7.3	2.5	7	19
6	6.8	8.1	1.6	7	34	6	7.0	8.8	2.5	7	63
7	6.4	5.6	1.8	22	63	7	6.1	7.9	1.1	7	29
7a	5.7	3.2	1.1	7	39	8	6.7	9.1	2.5	7	39
8	6.5	8.5	2.1	29	58	9	7.0	7.1	1.5	29	53
9	4.6	4.9	0.4	7	24	10	6.3	9.0	2.5	7	29
10	6.1	8.1	0.8	72	135	11	6.5	6.6	0.8	7	10
11	6.4	8.7	2.8	58	111	12	7.0	11.3	3.5	29	58
12	6.6	6.9	2.5	7	48	13	6.2	2.2	3.5	7	63
13	6.9	6.9	2.8	7	24	14	6.6	4.4	1.5	7	44
14	6.7	8.1	2.1	22	77	15	6.0	9.5	2.8	22	126
15	6.5	8.3	1.5	43	102	16	6.5	5.1	2.5	29	111
16	6.5	7.5	1.8	65	102	17	4.0	5.3	0.0	14	39
17	3.9	3.7	1.5	7	39	18	5.8	3.1	1.8	7	68
18	6.2	8.1	2.1	22	48	19	3.6	5.3	1.5	14	48
19	6.7	9.7	2.5	22	121	20	6.7	7.5	0.8	14	19
20	6.8	7.3	3.1	7	29	21	2.7	6.7	-	22	44
21	2.3	-	-	130	295	22	2.8	11.3	0.0	7	131
22	3.1	4.9	2.5	7	19	23	3.1	5.5	3.1	14	145
23	2.4	10.5	-	7	33	24	5.5	8.2	0.4	14	15
24	2.5	8.9	-	7	29	25	6.4	7.5	2.1	7	58
25	5.6	8.1	3.5	7	58	26	6.7	13.2	3.1	7	48
26	5.3	5.7	2.8	7	19	27	6.0	7.0	1.5	7	44
27	2.8	7.3	2.1	7	58	28	2.4	-	-	7	19
28	6.4	8.5	3.0	14	53						
SPP1	6.1	4.0	2.3	7	29						
2	5.3	6.0	3.3	14	58						
3	5.8	6.0	2.3	7	29						
4	5.8	6.4	2.8	36	145						
5	6.4	8.4	2.3	65	116						
6	2.9	11.3	1.3	7	39						
W. D.	7.2	3.2	5.8	14	343						
WAV1	6.5	4.3	2.0	7	19						
2	7.2	11.3	1.5	7	29						
3	7.1	-	4.5	22	135						

Appendix 2. August results.

Pool	pH	O mgl^{-1}	BOD mgl^{-1}	SRP μgl^{-1}	Total P μgl^{-1}
MF1	6.5	7.0	2.3	9	25
2	6.5	5.4	3.1	0	40
3	6.4	5.0	1.7	0	33
4	6.3	2.6	2.3	7	33
5	6.5	6.9	3.1	17	40
6	6.7	2.6	2.3	0	25
7	6.8	5.8	2.7	7	15
7a	6.9	6.2	0.7	7	15
8	7.0	5.7	6.8	2	50
9	6.9	6.3	1.1	13	23
10	7.0	3.7	1.7	4	38
11	7.0	3.9	1.5	4	18
12	6.9	4.1	1.9	9	23
13	6.9	7.6	1.5	0	20
14	7.0	6.7	1.9	0	10
15	6.9	7.6	1.1	9	10
16	6.9	4.7	1.3	9	23
17	7.0	5.6	1.9	9	20
18	7.0	3.6	1.9	0	23
19*	6.8	4.1	1.5	2	25
20*		DRIED UP			
21*		DRIED UP			
22*	3.2	6.3	3.3	0	35
23*		DRIED UP			
24*	2.9	3.5	4.7	9	13
25*	4.9	6.8	4.1	4	50
26*	4.8	6.6	1.5	2	25
27*		DRIED UP			
28*		DRIED UP			
SPP1*		DRIED UP			
2*	3.7	3.6	1.9	0	38
3*		DRIED UP			
4*		DRIED UP			
5*	6.1	5.0	2.9	0	40
6*	3.1	10.0	1.1	0	123
W. D.	7.5	2.0	2.4	162	342
WAV1	DRIED UP				
2	7.2	4.9	2.3	9	18
3	6.9	3.3	1.9	2	23

Pool	pH	O mgl^{-1}	BOD mgl^{-1}	SRP μgl^{-1}	Total P μgl^{-1}
LF1*		DRIED UP			
2*		DRIED UP			
3*	6.9	3.8	1.1	0	18
4	7.0	2.4	0.9	4	23
5	7.0	5.0	1.9	0	40
6	6.8	5.6	1.7	0	20
7	6.8	8.5	1.9	9	10
8	6.7	6.9	1.5	4	13
9	7.0	5.3	1.5	7	18
10	7.0	8.8	1.5	0	23
11	7.0	6.3	0.3	0	20
12	6.9	8.1	1.5	4	20
13	7.2	8.3	1.1	4	10
14	7.0	6.2	1.9	4	20
15	7.1	7.4	1.7	2	20
16	7.2	5.5	1.1	13	20
17	7.1	5.3	1.1	17	20
18	7.1	6.0	1.5	7	10
19	7.1	5.8	1.1	9	15
20	7.1	3.7	1.9	9	10
21	6.9	6.0	1.5	2	5
22	6.7	7.6	1.3	20	25
23	7.1	7.7	2.1	4	20
24	6.8	7.1	1.9	2	15
25	6.9	8.8	0.7	2	10
26	7.0	5.6	0.3	0	15
27	7.0	5.1	1.5	0	10
28	7.0	6.6	0.9	9	23

* Pools which did not have water pumped into them (untreated).



MAP: SHOWING LOCATION OF ADDITIONAL SITES SAMPLED FOR WATER CHEMISTRY 1991