REMOVAL OF ORGANICS FROM COLOURED WATER - PHASE 3 REPORT

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Authors: A Attenborough and I Walker

Contract Manager: I Walker

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Any enquiries relating to this report should be referred to the authors at the following address:

WRc Swindon, P O Box 85, Frankland Road, Blagrove, Swindon, Wiltshire SN5 8YR.
Telephone: (0793) 511711.

SUMMARY

I OBJECTIVE

To investigate the production of disinfection by-products during the treatment of coloured water using suitable, cost effective, methods, for their removal or control with due regard to other water quality determinands, such as colour, iron, manganese and aluminium.

II REASONS

The presence of disinfection by-products in drinking water derived from coloured sources may pose a health risk to the consumer and exceed regulated water quality criteria. Dissolved air flotation and 2 stage filtration has been identified as the most likely process to be used for treatment of upland coloured water; this process requires investigation and optimisation with respect to the control of the trace organics of concern.

III CONCLUSIONS

(i) Iron, manganese, aluminium and turbidity can be successfully removed by rapid gravity filters where GAC is used as the media.

(ii) GAC reduces the production of disinfection by-products by removing precursor molecules. The ability of a GAC to remove organics is not affected by solids deposition when used as a primary filter, nor by manganese deposition when used as a secondary filter. Bed life is dependent on empty bed contact time (EBCT) and carbon type.

(iii) Bed life can be extended by the use of ozone to reduce the load of precursors prior to the GAC.

(iv) Of the three carbons investigated coal based (Chemviron F400) performed better than peat based (Norit PK) which performed better than wood based (Pica Biol) for the removal of colour, TOC, THMs, AOX and mutagenic activity precursors.

(v) Powdered activated carbon (PAC) increases the solids load on the primary filters, when dosed to the flocculators.

IV RECOMMENDATIONS

Where it is not possible to reduce disinfection by-products by ceasing pre-chlorination and by optimising coagulation conditions, activated carbon can be considered as a viable means for further reducing the production of disinfection by-products. Where further reductions are required, ozone can be considered for use in conjunction with GAC.

V RESUME

A pilot plant investigation, examining the application of activated carbon at various points within a three stage treatment stream, has been carried out as the third phase of a 3 phase experimental programme. The details and results of that investigation are presented in this report.

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SECTION 1 - INTRODUCTION

This report details the results obtained from running a three stage dissolved air flotation (DAF) water treatment pilot plant for the removal of organics from upland water. It contains all the results obtained from the third phase of a three phase experimental programme. A full description of the pilot plant, its operation, and the three phases of the experimental programme are given in the Interim Progress Report No. 1 (1). The results obtained from the first two phases of the experimental programme are detailed in the Phase 1 Report (2), and the Phase 2 Report (3). An overview of all three phases of the experimental work is given in the Overview Report (4).

SECTION 2 - EXPERIMENTAL PROGRAMME

2.1 PROGRAMME OBJECTIVES

The principal objective of Phase 3 of the experimental programme was to investigate the use of granular activated carbon (GAC) for the removal of organic compounds and thereby the control of disinfection by-products. The main variables addressed were: GAC location in the process stream, GAC type, and the effect of ozone on the performance of GAC.

2.1.1 Location of GAC in the treatment process

GAC can be used as a filtration medium replacing sand in either a primary RGF or a secondary RGF; in both locations the GAC will have a dual role. In the primary filter the roles will be: particulate removal (DAF carry-over) and organics adsorption, whilst in a secondary filter they will be: manganese removal and organics adsorption. The questions to be answered are:

- will the attachment of particulate material to the outer surface of the GAC or the deposition of manganese reduce the ability of the GAC to adsorb organics?

- will GAC be as effective as sand at removing particulates?

- and will the catalytic removal of free chlorine by GAC prevent manganese oxidation?

The contact time available in rapid filters is limited by the size of existing tanks and filtration rates, this is not the case for a third possible location for GAC, which is as a final (fourth) stage of treatment as an adsorption column. GAC in this position would be expected to be unaffected by particulate attachment or manganese deposition and could be installed with a longer contact time to reduce regeneration frequency.

By comparing the performance of GAC in the different locations, the effects of contact time, particulate removal, manganese deposition and backwashing can be established.

2.1.2 Use of GAC after ozonation

Ozone is a potent oxidant and will break down large refractory molecules into smaller entities which may have different adsorptive properties to the parent molecule. Combining ozone and GAC may, therefore, affect the amount of organic material adsorbed, and the composition of the organic material breaking through.

The smaller molecules may also be assimilated by micro-organisms and the entry of such material into the distribution network could have an impact on the level of regrowth and, therefore, bacterial numbers at the consumer's tap. It is currently recommended that to prevent this from becoming a problem, ozonation is followed by some form of potentially biologically active process (such as a filter). It is common practice in France to follow ozonation with GAC adsorption; such a combination is claimed to remove more organic material than either process on its own. This is usually attributed to the development of biological activity within the pores of the GAC which breaks down the assimilable compounds, thus regenerating the GAC's capacity for these compounds.

2.1.3 Types of GAC

The source material for GAC can have a significant effect on its physical character and adsorptive abilities. GAC is usually manufactured from coal, peat, coconut shells, or wood. The first is recognised as being one of the best all-round adsorbers whilst the last is often recommended for use as a "biologically-active-carbon" (BAC) because its macroporous structure encourages the growth of bacteria and protects the growth during backwash. In this programme coal-based, peat-based, and wood-based, GACs were examined. Coal based (Chemviron F400) was used to examine the effect of location; the other GACs, wood-based (PICA-BIOL) and peat-based (Norit PK) were used as final stage adsorbers, with the wood based being preceded by ozonation, to allow direct comparisons between different carbon types. Coconut based GAC was not assessed in this programme.

2.2 ADDITIONS AND ALTERATIONS TO THE PILOT PLANT

On completion of phase 2 of the experimental programme, the following additions and alterations were made to the pilot plant.

2.2.1 Post adsorbers

Five adsorbers were added to the pilot plant. These were 3.5m tall, 150mm bore stainless steel columns, containing a 0.71m bed of carbon, giving an give an empty bed contact time (ebct) of 10 minutes at a superficial velocity of 4.3 m/hr. Figure 1 shows a drawing of one of the adsorbers.

2.2.2 Streaming current detector and solenoid valve

During the first two phases of the experimental programme, an intermittent nuisance tripping of the residual current detector which protected the power supply to the DAF had been experienced. During phases 1 and 2, this problem was only an operational nuisance, with no adverse effect on the experimental results. However, during phase 3, this nuisance tripping would have resulted in uncoagulated water being fed to the carbon filters and adsorbers, thus overloading the carbon with organics, and causing premature breakthrough. It was, therefore, decided to install a solenoid valve after the DAF, which would close in the event of the power supply to the DAF failing, thus protecting the carbon filters and adsorbers.

It was decided to take advantage of the solenoid valve and interlock it with the alarms on the streaming current detector used to control the coagulant dose to the DAF. Thus in the event of a failure of the coagulant or coagulation pH correction caustic dosing pumps, the alarm on the streaming current detector would operate, and the supply of uncoagulated or poorly coagulated water to the carbon filters and adsorbers would cease.

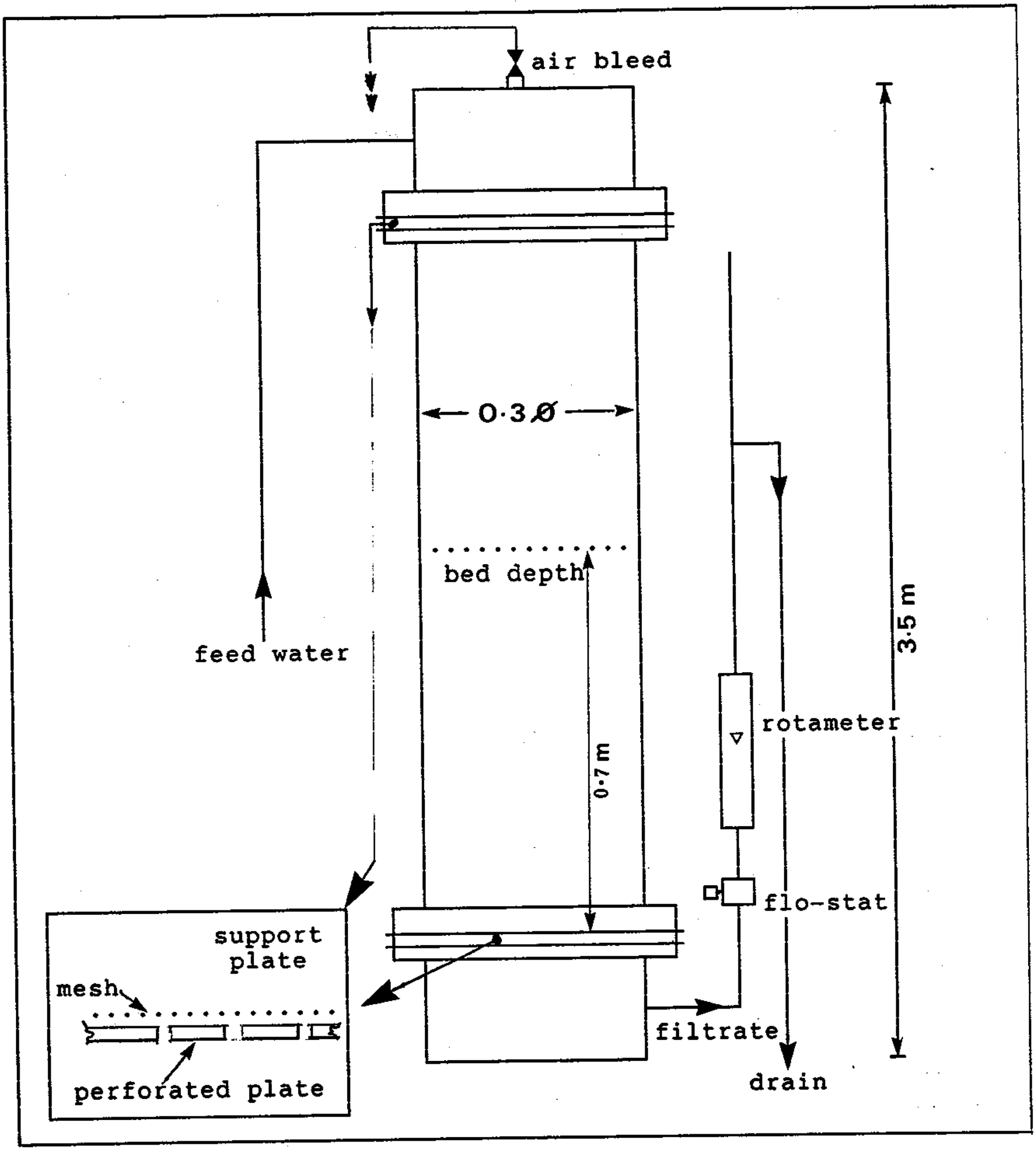


Figure 1: Post Adsorber

2.2.3 Ozone alarms

For safety reasons, two ozone sensors were installed. One was installed close to the ozone generator, and the other close to the ozone destructor. In the event of an ozone leak at either of these places, the sensors would have operated an alarm and a relay which in turn would have stopped the supply of ozone.

2.3 PILOT PLANT OPERATION

The position, operating conditions, and characteristics of the GACs used in the programme are summarised in Table 1. The overall flow scheme is provided in Figure 2.

Proper assessment of the breakthrough of organics from GAC required that the water quality was maintained at a consistent level. The pilot plant was therefore operated under fixed conditions for the duration of phase 3.

Only one DAF was operated during phase 3, with the coagulant dose controlled by the streaming current detector, and the pH controlled to 4.6. For the majority of the programme the streaming current detector was allowed to control the coagulant dose but, however, on some occasions, the zero for the streaming current detector was adjusted in an attempt to provide a constant quality of sand filtered water with respect to uv absorbance.

After flotation, the water was dosed with caustic to give a pH of 6.5 before being split to feed the two primary RGFs; one containing F400 carbon, the other sand. The filtrate from each primary RGF was then dosed with caustic and hypochlorite before being split to feed one F400 carbon secondary RGF and one sand secondary RGF. For each stream, the caustic dose was controlled manually to give a pH of 9.0. The hypochlorite doses were set manually such that the free chlorine residual after the sand secondary filter was 0.1 mg/l; the GAC secondary filter had an identical dose but there was no residual due to the action of the GAC.

Water from the stream with a primary GAC RGF followed by a secondary sand RGF was fed to an adsorber containing F400 GAC.

Water from the stream with primary and secondary sand RGFs, was split and fed either directly to two adsorbers (one containing F400 and one containing Norit PK), or via an ozone contactor to two further adsorbers (one containing F400 and one containing PICA-BIOL). The ozone contactor provided a contact time of 15 minutes with an applied dose of 2 mg/l.

Table 1 - GAC parameters

GAC Position	1°RGF	1°RGF + 2°RGF	2°RGF	1°RGF + 3°	3°	3°	3°	Ozone +3°
GAC Type Density g/l	F400 425	F400 425	F400 425	F400 425	F400 425	NORIT PK 260	F400 425	PICA BIOL 310
EBCT mins Depth cm Diameter cm Flowrate l/hr Bed Weight kg	6.33 63 40 750 31.7	10.07	3.73 63 21 350 8.7	16.33	10.00 71 15 75 5.0	10.00 71 15 75 3.1	10.00 71 15 75 5.0	10.00 71 15 75 3.7
Sample No.	5	6	7	10	11	12	13	14

1° : Primary 2° : Secondary 3° Post Treatment Adsorber.

2.4 SAMPLING AND ANALYSIS

The following analyses were made throughout the duration of the experimental programme.

pH	Daily
turbidity	Daily
colour	Daily
uv absorbance	Daily
free and total chlorine residual after sand 2° RGF	Daily
ozone residual after contactor	Weekly

iron	Weekly
manganese	Weekly
aluminium	Weekly
TOC	Weekly
bacteriological quality	Weekly
chlorine demand	Weekly
THMs	Weekly
AOX	Fortnightly
mutagenic activity	Monthly

During most of phase 3, sampling and analysis were as described in the Interim Progress Report (1). However, for the first 7 weeks of phase 3, 'steadifac' tablets were used to compensate for manganese interference in the measurement of chlorine residuals. After 7 weeks of using 'steadifac' tablets, it became apparent that this was not necessary, as none of the samples produced a manganese interference greater than 0.05 mg/l of chlorine equivalent. The reason for this was that water was only ozonated after manganese removal had been achieved.

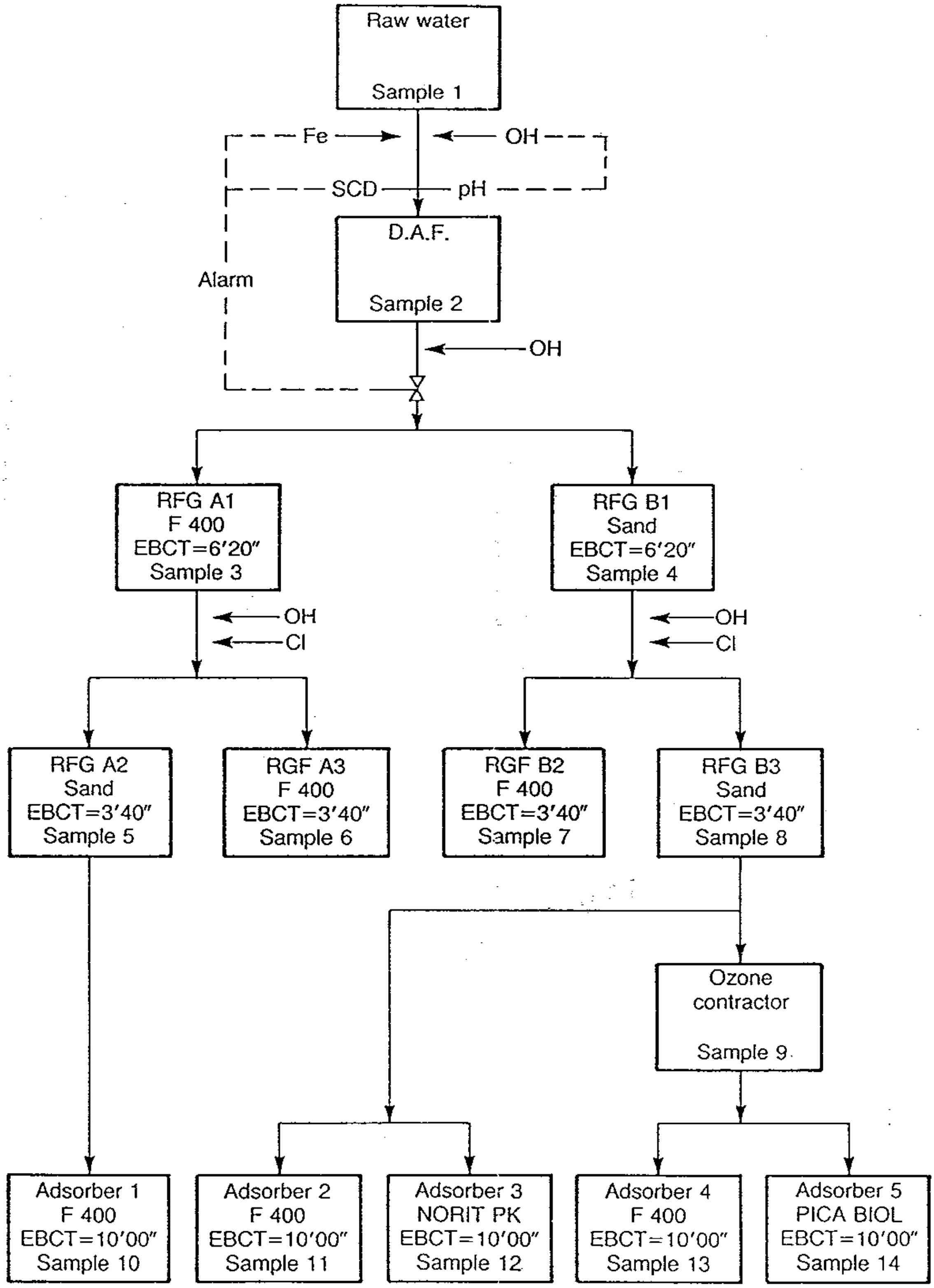


Figure 2 Pilot Plant Flowsheet

SECTION 3 - RESULTS AND DISCUSSION

In the following text samples may be described by reference to their number, this has been done because of the complexity that would be required to describe the process combinations that were examined. The sample numbers are shown in figure 2 which can be folded out for ease of use.

Because most of the results relate to the performance the GAC during the run the majority of the graphical presentations are plotted against time; this is expressed as days run since the beginning of phase 3; Appendix A, Table A1, gives dates for days run. For brevity the terms 1°, 2° and 3° are used to denote primary, secondary, and post treatment filters.

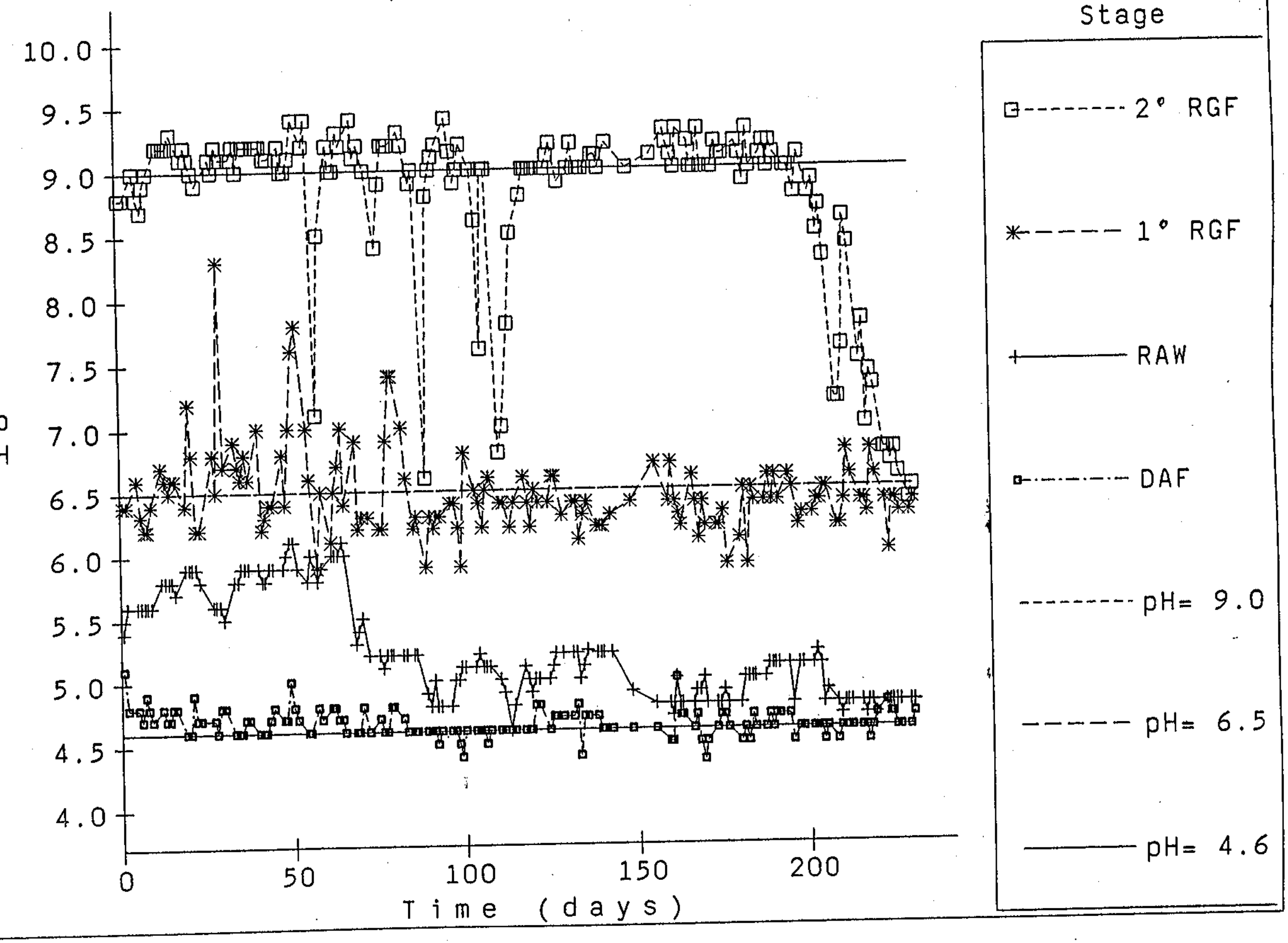
3.1 pH

Figure 3 shows a plot of pH against time. The pH is plotted for raw water, DAF effluent, 1° sand filtered water and, 2° sand filtered water.

At the beginning of the trial the raw water pH increased gradually from 5.5 to 6.0, then, from day 60 (October), the raw water pH decreased rapidly to below 5.0; this was also seen during the previous two years (see phase 2 report (3)). This phenomenon is caused by heavy autumn rains falling onto decaying Summer vegetation, and is generally known as the "Autumn Flush". From day 100 (November) the raw water pH remained constant at around 5.0.

DAF, 1° RGF and 2° RGF pH indicate the effectiveness of pH control on the pilot plant; target pHs are shown. It can be seen that DAF pH control was consistently good, reflecting the automatic control system and the relatively high buffering capacity of the water at this pH. 1° RGF pH shows generally good control, but with occasional high peaks; these peaks were caused by the very low buffering capacity of the water between pHs of just under 7 to just over 8, making the setting of the caustic dose critical. The plot of the 2° RGF pH also shows problems caused by this low buffer capacity region, although some of these peaks were caused by failure of the caustic dosing pump.

Fig 3. pH at Various Stages of 3 Stage Treatment
(Both Filters Contain Sand)



During the last month of the trial, the 2° RGF pH was allowed to drop gradually from 9.0 to 6.5 to investigate the influence of pH on manganese removal.

Virgin F400 GAC increased the pH of water passing through it; for the first 5 days the pH of sample 3 (1° GAC RGF) was much higher than sample 4 (1° sand RGF) (see Table A2 Appendix A). Samples 10 and 11 (both F400 post adsorbers), also increased pH for the first two days. However, the Norit PK carbon, sample 12, showed little initial effect on pH. After these initial effects on pH, each of the three unozonated port adsorbers reduced pH by an average of 0.3 pH units.

Ozonation reduced pH by up an average of 0.8 units, probably due to the introduction of nitric acid and CO_2 into a poorly buffered water. The port ozonation adsorbers further reduced pH by averages of 0.7 (F400) and 0.8 (Pica Biol) units.

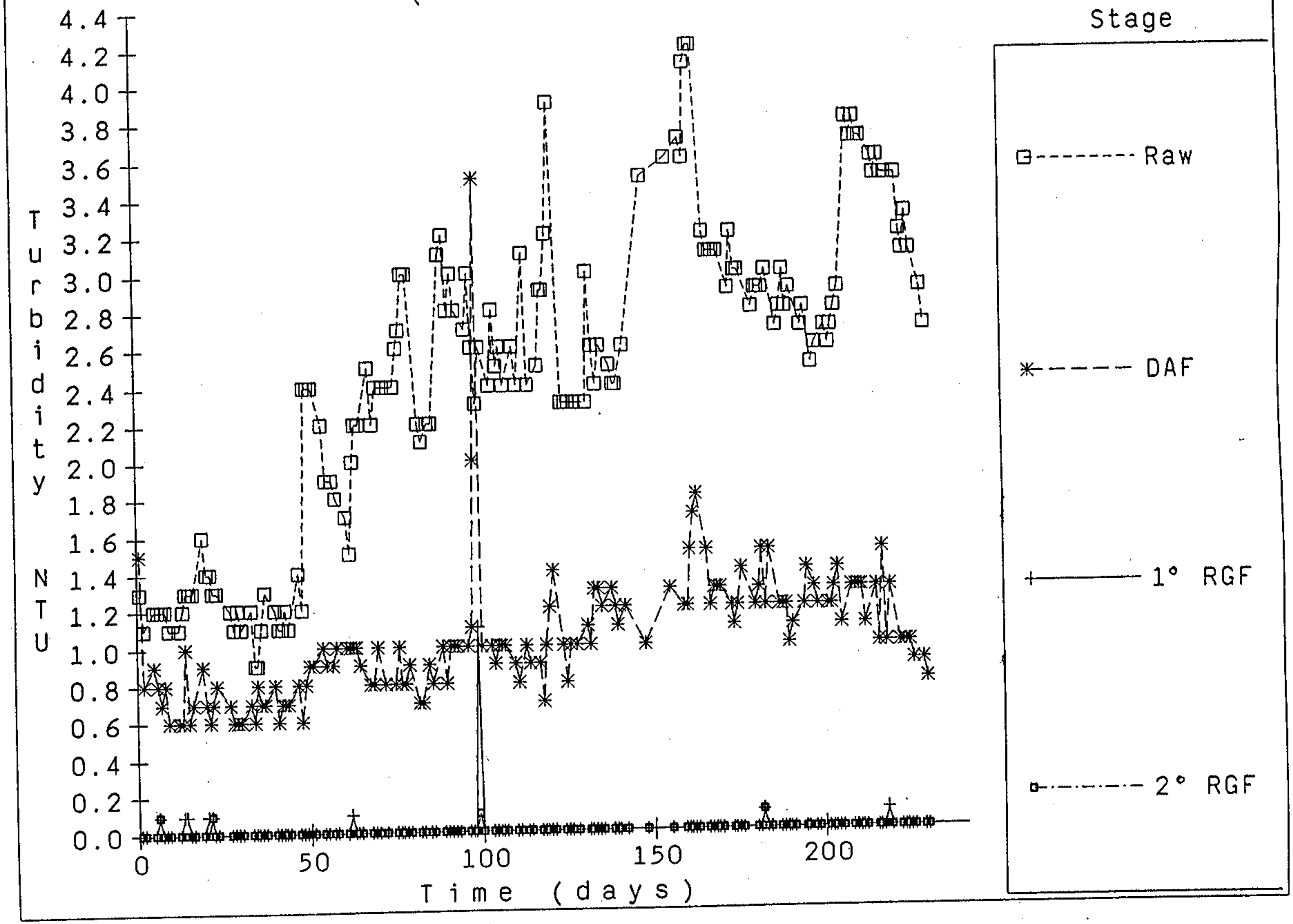
3.2 TURBIDITY

Figure 4 shows a plot of turbidity against time. The plot of the raw water turbidity shows an increase during October and November, corresponding to the Autumn Flush. Other peaks which can be observed coincide with periods of heavy rain.

The turbidity of the DAF overflow was generally about 1 NTU, this showed a slight increase with increases in raw water turbidity. The plots for the RGFs show that turbidity was successfully removed by the first stage of filtration. The high turbidities on day 99 were caused by a mechanical failure of the DAF.

By comparing the results for samples 3 (1° GAC RGF) and 4 (1° sand RGF) (see Table A3 Appendix A), it can be seen that, in terms of turbidity, GAC and sand performed equally well in a 1° filter.

Fig 4. Turbidity at Various Stages of 3 Stage Treatment (Both Filters Contain Sand)



3.3 METALS

3.3.1 Iron

Figure 5 is a plot of iron concentration against time. The raw water iron concentration increased from day 34 to day 69 (September and early October), as a result of the Autumn Flush and then decreased slowly during the rest of the trial. The coagulant carry-over from the DAF consistently resulted in a higher concentration of iron in the DAF treated water than in the raw water, but this carry-over was always removed by the first stage of filtration. It appears that there may have been a very slight increase in DAF iron as a result of the Autumn Flush, but the final water iron concentration was independent of seasonal factors.

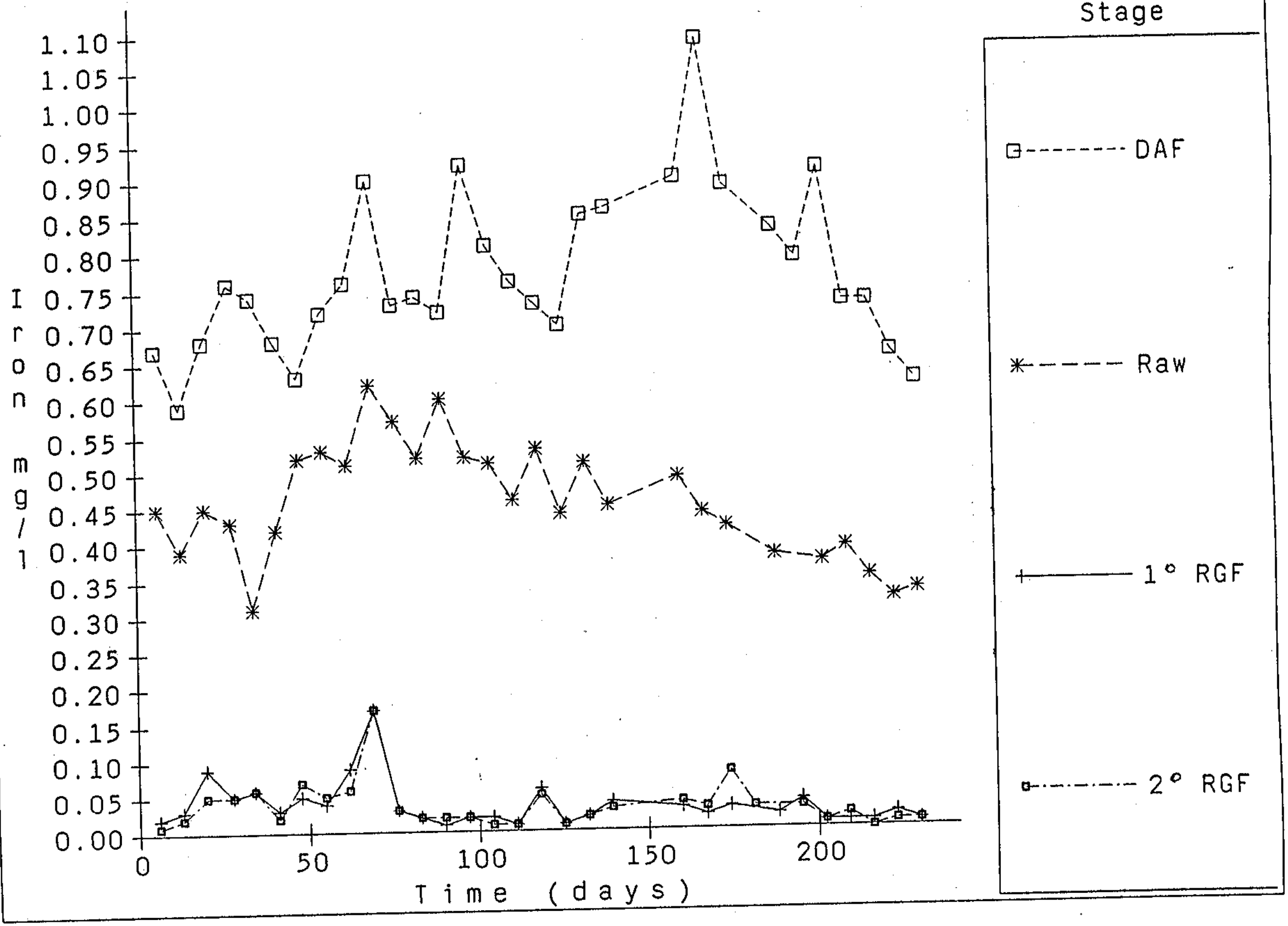
Table 2 gives summary iron statistics for the raw water, DAF treated water and the two 1° RGFs and shows that the mean iron concentration for both of the primary filtrates was equal to or less than the EC guide level of 0.05 mg/l, and that none of the samples had an iron concentration greater than the prescribed concentration or value (PCV) of 0.2 mg/l.

Table 2 - Summary iron statistics for sample numbers 1 to 4

Sample No.	1	2	3	4
Mean	0.46	0.77	0.05	0.04
Std.Dev.	0.08	0.11	0.04	0.03
No.Points	29	30	30	30
Maximum	0.62	1.09	0.17	0.17
Minimum	0.31	0.59	0.01	0.01

A two sided 't' test at the 95% significance level (Table A5 appendix A) showed that the iron concentration in sample 4 (sand RGF) was statistically lower than the iron concentration in sample 3 (GAC RGF), indicating that sand performed slightly better than F400 GAC in a 1° RGF, but the results in Table 2 show that both types of 1° RGF performed satisfactorily.

Fig 5. Iron at Various Stages of 3 Stage Treatment (Both Filters Contain Sand)



3.3.2 Manganese

Figure 6 shows a plot of manganese concentration after various stages of three stage treatment. There was little variation in raw water manganese concentration during the trial. Two sided 't' tests at the 95% significance level were carried out on a number of pairs of samples (see Table A7, appendix A). There was a small, statistically significant, increase in manganese concentration in the DAF which can be attributed to manganese contamination of the ferric sulphate coagulant (E&A West grade W ferric sulphate is quoted as having 700ppm manganese (7), which would produce an increase in manganese concentration of about 0.012mg/l for a ferric dose of 3 mg Fe/l). There were also occasional small increases in manganese concentration through the 1° sand filter, which has been observed in previous trials. One possible explanation for this is that just after backwashing (with works treated water at pH 9.0), the pH of the filter was temporarily high enough to achieve manganese removal, but when the filter pH dropped back to normal,this manganese was leached off the filter. There was a statistically significant (although small) removal of manganese by the 1° GAC RGF.

Table 3 gives summary manganese statistics for sample numbers 1 to 8 and shows that the mean manganese concentration for all 2° filtered samples was less than the EC guide level of 0.02 mg/l. Only one of the samples during the whole trial (sample 6 on 13-Nov-91) exceeded the PCV of 0.05 mg/l, which was the result of a failure of the caustic dosing pump.

Table 3 - Summary manganese statistics for sample numbers 1 to 8

Sample No.	1	2	3	4	5	6	7	8
Mean	0.17	0.18	0.18	0.19	0.01	0.01	0.01	0.01
Std.Dev.	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01
No.Points	29	30	30	30	29	28	28	30
Maximum	0.20	0.21	0.23	0.23	0.03	0.06	0.02	0.02
Minimum	0.15	0.15	0.13	0.17	0.00	0.00	0.00	0.00

During the last month of the trial a study of the effect of pH and available free chlorine was carried out and so the 2° RGF pHs were gradually lowered and the chlorine dose to one pair of the 2° RGFs was stopped. The effect on manganese removal was monitored daily (high manganese results obtained during this trial are not included in Tables 3, or A7, or in any of the manganese statistics quoted above). Figure 7 shows the results.

Without chlorine, manganese was only completely removed by both sand and GAC at pHs above 8.5; partial manganese removal required a higher pH (>8.0) for GAC than for sand (>7.5). If a reasonable (i.e. >0.1 mg/l) free chlorine residual is maintained then manganese can be removed on sand at any pH between 6.4 and 9.0.

It can also be seen that by dosing chlorine before the GAC the minimum pH for manganese removal reduced from 8.5 to 7.0, despite the absence of a free chlorine residual in the filtrate. This surprising result was obtained from a GAC filter which had been removing manganese at high pH for 7 months, and it is therefore possible that an active surface of manganese dioxide had built up on the surface of the carbon. This surface could be capable of effecting manganese removal at a pH of 7 in the presence of free chlorine which would be subsequently removed by 'clean' GAC deeper in the bed.

Samples of GAC were taken from the 2° filters at the end of the trial and were washed with water to remove "loose" deposits. The samples were then acid washed and the washings were analysed for manganese. The results

Fig 6. Manganese at Various Stages of 3 Stage Treatment (Both Filters Contain Sand)

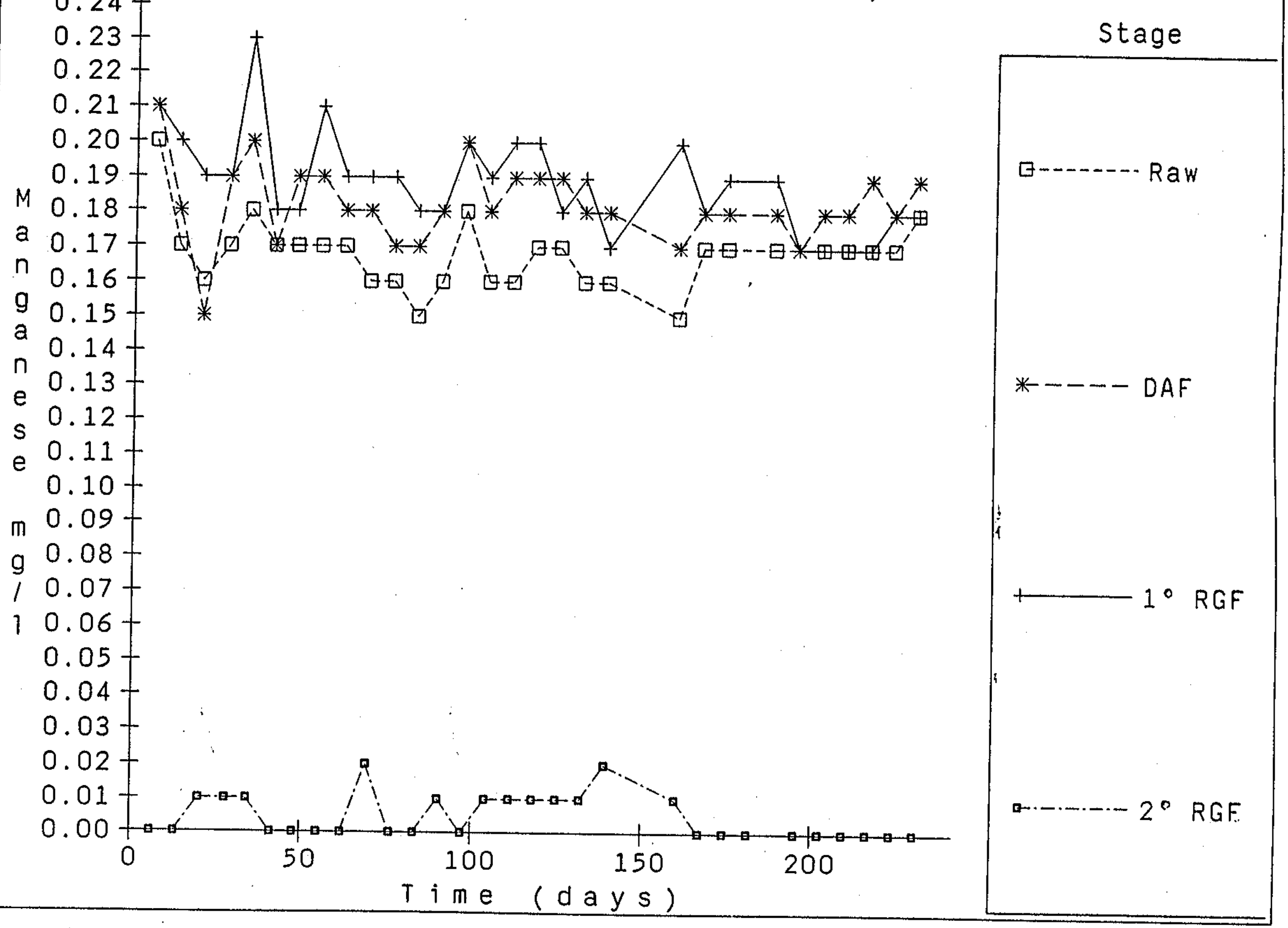
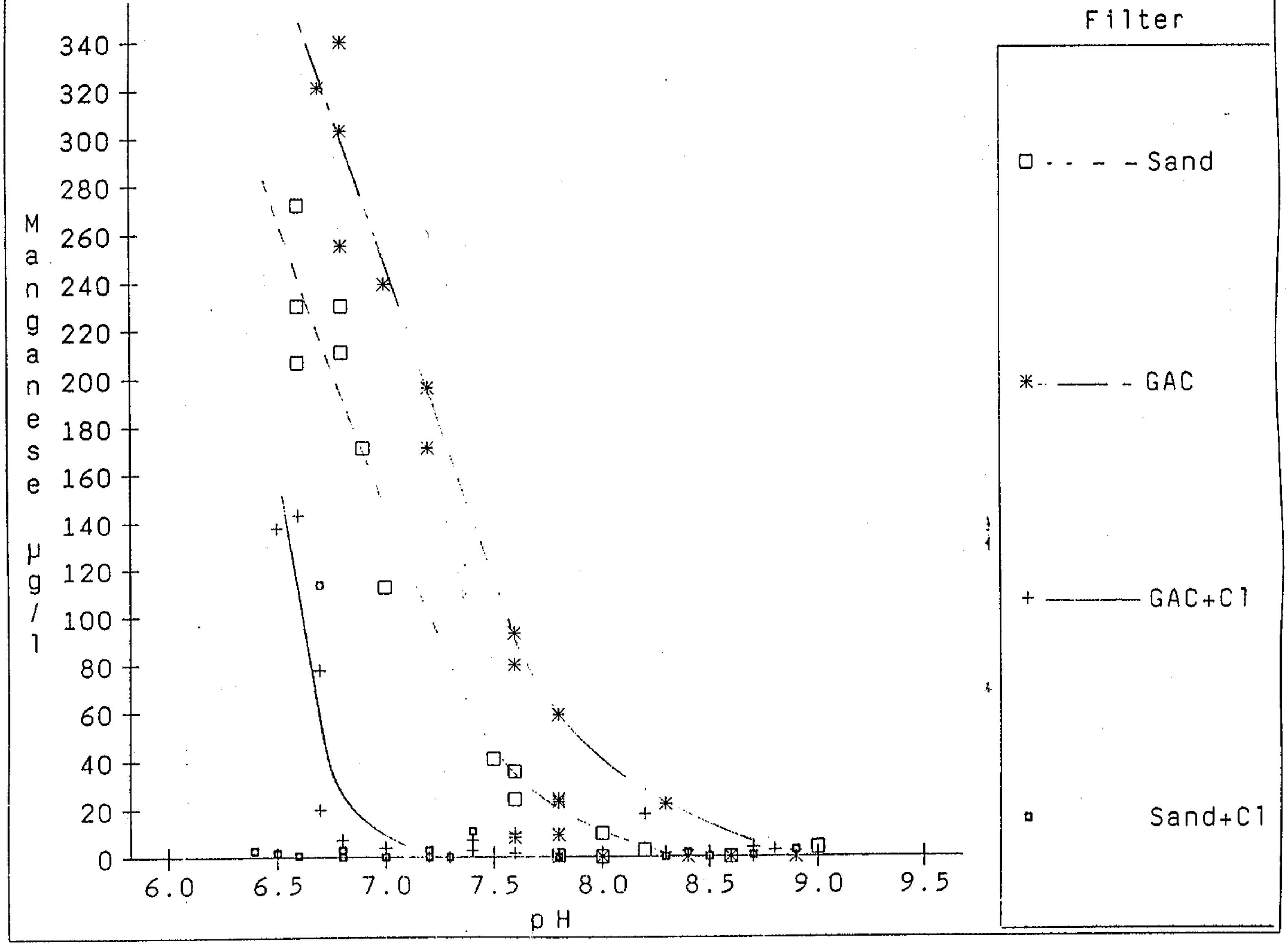


Figure 7. Manganese vs. Secondary RGF pH



indicated that the manganese deposit decreased down the bed from 57.7mg/g at the top to 20.7mg/g at the bottom.

3.3.3 Aluminium

Figure 8 shows a plot of aluminium concentration after various stages of three stage treatment. There was a large increase in aluminium during days 60 to 90 (October) as a result of the Autumn Flush. Only a small amount of the aluminium in the raw water was removed by the DAF, due to the low coagulation pH (4.6) but it was successfully removed by the 1° RGF.

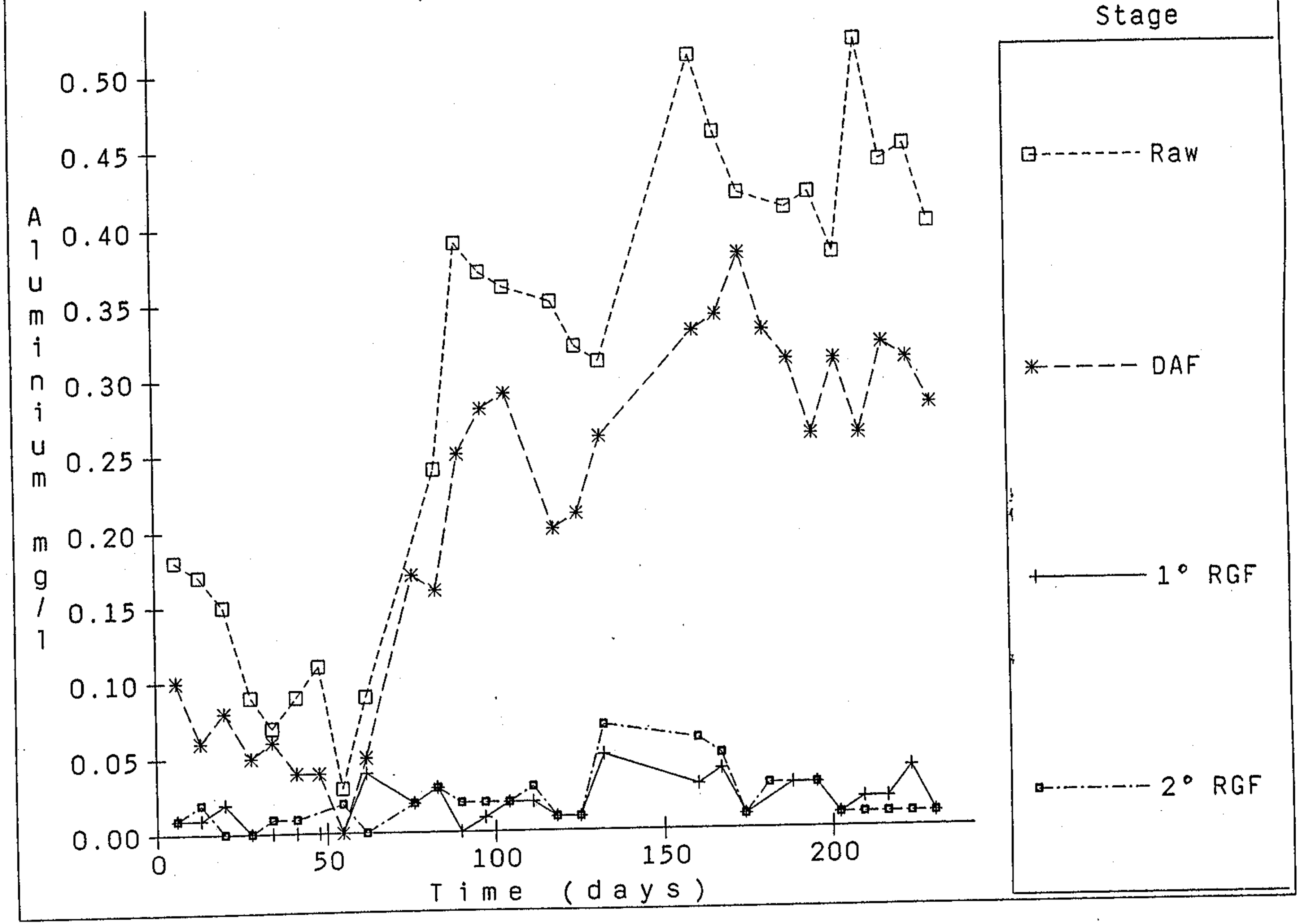
Table 4 gives summary aluminium statistics for the raw water, the DAF treated water, and the two 1° RGFs and shows that the mean aluminium concentration for both RGF filtered samples was less than the EC guide level of 0.05 mg/l, and that none of the samples was in excess of the PVC of 0.2 mg/l.

Table 4 - Summary aluminium statistics for sample numbers 1 to 4

Sample No.	1	2	3	4
Mean	0.30	0.20	0.02	0.02
Std.Dev.	0.15	0.12	0.02	0.01
No.Points	26	28	28	28
Maximum	0.52	0.38	0.07	0.05
Minimum	0.03	0.00	0.00	0.00

A two sided 't' test at the 95% significance level (Table A10, Appendix A) showed that there was no significant difference in aluminium concentration between the sand 1° RGF and the GAC 1° RGF.

Fig 8. Aluminium at Various Stages of 3 Stage Treatment
(Both Filters Contain Sand)



3.4 BACTERIOLOGICAL QUALITY

Throughout the trial, weekly samples of hand chlorinated final waters together with an unchlorinated, ozonated, sample (sample 9), were taken and assayed for bacteriological quality.

No coliforms were detected in any of the samples; Tables 5 and 6 give summary statistics for 1 Day (37°C) and 3 Day (22°C) colony counts respectively.

Table 5 - Summary statistics for 1 day (37°C) colony counts

Sample No.	5	6	7	8	9	10	11	12	13	14
Mean	3	2	2	1	2	3	2	3	2	2
Std.Dev.	6	4	3	2	2	5	2	5	2	2
No.Points	30	30	29	30	28	30	30	30	28	29
Maximum	29	22	14	9	10	27	10	26	10	8
Minimum	0	0	0	0	0	0	0	0	0	0

Table 6 - Summary statistics for 3 day (22°C) colony counts

Sample No.	5	6	7	8	9	10	11	12	13	14
Mean	19	12	6	13	87	18	18	23	14	10
Std.Dev.	34	15	6	25	157	43	40	41	11	13
No.Points	30	30	29	30	28	30	30	30	28	29
Maximum	157	69	23	131	722	227	207	196	51	51
Minimum	0	0	0	0	0	0	0	0	0	0

Tables 5 and 6 show that the mean colony counts were less than the EC guide level values (10 for 1 day colonies and 100 for 3 day colonies), although the maximums for several of the samples are in excess of those EC guide levels, in particular the ozonated water and the water from unozonated post treatment GAC adsorbers.

With the exception of sample 9, none of the samples had colony counts that were statistically greater than sample 8 (two sided paired 't' test at 95% significance level), indicating that the ozonation system used was not as effective as the hand chlorination. (However, none of the sample points could be flamed prior to sampling for bacteriological quality). A limited number (4 weeks) of ozonated samples were hand chlorinated and this reduced the 3 day counts to less than 12/100ml.

GAC adsorbers have the potential to release bacteria laden particles of carbon ,which would afford some protection against chlorination, and this may have been the cause of higher maximum 3 day counts in the samples from the post-treatment adsorbers. However, as there was no overall statistically significant difference between the GAC and sand filtered water, it can be assumed that release of particles of carbon was not generally a problem.

If bacteriological activity had developed on the carbon then this might be expected to result in higher bacterial numbers in the filtrate prior to hand chlorination; un-chlorinated filtrates were therefore examined weekly for four weeks between days 132 and 167. The results are shown in Tables 7 and 8.

Table 7 - 1 day colony counts (37°C), unchlorinated

sample No.> date	5	6	7	8	10	11	12	13	14
11-DEC-1990	3	1	2	3	0	2	7	2	-
18-DEC-1990	0	0	1	3	0	2	2	0	0
8-JAN-1991	0	5	3	0	1	0	1	6	10
15-JAN-1991	1	1	1	0	3	0	0	5	0

Table 8 - 3 day colony counts (22°C), unchlorinated

sample No.> date	5	6	7	8	10	11	12	13	14
11-DEC-1990	55	59	2	1	23	98	79	182	-
18-DEC-1990	1	29	14	11	9	16	14	760	330
8-JAN-1991	6	26	6	9	10	41	146	163	74
15-JAN-1991	16	11	7	0	53	41	55	107	42

The 3 day colony counts in the unchlorinated post adsorber samples were greater than those in the feed water (sample 5), suggesting that bacterial growth had occurred within the GACs, but the differences were not statistically significant at the 95% confidence level (Table A17 Appendix A). If there had been more samples collected the differences may have become more significant. The adsorbers receiving ozonated water did not produce higher counts than those receiving unozonated water.

3.5 ORGANICS

3.5.1 uv absorbance

(a) **Effect of 3 stage treatment (control)**

Figure 9 shows uv absorbance at various stages of three stage treatment (using sand at both filtration stages) plotted against time. The raw water apparent-uv and true-uv absorbances increased greatly during October (days 61 to 91) due to the Autumn Flush; this was also observed in the previous year (3). The apparent-uv absorbance of the DAF overflow appears to have been affected by the seasonal changes but this was more an indication of increased turbidity (figure 4) and not of increased organic content. True-uv absorbance of the overflow and the uv absorbances of the sand RGF filtrates did not change and this consistency in treated water quality is a reflection of the effectiveness of the SCD coagulant dose control system (which changed the coagulant dose in response to raw water quality changes (Figure 10)). Table 9 shows summary statistics for the results plotted in Figure 9.

Table 9 - Summary uv statistics at various stages of 3 stage treatment

Treatment Stage >	RAW WATER		DAF		SAND 1° RGF	SAND 2° RGF
	Appar	True	Appar	True		
Mean	21.3	17.0	10.1	4.3	3.9	3.9
Std. Dev.	4.8	3.5	1.6	0.5	0.6	0.5
No. Points	147	146	147	147	147	147
Maximum	27.3	22.1	20.7	6.6	8.2	5.7
Minimum	13.0	10.7	7.6	3.0	2.5	2.7

The DAF removed, on average, 75% of the organic material responsible for true-uv absorbance but there was still a significant amount of uv absorbing material in the floc carry-over.

The uv absorbance of the 1°RGF filtrate was less than that of the DAF clarified water which indicates that there was further precipitation of organic material in the 1° RGF, presumably resulting from the pH correction prior to primary filtration. The equality of the means for the 1° and 2° RGF filtrates indicates that there was no further organics removal after the first stage of filtration.

(b) **Location of GAC**

Figure 11 shows apparent-uv absorbance levels in the water after treatment by F400 GAC at different locations in the treatment process plotted against days of operation. The water treated by two stages of sand filtration is shown as a control. A principal difference between the locations is the available empty bed contact time (EBCT) as summarised below (Table 10).

Table 10 - EBCTs of different carbon combinations

LOCATION	EBCT
2° RGF:	3.73 mins
1° RGF:	6.33 mins
1°+2°:	10.07 mins
3°adsorber:	10.00 mins
1°+3°adsorber:	16.33 mins

The breakthrough curves shown in Figure 11 indicate that the GACs with the longer EBCTs removed more apparent-uv absorbance and for a longer period of time than the GACs with the shorter EBCTs. Where the total EBCT was the same but the GAC location was different (1°+2°RGF and 3°adsorber), the breakthrough curves were essentially identical for the first 100 days. After this the 3° adsorber performed slightly better but this difference can be attributed to a loss of around 17% of the GAC from the 1°and 2° RGFs during backwashing. It can, therefore, be concluded that uv absorbance removal was not hindered by floc carry-over onto the 1° RGF nor by manganese deposition in the 2° RGF. It can also be concluded that there was no great difference in carbon performance for uv absorbance removal between a pH of 6.5 and 9.0, since the 1° RGF pH was 6.5 and that of the 2° RGFs and post adsorbers was 9.0.

To investigate further if operating environment (pH, manganese deposition, floc removal, backwashing etc.) had any effect on performance, the measured breakthrough curves were compared to a computer-based mathematical-model prediction. The model was developed by WRc and has been extensively used to predict bed life for a range of GACs and contaminants (6). The equilibrium constants used in the model were obtained by reiteratively adjusting them to obtain the best fit to the data from the 2° RGF (with an EBCT of 3.73 mins). Once chosen, these constants were used to predict breakthrough for longer EBCTs, corresponding to those used at the other locations on the pilot plant.

If location within the treatment stream has a significant effect on GAC performance then the predictions of 1° or 3° breakthrough curves (based on 2° derived constants) should not match the measured curves. Figure 12 shows the predicted breakthrough curves together with the measured data points.

For the first 180 days there is very good agreement between the experimental data and all of the model predictions, which confirms that the operating environment was not having a great effect on GAC performance. However for the 3° (and to a lesser extent for the 1°+2°) adsorbers there is divergence from the predicted after 180 days when removal appears to have increased.

One possible explanation for this is that the very low temperature experienced between days 160 and 210 (Figure 13) could have increased the equilibrium capacity of the carbon (this is why laboratory tests are done at a fixed temperature to produce isotherms); the effect of such an increase would be more apparent at a longer EBCT. Alternatively it is possible that some biological activity had begun to build up, but the low temperatures and the relatively large difference that was observed in removal would mitigate against this. An additional factor contributing to this effect could have been differences in actual flowrate caused by varying water viscosity. At lower temperatures, water viscosity increases, and a greater viscosity causes a greater apparent flowrate to be indicated by a rotameter. Since flowrate was controlled by rotameter readings, without temperature correction, it is estimated that the flowrate of the hottest time of the year could have been 5 - 10% greater than at the coldest time of the year. This would have resulted in a greater EBCT during the cold spell, with consequent improved GAC performance. Again, the observed effect on breakthrough would have been greatest for the longer EBCTs.

(c) **Carbon type and ozone**

Figure 14 shows a comparison between the Norit PK and the F400 post adsorbers, which had the same EBCT; the unozonated sand filtered water, which was the feed for both is also shown. The figure clearly shows that the coal based F400 was more effective at removing uv absorbance for a longer period than the peat based Norit PK. This is reflected by the mean values for uv absorbance, given in Table 11 which lists summary statistics of uv absorbance for the sand filtered water, and all post treatments; ozone dose is also given.

Table 11 - Summary uv statistics for final waters, and ozone doses

	SAND 2° RGF	NORIT PK	F400	Ozone Dose mg/l	Ozone Resid mg/l	SAND 2° RGF + OZONE	OZONE + PICA BIOL	OZONE + F400
Mean	3.9	3.0	1.7	2.0	0.13	1.8	1.4	0.7
Std. Dev.	0.5	0.9	1.0	0.6	0.18	0.6	0.5	0.5
No.Points	147	147	147	141	32	141	141	141
Maximum	5.7	5.2	3.6	4.2	0.62	5.1	4.3	2.6
Minimum	2.7	-0.6	-0.8	0.0	0.00	0.8	-0.4	-0.7

An ozone dose of 2 mg/l reduced uv absorbance in the 2° sand filtered water by about 50%; this ozone dose was enough to give a small ozone residual after the contactor. The level of uv in the ozonated water is plotted in Figure 15 which compares the performance of the wood based Pica Biol and the coal based F400 when treating the ozonated water; both GACs had the same EBCT of 10 minutes. The coal based F400 clearly removed more uv absorbance, and for a longer period, than the Pica Biol.

It is worth noting that although the Pica Biol was 80% saturated after just 3 weeks, it continued to remove around 15-20% of the uv absorbance and within the trial period it never became saturated. This suggests that adsorption onto Pica Biol may be

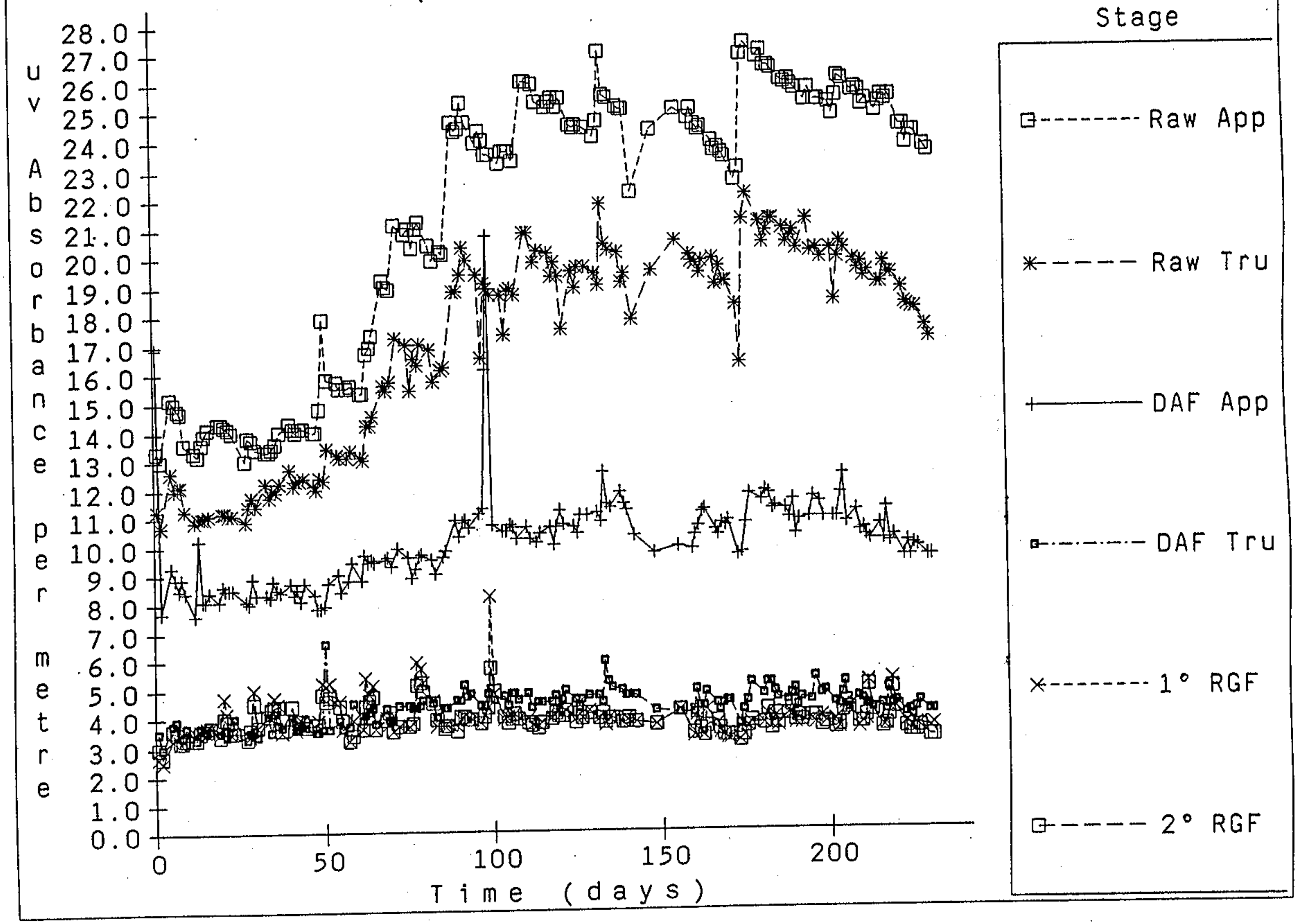


Fig 9. uv Absorbance at Various Stages of 3 Stage Treatment
(Both Filters Contain Sand)

Fig 10.   Seasonal Variation in Ferric Dose

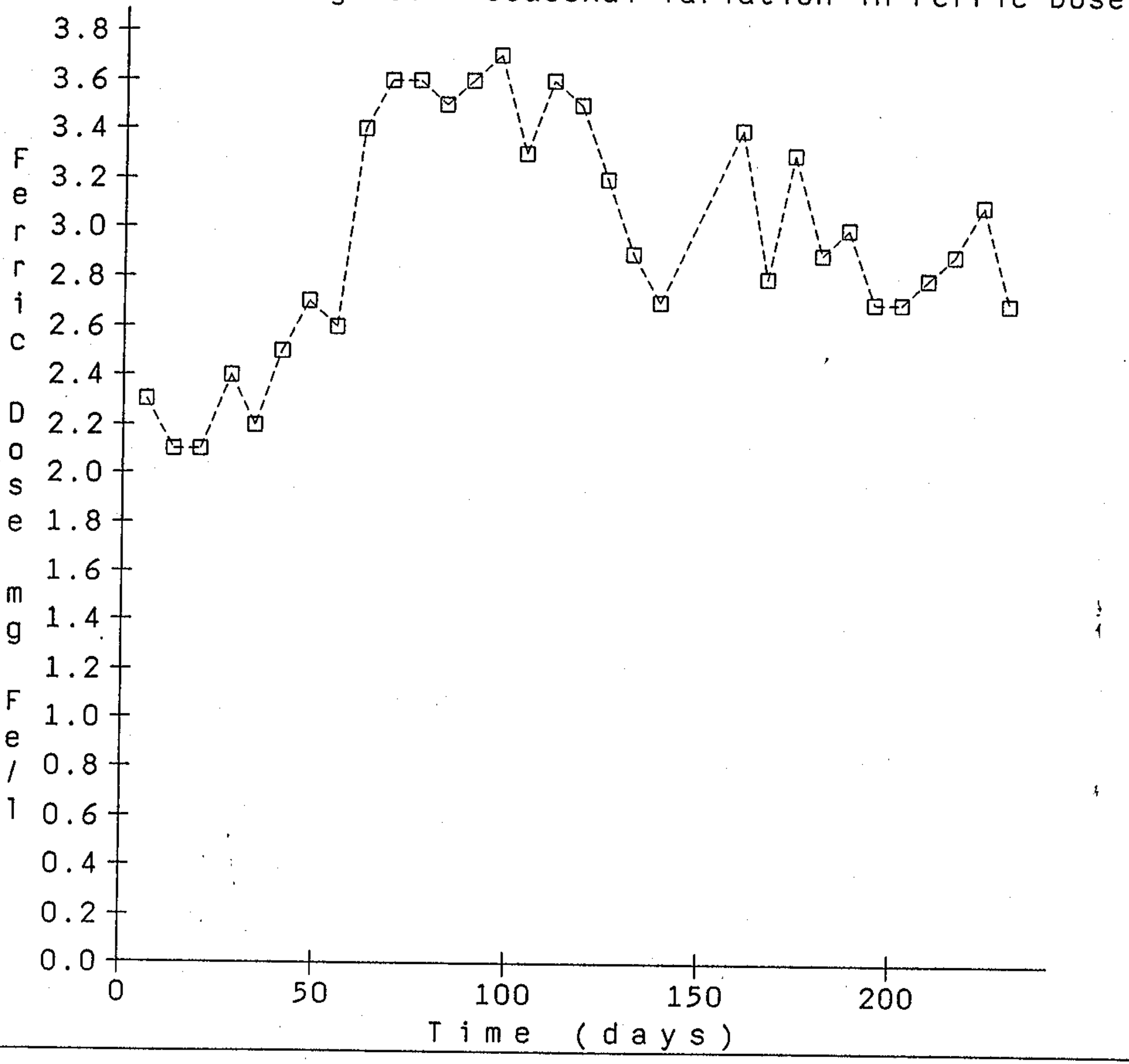


Fig 11. Effect of Empty Bed Contact Time
- uv Absorbance Breakthrough

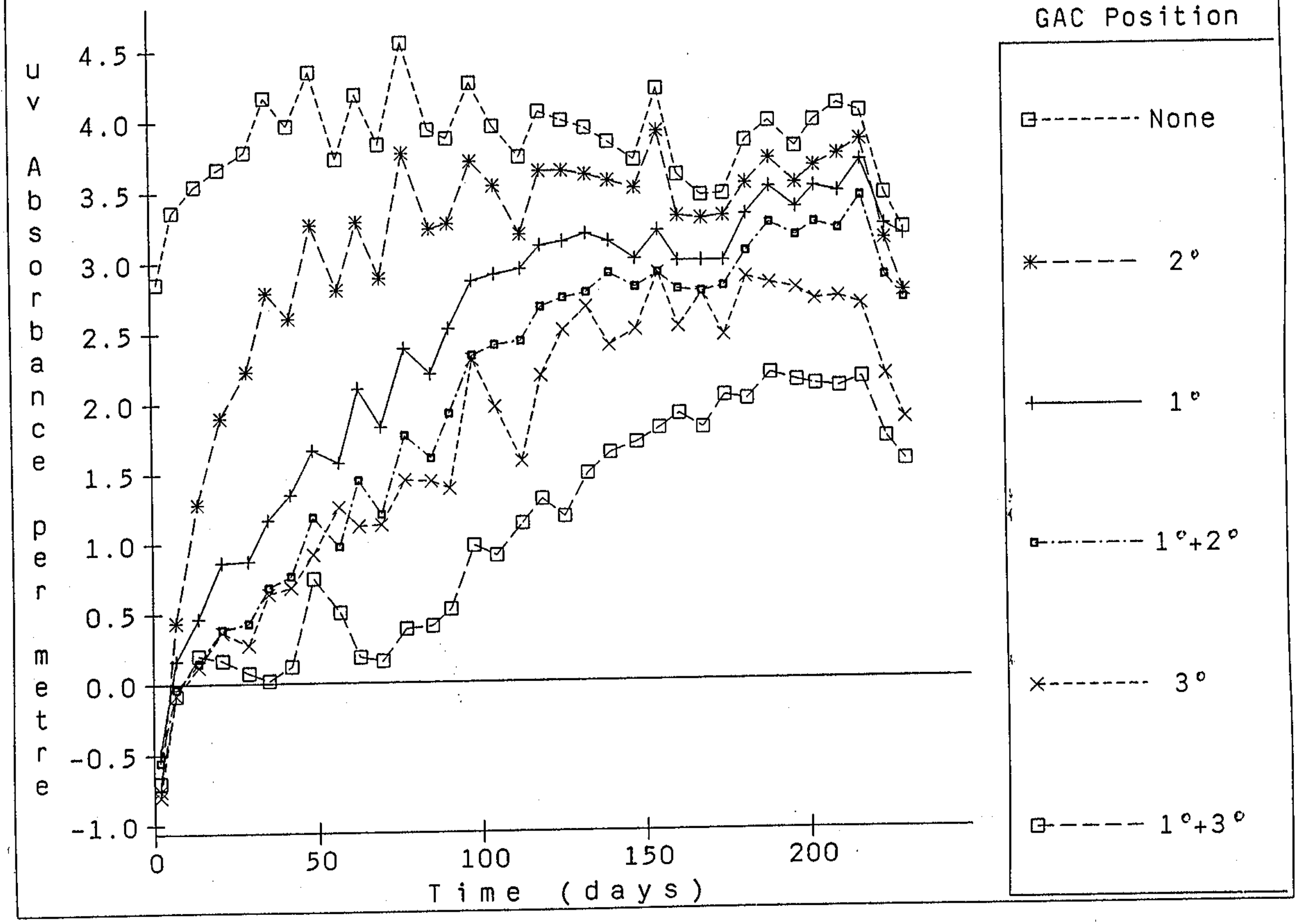
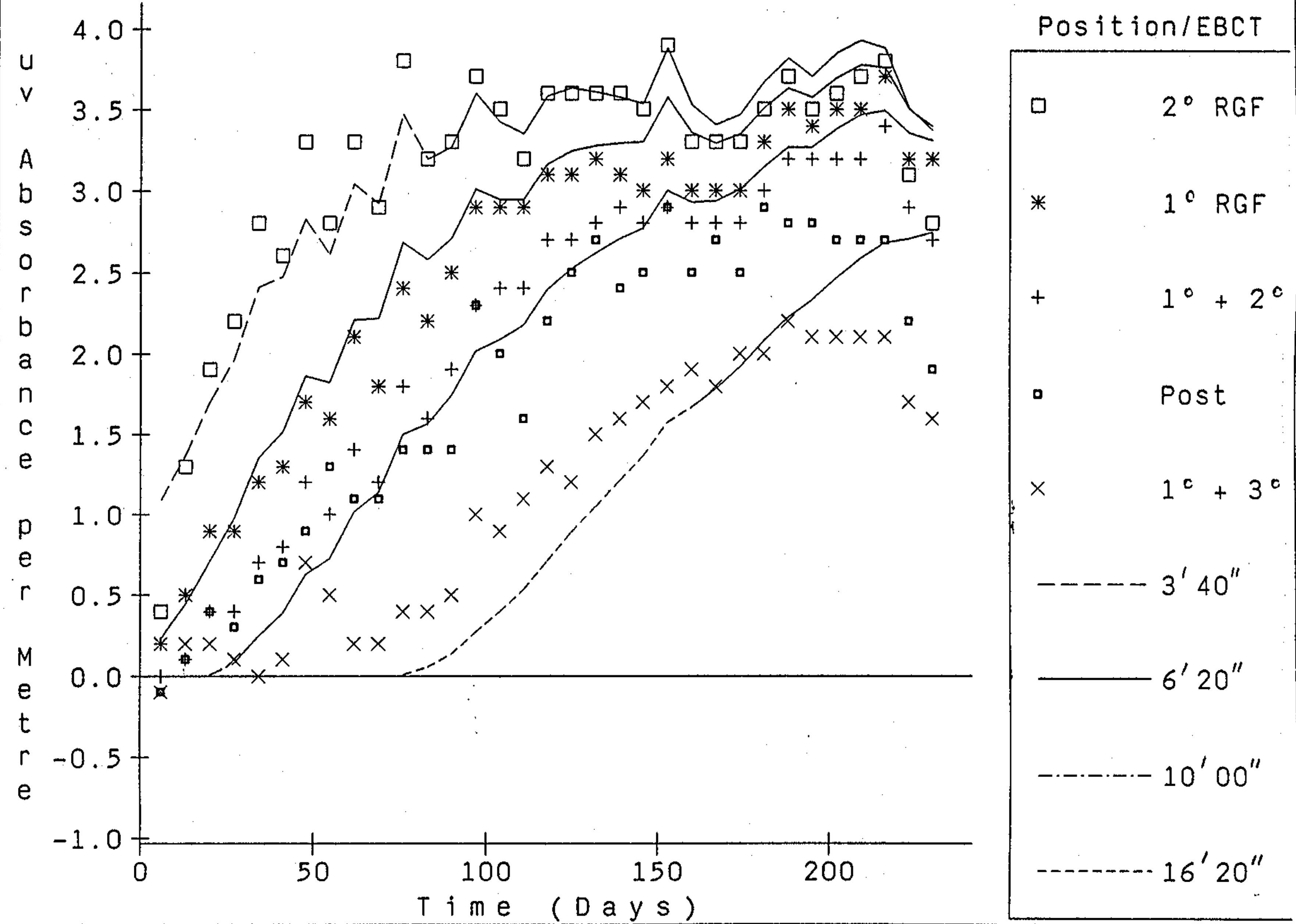


Fig 12. Model Prediction uv Absorbance Compared to Actual Breakthrough



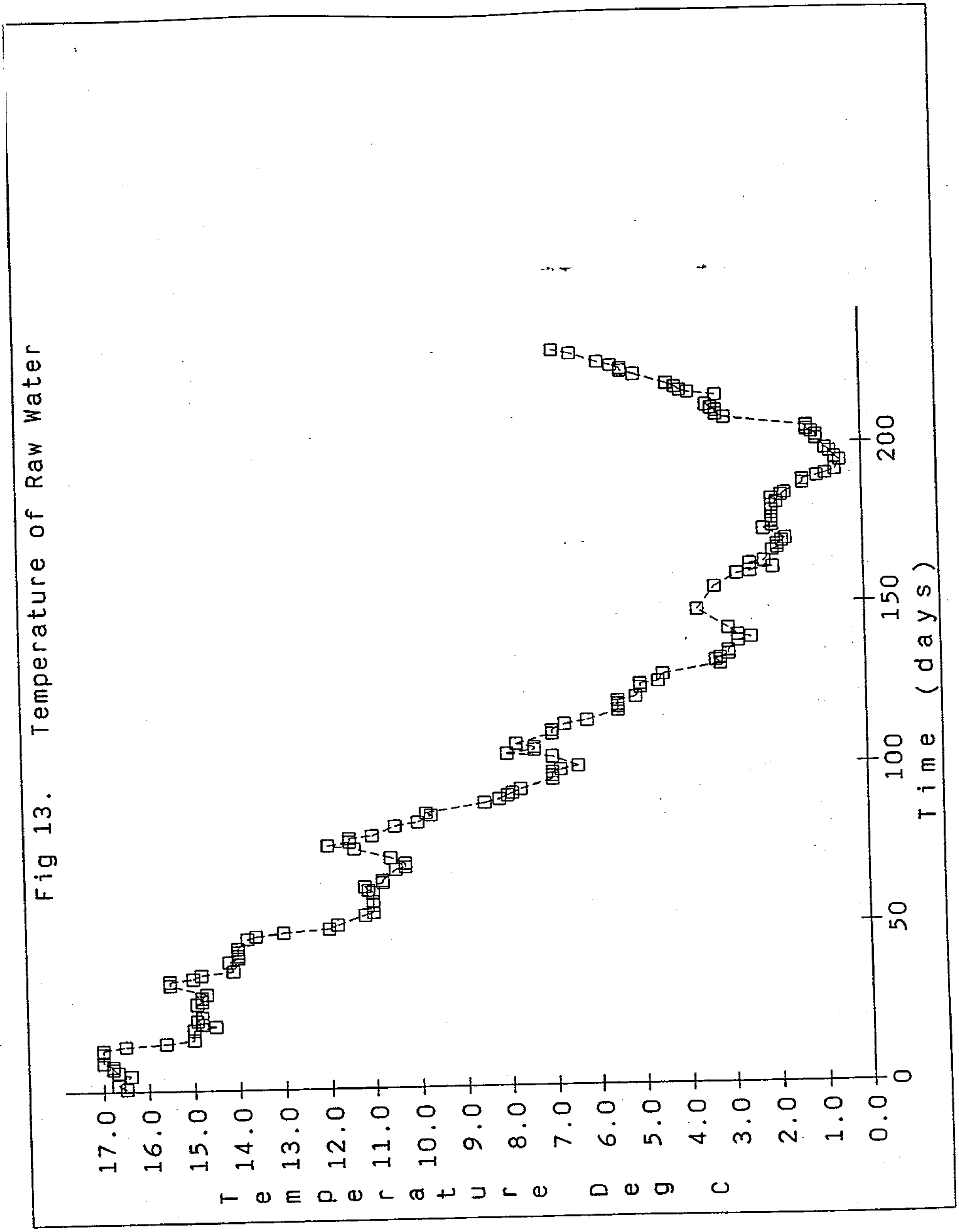


Fig 13. Temperature of Raw Water

Fig 14. Comparison of Norit PK and F400
- uv Absorbance Breakthrough

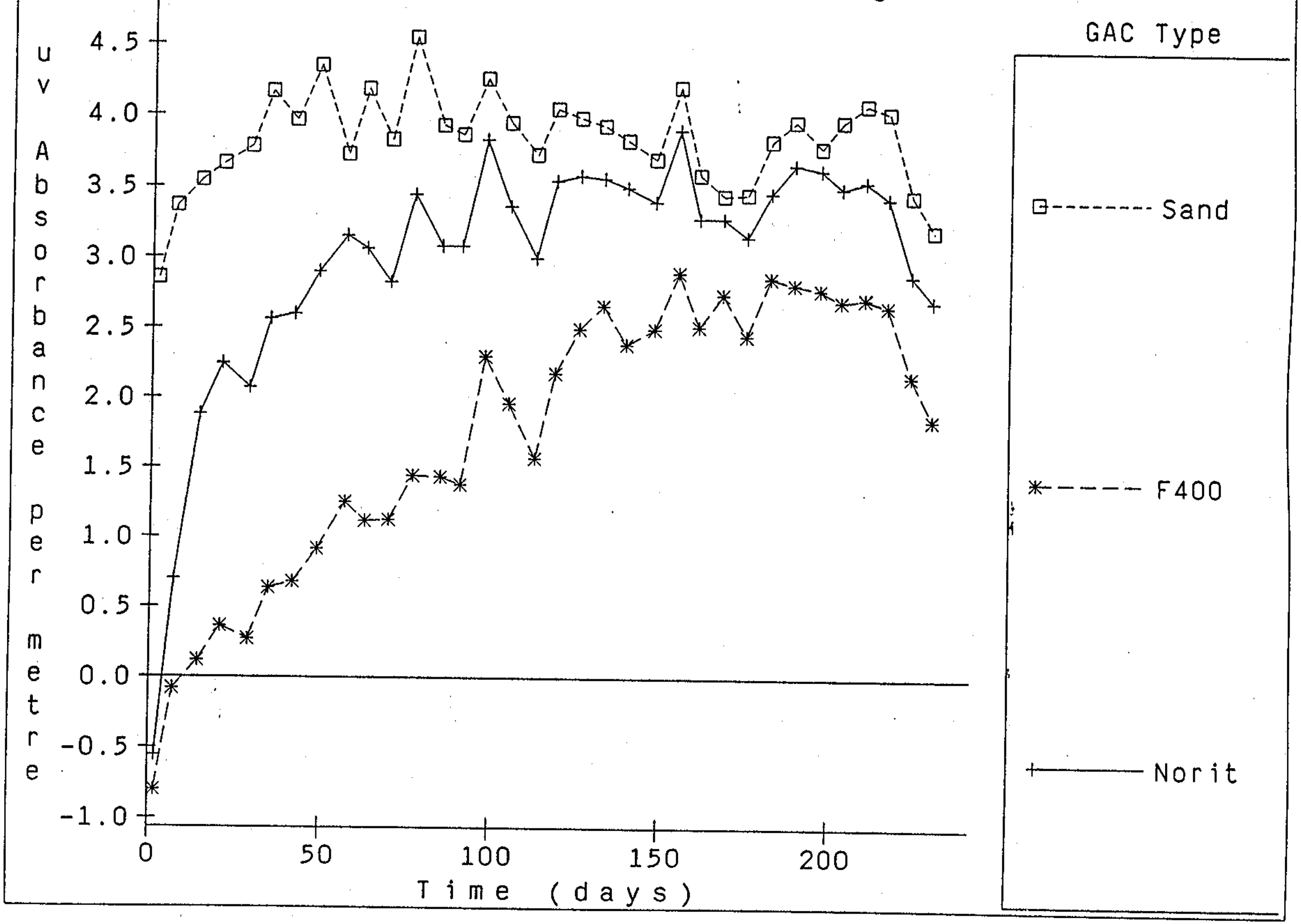
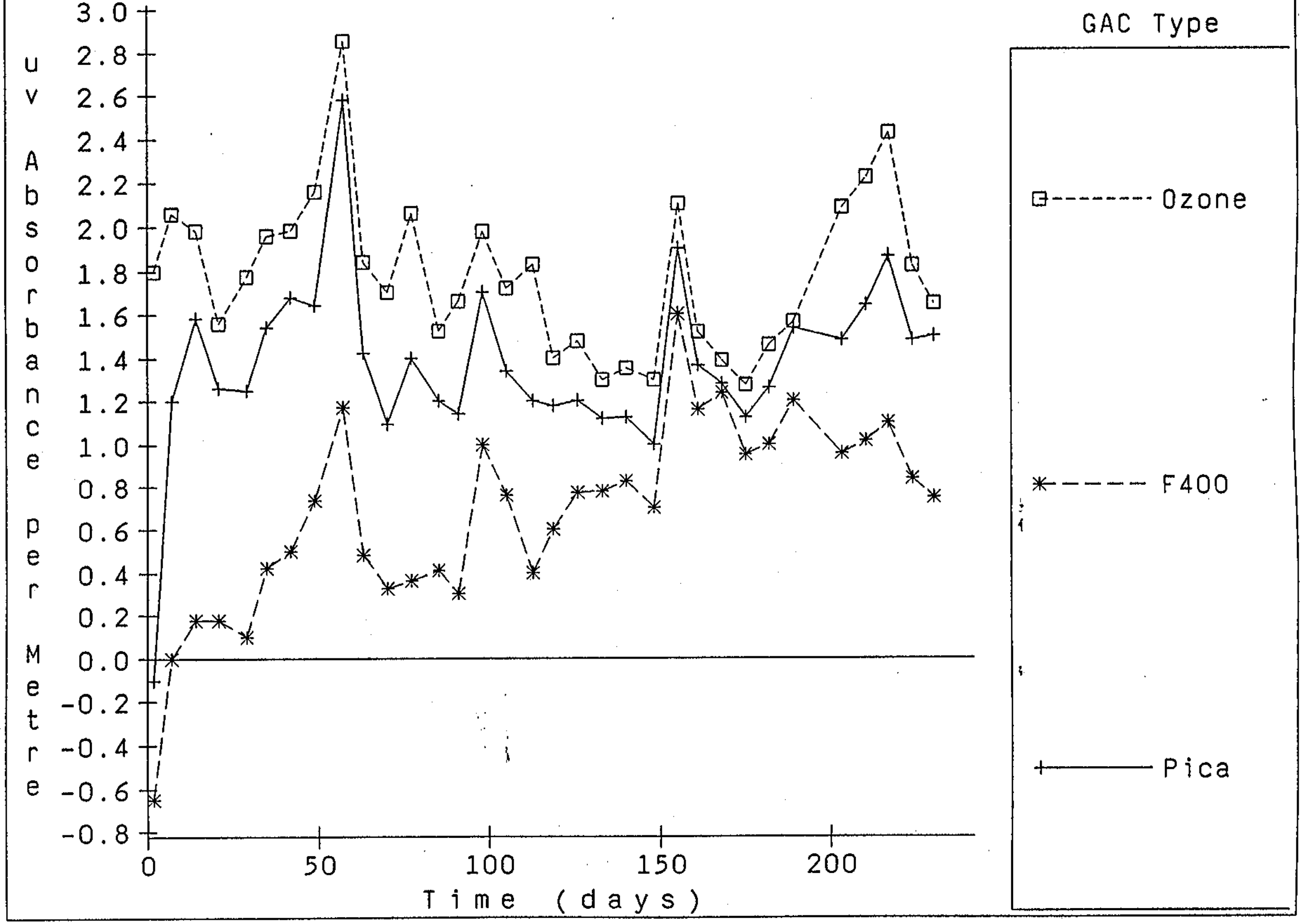


Fig 15. Comparison of Pica Biol and F400 (after Ozone) - uv Absorbance Breakthrough



highly compound specific with about 80% of the organics being unsuitable for adsorption by Pica Biol. In contrast, F400 was capable of adsorbing a far greater proportion of the organic material in the water.

3.5.2 Colour

(a) Effect of 3 stage treatment

Figure 16 shows colour at various stages of three stage treatment (using sand filters at both filtration stages) plotted against time. Summary statistics for the data plotted in Figure 16 are given in Table 12.

Table 12 - Summary colour statistics at various stages of 3 stage treatment (all values in Hazen)

Treatment Stage	RAW WATER		DAF		1° RGF	2° RGF
	Appar	True	Appar	True		
Mean	37.8	21.6	16.5	2.9	2.2	2.2
Std. Dev.	10.5	5.4	4.8	1.2	1.7	1.3
No. Points	147	147	147	147	147	147
Maximum	51	32	50	9	17	7
Minimum	18	12	11	0	-1	-1

The seasonal trends in colour were the same as the seasonal trends in uv absorbance and it can be seen that colour removal paralleled uv absorbance removal (i.e. some removal in the DAF, and the remainder in the first filtration stage).

(b) Location of GAC

Figure 17 shows cumulative colour removal by F400 carbon at different locations in the treatment process plotted against days run. The same trend can be seen in Figure 17 as was seen for uv absorbance in Figure 11 : increasing EBCT resulted in more colour removal for a longer period of time. The cumulative plot is shown due to the high degree of scatter in the actual breakthrough curves (colour was measured to the nearest 1° Hazen, which was a significant proportion of the values being measured).

(c) **Carbon type and ozone**

Figure 18 shows a comparison of colour removal by F400 and Norit PK, and Figure 19 shows a comparison of colour removal after ozonation by Pica Biol and F400 BACs. F400 performed better for colour removal than Norit PK, and F400 BAC performed better than Pica Biol. Summary statistics for the data in figures 18 and 19 are given in Table 13.

Table 13 - Summary colour statistics for treated waters

Post Treatment	SAND 2° RGF	NORIT PK	F400	SAND 2° RGF + OZONE	OZONE + PICA BIOL	OZONE + F400
Mean	2.2	1.6	1.0	0.5	0.5	0.2
Std. Dev.	1.3	1.2	1.1	1.2	1.2	1.0
No.Points	147	147	147	147	147	147
Maximum	7	3	6	6	6	3
Minimum	-1	-1	-3	-3	-2	-2

Table 14 compares the mean percentage reduction in colour with that for uv for the various post treatments and, with the exception of ozone dose, the same proportion of colour as of uv absorbance was removed by each treatment.

Table 14 - Comparison of the effect of post treatment on colour and uv

Carbon	% Reduction in	
	Colour	uv
F400	57	55
Norit PK	28	22
Ozone	77	53
Ozone +F400	89	82
Ozone +Pica	77	64

The good correlation between colour and uv absorbance is demonstrated further by Figure 20 which plots mean colour for each sample point against uv absorbance. The figure shows that there is a good correlation between colour and uv absorbance, but that the correlation appears to be non-linear.

Fig 16. Colour at Various Stages of 3 Stage Treatment (Both Filters Contain Sand)

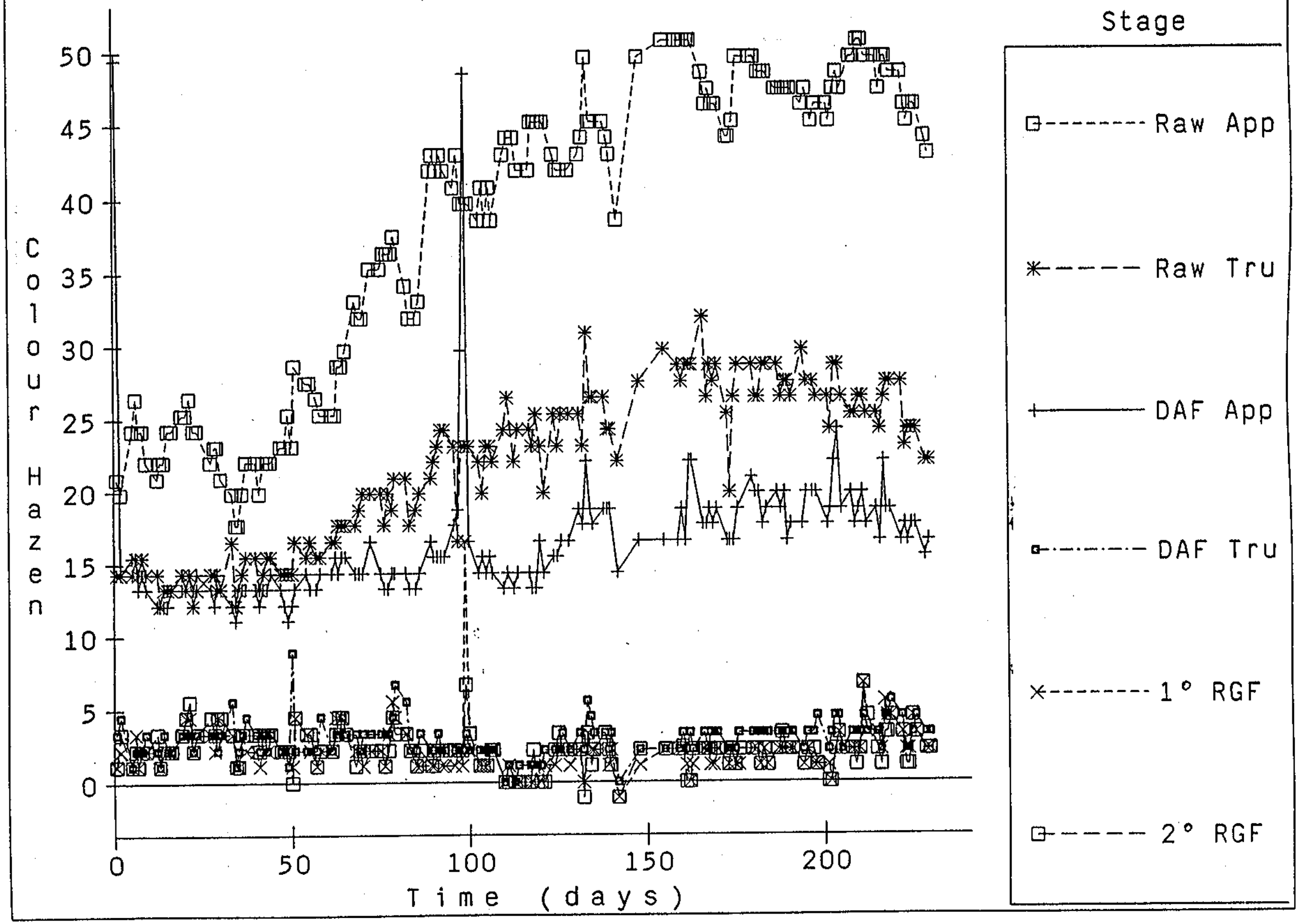


Fig 17. Effect of Empty Bed Contact Time
- Cumulative Colour Removal

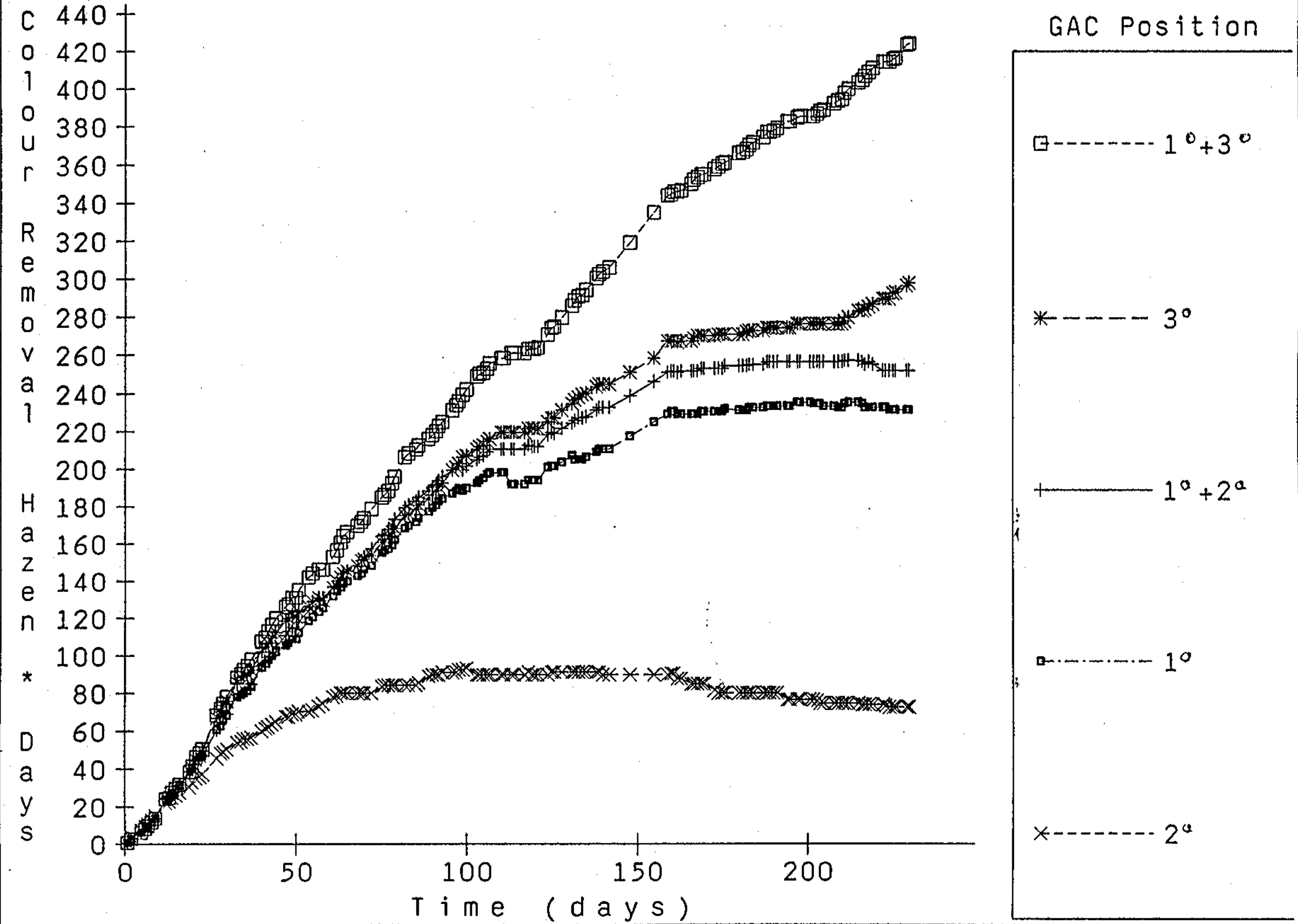


Fig 18. Comparison of Norit PK and F400 - Colour Breakthrough

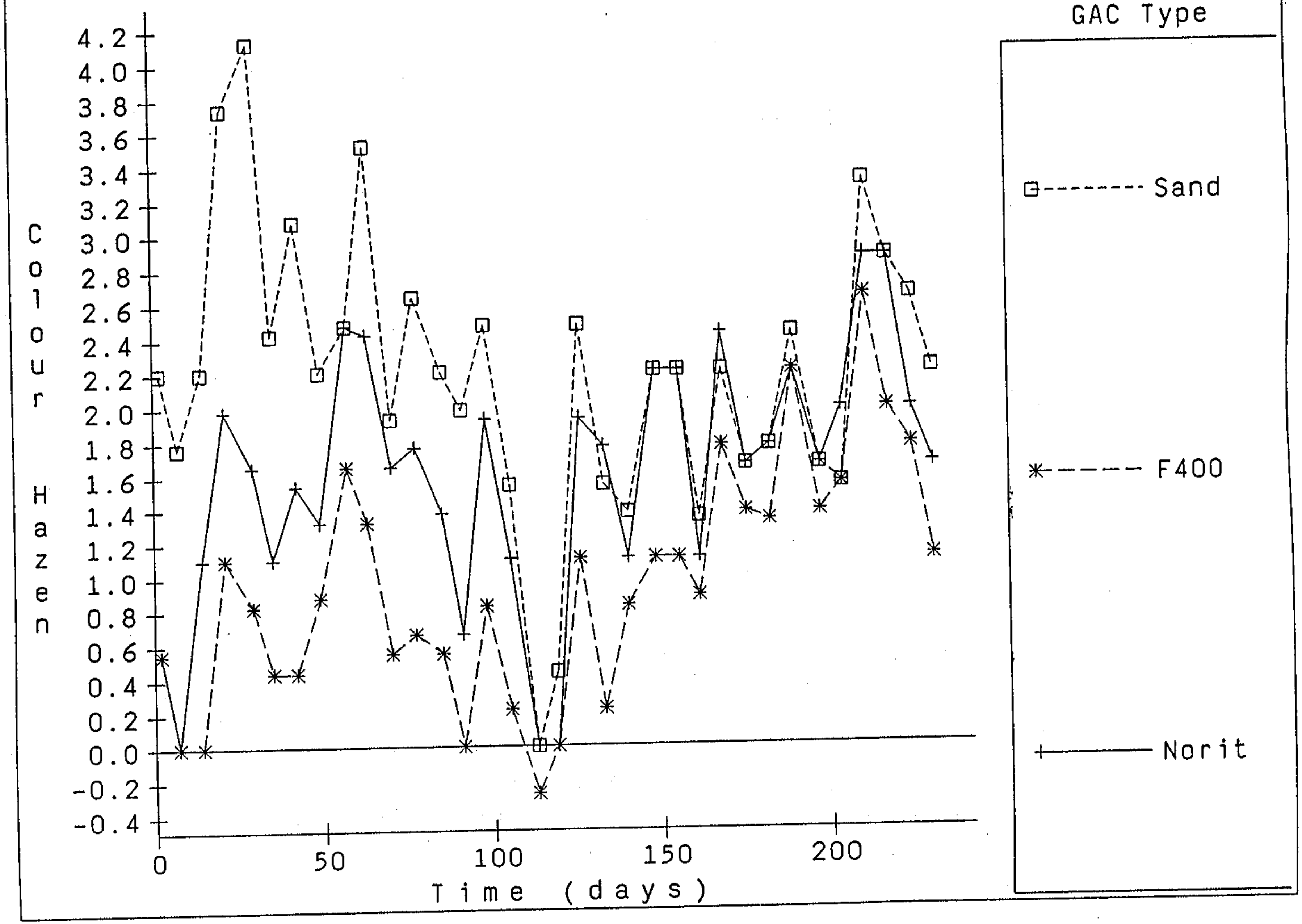


Fig 19. Comparison of Pica Biol and F400 (after Ozone) - Colour Breakthrough

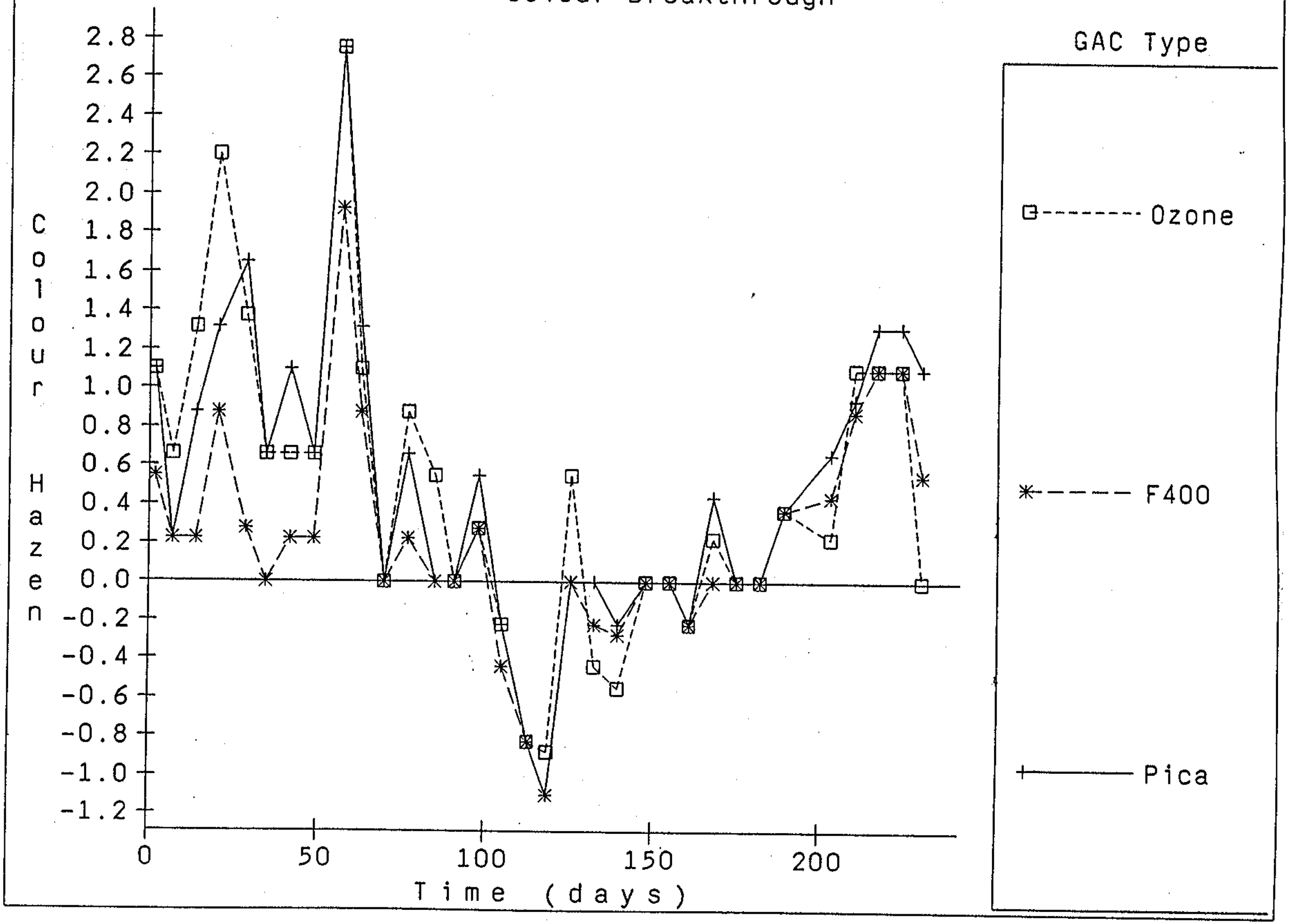
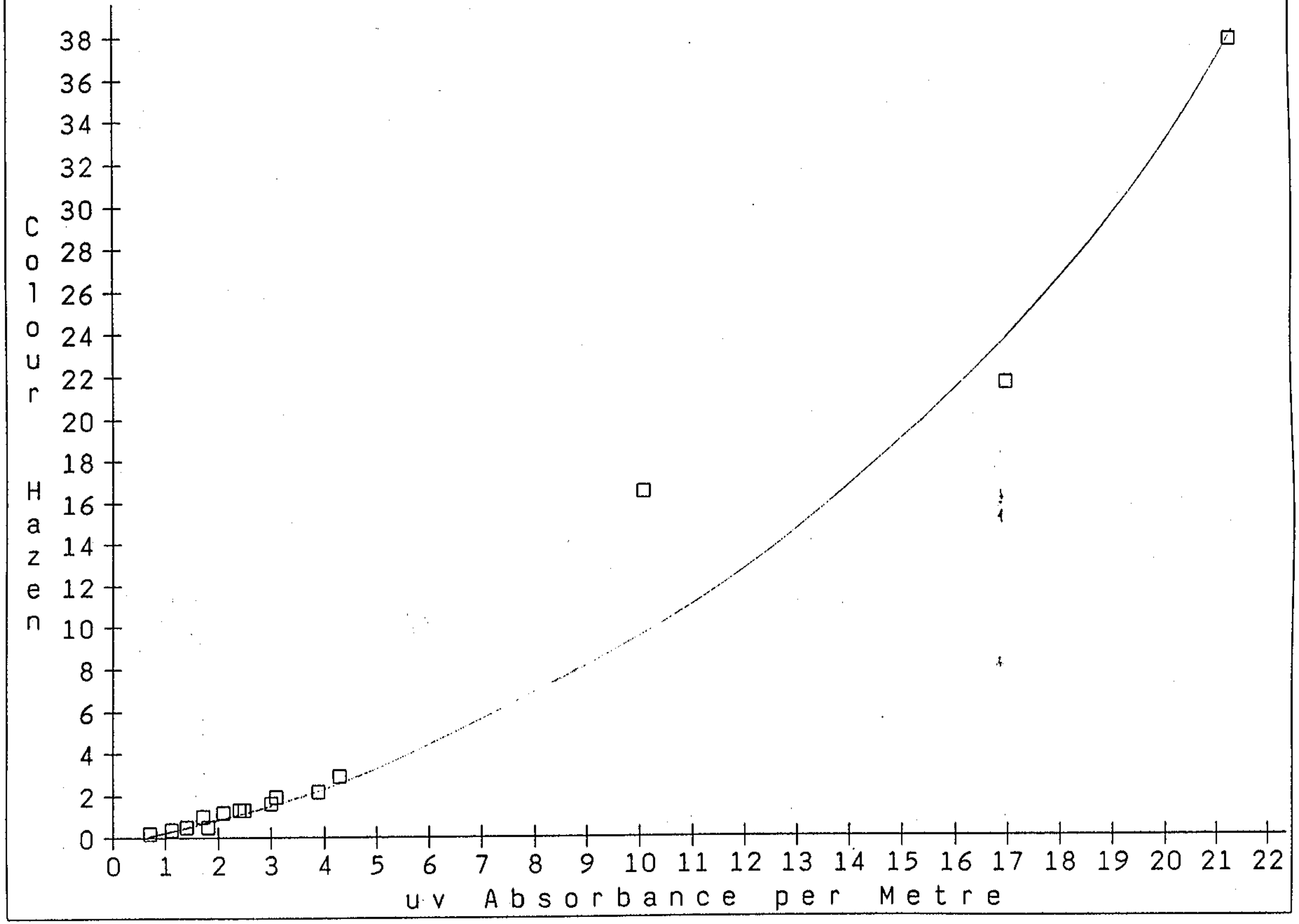


Fig 20. Correlation Between Colour and uv Absorbance
(Mean Values for each Sample Point)



3.5.3 Total organic carbon

(a) **Effect of 3 stage treatment**

Figure 21 shows TOC in the raw water and in the sand filtered final water plotted against time. The plot shows that TOC increased as a result of the Autumn Flush, and that this was reflected by an increase in final water TOC. Since sand filtered water colour and uv absorbance did not respond to changes in raw water colour quality there must be a proportion of the TOC that is non-coloured and uv inactive and resistant to removal by coagulation. Summary statistics of the data plotted in Figure 21 are given in Table 15.

Table 15 - Summary TOC statistics for raw and sand filtered water

	RAW WATER	TREATED WATER
Mean	5.25	2.68
Std. Dev.	1.48	0.80
No. Points	28	30
Maximum	7.80	4.80
Minimum	2.54	1.26

(b) **Location of GAC**

Figure 22 shows cumulative colour removal by F400 carbon at different locations in the treatment process plotted against days run. As was seen for colour (Figure 17) and uv absorbance (Figure 11), increasing EBCT resulted in more TOC removal for a longer period of time. The cumulative plot is shown due to the high degree of scatter in the actual breakthrough curves. Summary statistics of the TOC results are given in Table 16.

Table 16 - Summary TOC statistics for effect of EBCT using F400

CARBON POSITION	NONE	2° RGF	1° RGF	1°+2° RGFs	POST	1° RGF + POST
Mean	2.68	2.50	2.29	1.98	2.03	1.74
Std. Dev.	0.80	1.05	1.07	1.09	1.19	1.09
No. Points	30	30	30	30	30	30
Maximum	4.80	4.73	4.15	4.30	5.05	4.50
Minimum	1.26	0.51	0.23	0.00	0.13	0.15

(c) **Carbon type and ozone**

Figure 23 shows a comparison between Norit PK and F400 used in post adsorbers, Figure 24 shows a comparison between Pica Biol and F400 treating ozonated water. F400 removed more TOC for a longer period of time than Norit PK, and Pica Biol. Summary statistics for the data plotted are given in Table 17.

Table 17 - Summary TOC statistics for effect of post treatment

POST TREATMENT	NONE	NORIT PK	F400	OZONE	OZONE PICA	OZONE F400
Mean	2.68	2.66	2.03	2.60	2.57	1.76
Std. Dev.	0.80	1.07	1.19	0.86	1.29	1.11
No. Points	30	30	30	29	29	29
Maximum	4.80	4.60	5.05	4.90	6.18	5.25
Minimum	1.26	0.43	0.13	1.19	1.10	0.16

A comparison of the effect of using ozone and/or GAC on TOC is provided in Table 18, which gives the results of student's paired 't' test statistics for a number of paired samples.

Table 18 - Paired 't' tests for TOC

	Mean Difference	Std.Dev. of Diff	No.Points	't'	Significant
Sand Only - Ozonated	0.06	0.48	29	0.68	NO (1)
Dual GAC - Post	-0.05	0.44	30	-0.63	NO (2)
OZONE/F400-F400	-0.23	0.40	29	-3.04	YES (2)
Pica Biol - Ozonated	-0.04	0.80	29	-0.24	NO (1)

(1) = one sided 95% significance level
(2) = two sided 95% significance level

Statistically, ozonation had no effect on TOC concentration and there was no difference in the TOC removal between the two stage (1° + 2° RGF) carbon and the post adsorber when both contained F400 GAC. There was significantly greater removal of TOC, after ozonation, by the F400 but not by the Pica Biol. It is possible that ozonation altered the nature of the TOC by, for example, breaking down large molecules and altering polarity (the observed reduction in uv absorbance supports this) making it more readily adsorbed by F400, but the improvement was not very great.

Figure 25 shows a plot of mean TOC for each sample point against mean uv absorbance. From this figure, it can be seen that there is a good correlation between TOC and uv absorbance, but that it is not linear, and that there is still a significant TOC concentration (1 - 3 mg/l) at zero uv absorbance.

It can also be seen that ozonation tended to reduce uv absorbance more than TOC (the ozonated points lie above and to the left of the unozonated points).

Fig 21. TOC of Raw and Final Sand Filtered Waters

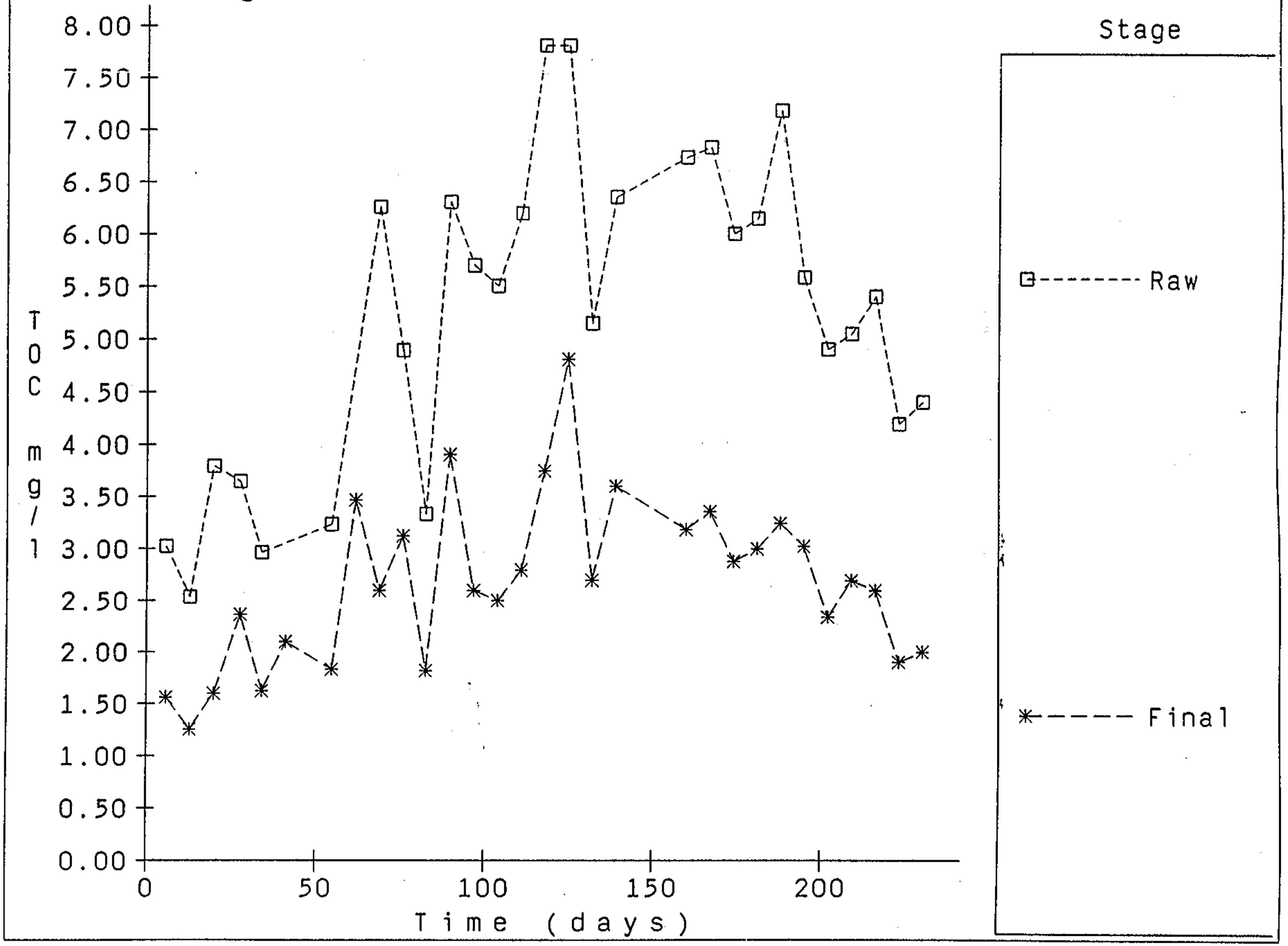


Fig 22. Effect of Empty Bed Contact Time
- Cumulative TOC Removal

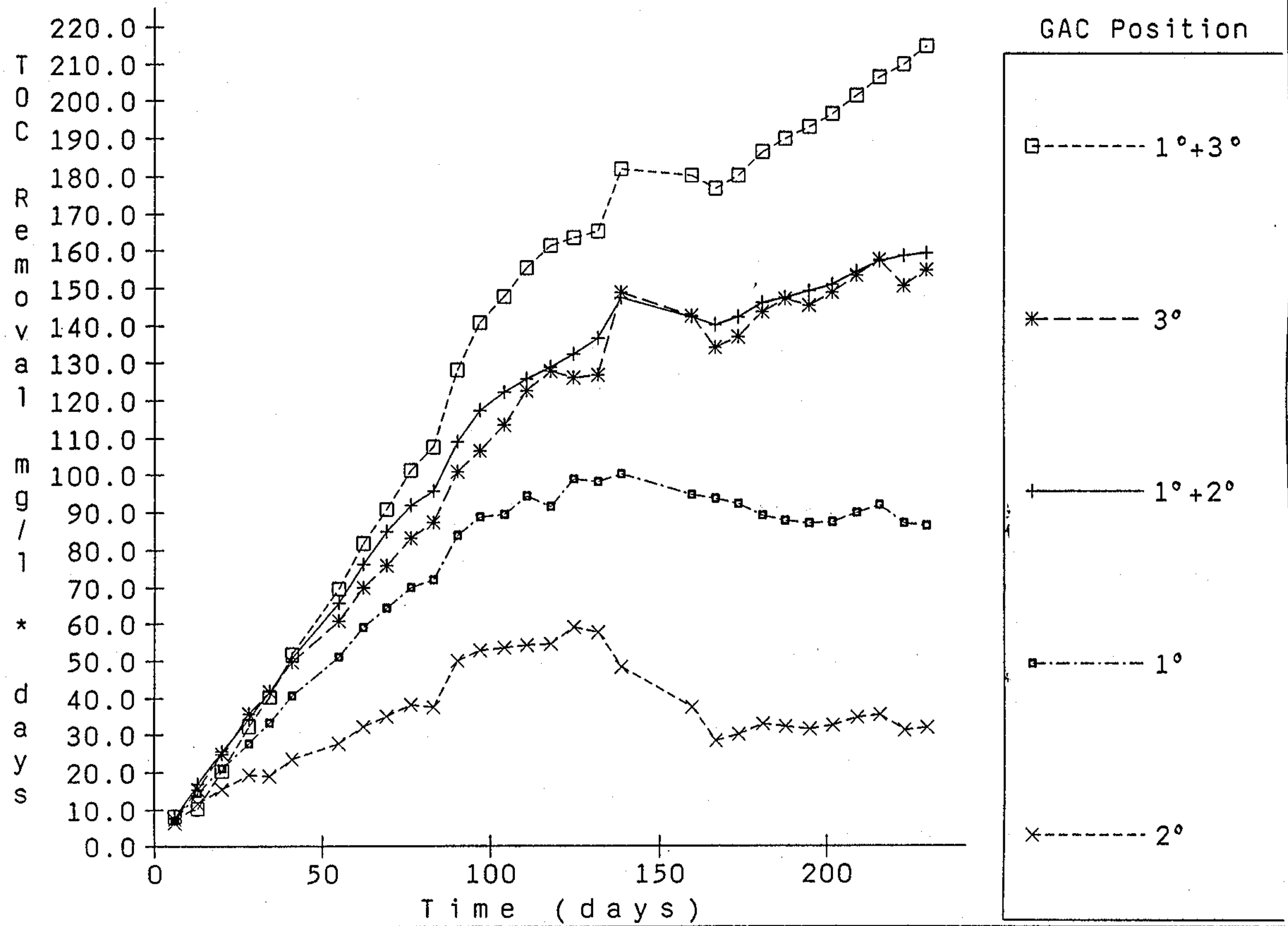


Fig 23. Comparison of Norit PK and F400 - TOC Breakthrough

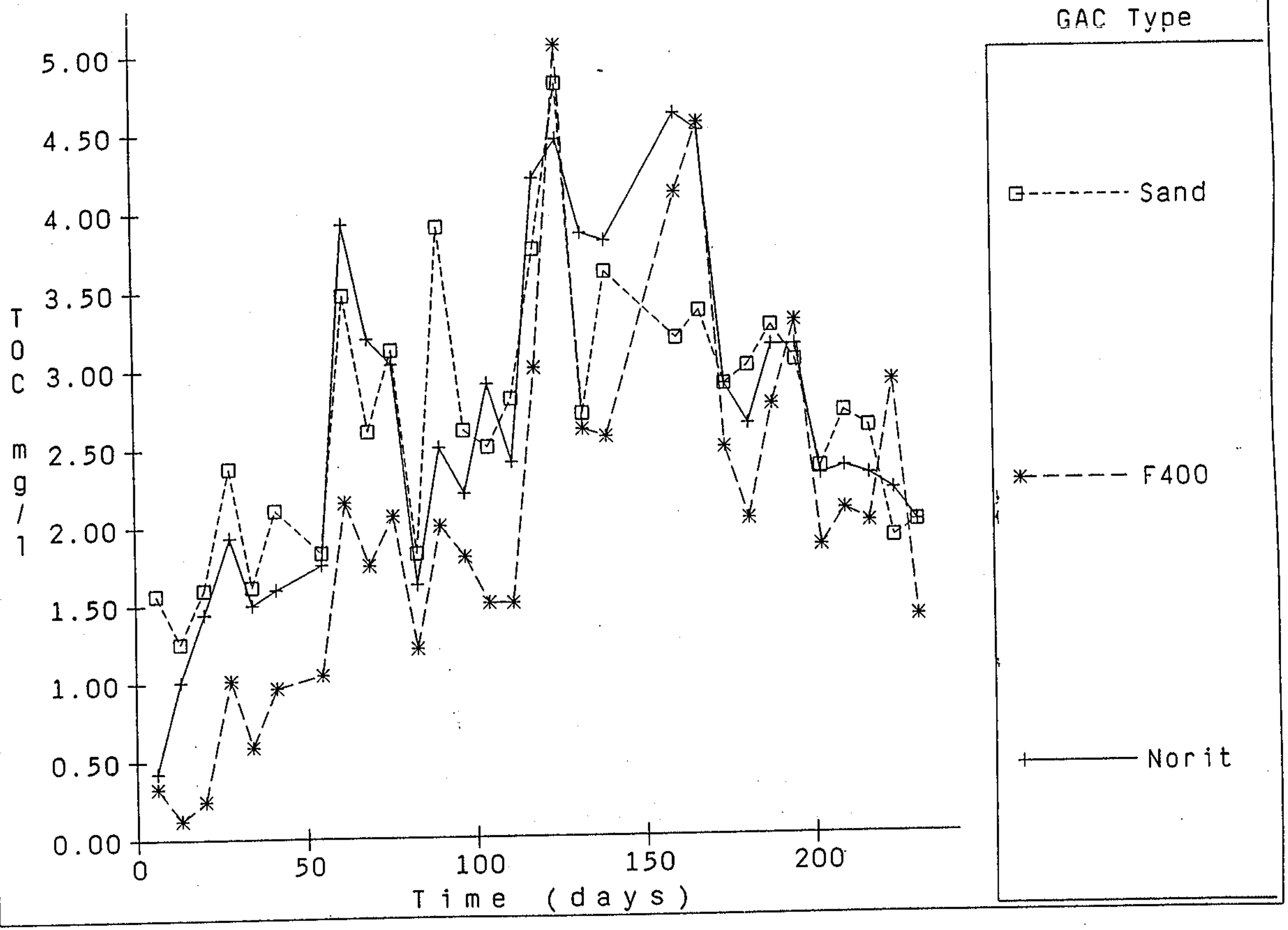


Fig 24. Comparison of Pica Biol and F400 (after Ozone) - TOC Breakthrough

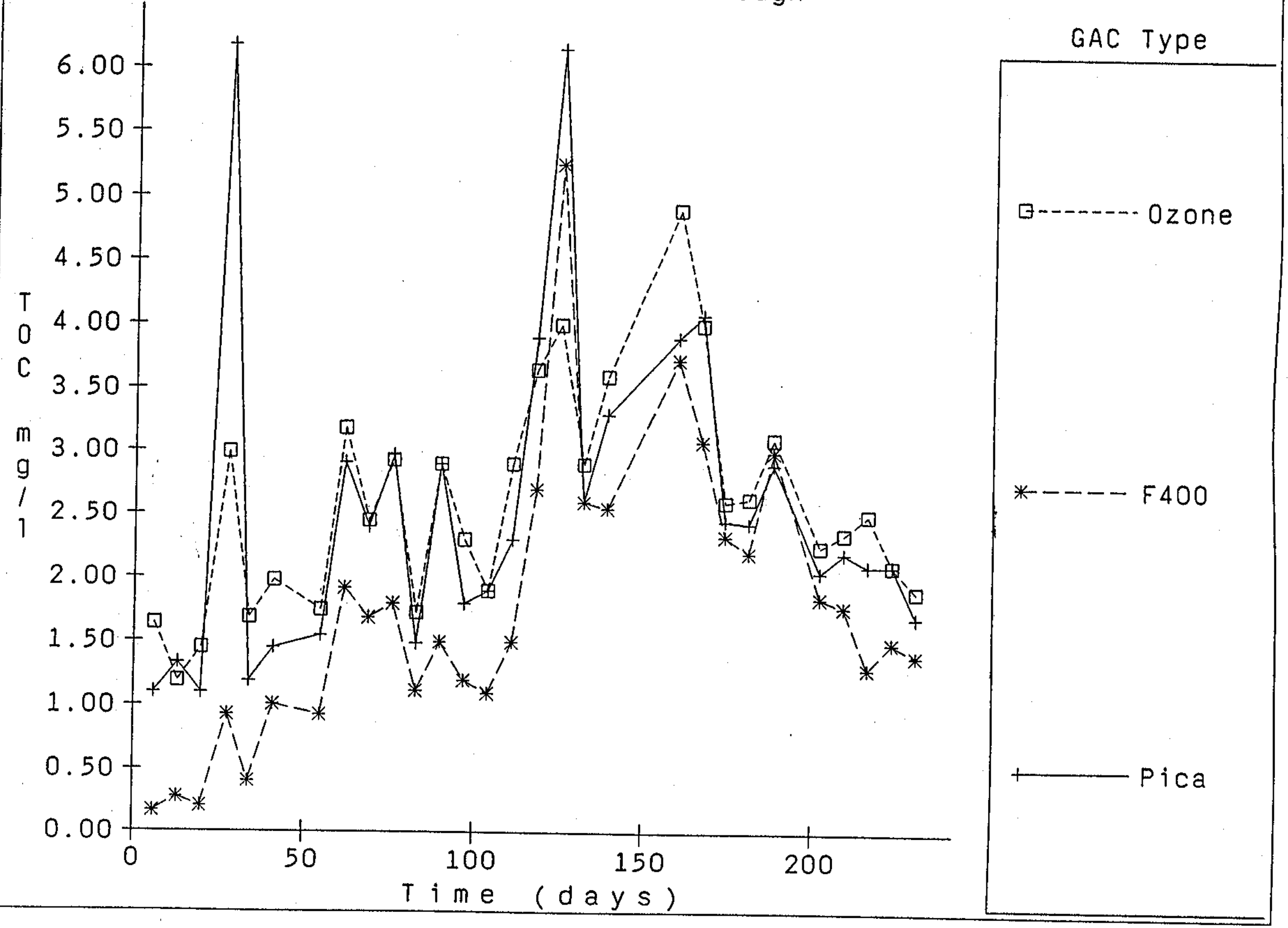
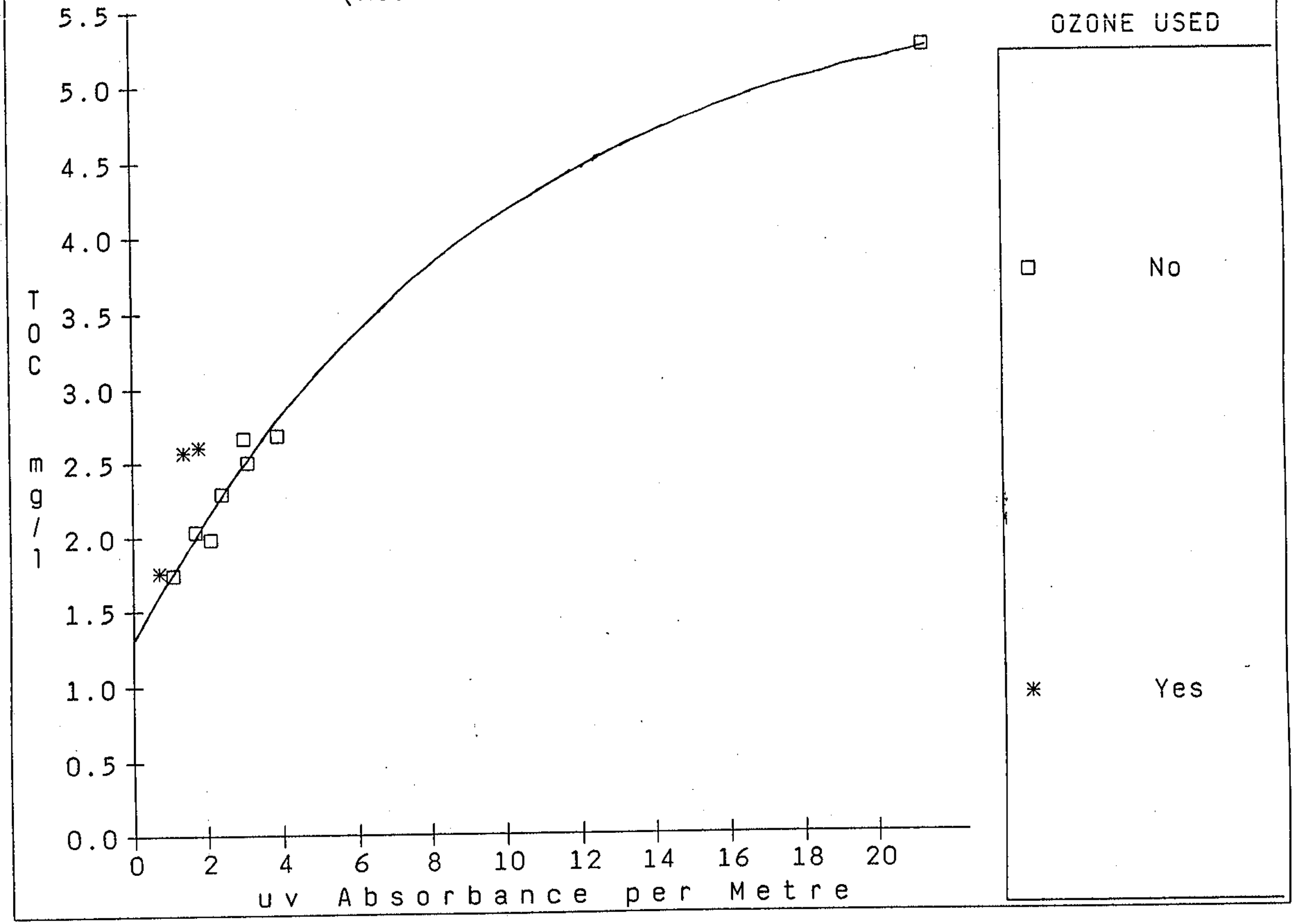


Fig 25. Correlation Between TOC and uv Absorbance
(Mean Values for each Sample Point)



3.6 DISINFECTION BY-PRODUCTS

3.6.1 Chlorine demand

Figure 26 shows chlorine demand at various stages of three stage treatment plotted against time. The raw water chlorine demand increased gradually during the Autumn Flush, but there was a large increase in raw water chlorine demand after about day 200. This is thought to have been caused by high ammonia in the raw water which is often present after the thawing of heavy snowfalls.

The plot for the 1° RGF filtered water does not to follow the same seasonal trend, but is consistent throughout the period of the trial, excepting the increase after day 200 as a result of the suspected high raw water ammonia concentration. The 2° RGF filtered water showed very little response to variations in raw water chlorine demand, since most of the chlorine demand was met by the chlorine dosed before the filter for manganese removal.

Figure 27 is a plot of chlorine demand satisfied by the 2° RGF (i.e. chlorine dosed for manganese removal less free residual after filter) against time for the sand 2° RGFs in streams A and B; stream A included a GAC 1°RGF whereas stream B included a sand 1°RGF. Stream B shows a weak seasonal trend and a very clear increase in chlorine demand due to the suspected increase in raw water ammonia. Initially the carbon reduced the chlorine demand but as the carbon became saturated the difference between the two streams reduced.

During the last four weeks of the trial, no chlorine was dosed to stream A's 2°RGF because of the investigation into manganese removal. Summary statistics of the data shown in figures 26 and 27 are given in Table 19.

Table 19 - Summary chlorine demand statistics, excluding last 4 weeks of trial, at different treatment stages

Treatment Stage	RAW	1° RGF		2°RGF/filter		2°RGF/lab	
	WATER	Str A GAC	Str B sand	Str A sand	Str B sand	Str A	Str B
Mean	1.05	0.30	0.46	0.40	0.54	0.06	0.12
Std. Dev.	0.15	0.12	0.07	0.10	0.07	0.09	0.05
No.Points	27	27	26	27	27	27	27
Maximum	1.29	0.56	0.59	0.57	0.72	0.43	0.27
Minimum	0.72	0.01	0.37	0.24	0.40	-0.02	0.03

Table 19 shows that the reduction in chlorine demand of the primary filtrate as a result of the carbon was reflected by the reduction in the chlorine demand for the subsequent sand filter. It also shows that the overall chlorine demand of 2° RGF water (i.e. the demand in the filter added to the demand in the laboratory) was much greater than the 1° RGF filtrate's chlorine demand. This agrees with the results presented in the phase 2 report (3), where it was suggested that the difference was attributable to a catalytic action of the sand surface in the 2° RGFs.

Table 20 shows summary statistics for chlorine demands of final waters (excluding the last four weeks of the trial), including all ozone and GAC post-treatments.

Table 20 - Summary chlorine demand statistics (all hand chlorinated final waters) showing the effects of carbon position and post treatment

	None	1°RGF F400	2°RGF F400	1°+2° F400	3° F400	1°+3° F400	3° NORIT	OZONE	OZONE +F400	OZONE +PICA
Mean	0.12	0.06	0.20	0.15	0.19	0.15	0.17	0.13	0.12	0.17
Std. Dev.	0.05	0.09	0.06	0.06	0.09	0.09	0.08	0.06	0.07	0.05
No.Points	27	27	27	27	27	27	27	26	26	26
Maximum	0.27	0.43	0.34	0.30	0.36	0.32	0.36	0.24	0.22	0.27
Minimum	0.03	-0.02	0.07	-0.02	-0.03	-0.03	0.07	-0.03	-0.05	0.06

Fig 26. Chlorine Demand at Various Stages of 3 Stage Treatment
(Both Filters Contain Sand)

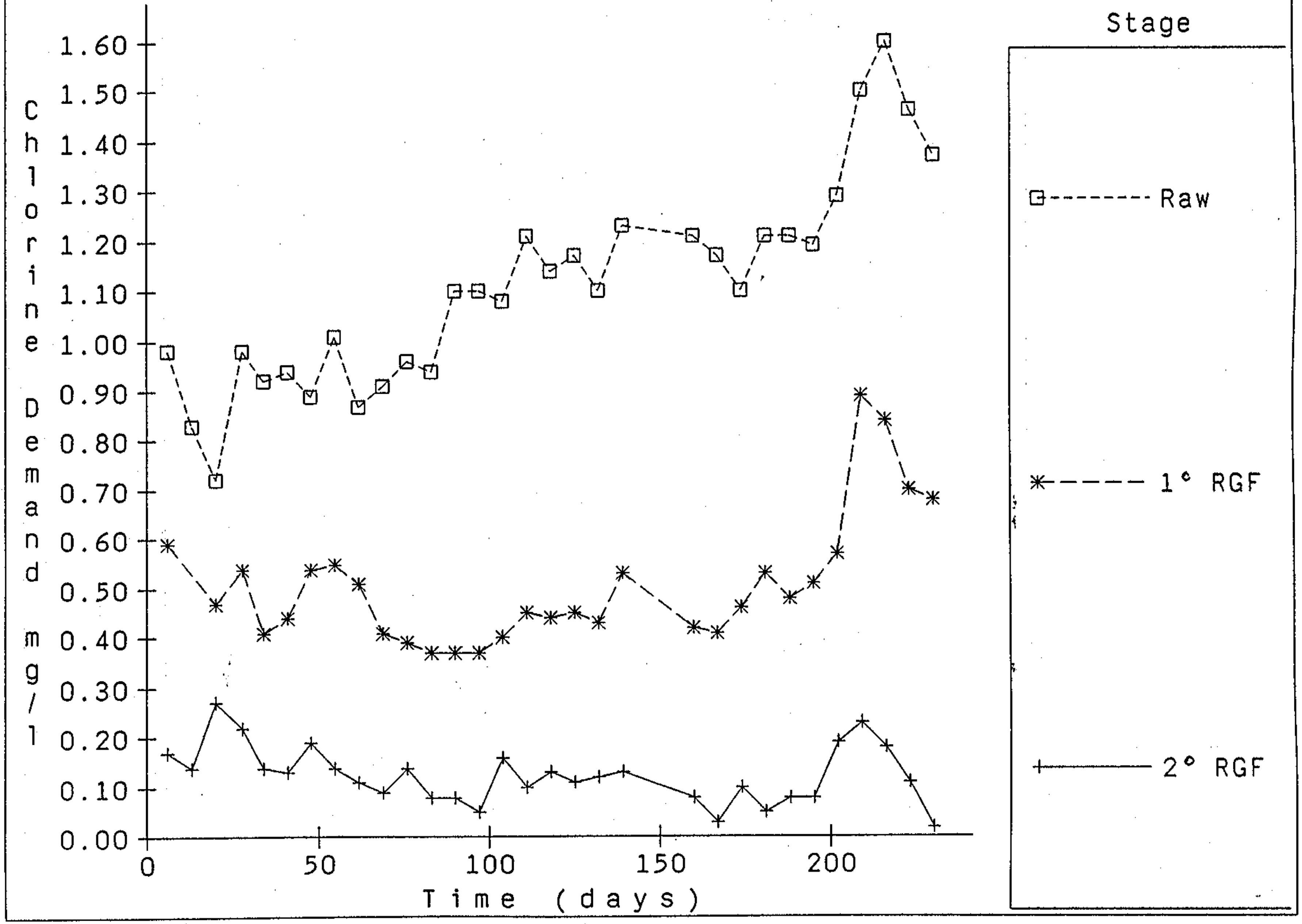
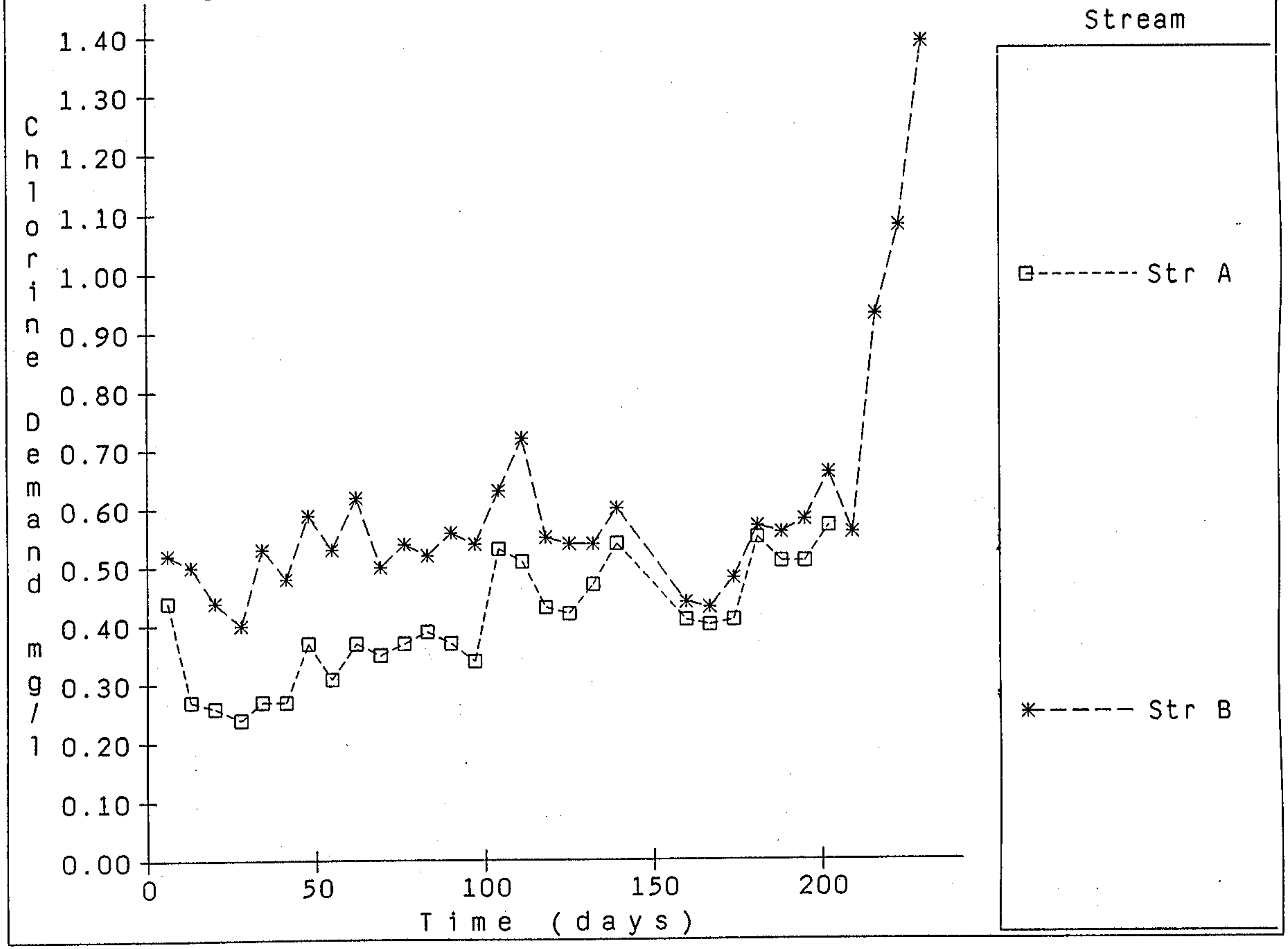


Fig 27. Chlorine Consumed During 2° (Sand) Filtration



None of the post adsorbers nor ozonation had a great effect on final chlorine demand when compared to the final, sand filtered, water but the demand was generally low. The chlorine demand after 2° sand filtration was less than that after 2° GAC filtration which suggests that chlorine demand was better satisfied in a sand filter than in a carbon filter, due to the removal of chlorine by the carbon.

3.6.2 Trihalomethanes

(a) Hand chlorination and THM development

Throughout the three phases of the experimental work, the 30 minute hand chlorination method was always used to produce THMs. The method is based on the WHO recommendations for disinfection (5), whereby chlorine is dosed to give a free residual concentration, c (mg/l), after time ,t (minutes), of disinfection such that the product c*t = 15. Thus for 30 minutes disinfection time, a free residual of 0.5 mg/l is required. The advantages of using the 30 minutes hand chlorination method in the laboratory are that the conditions are fixed, and it is reproducible, so that different waters can be compared. It is also quick, and easy to carry out. However, under operational conditions disinfection contact times range from 30 minutes to several hours, and a free chlorine residual is usually maintained up to the consumer's tap. The total available contact time for THM generation could, therefore, be up to 7 days and the levels of THMs would be greater than those produced after only 30 minutes. Experiments were, therefore, undertaken to determine the relationship between THMs produced by the 30 minute hand chlorination procedure, and THMs produced under extended contact times.

(i) Development of THMs without excess free residual

In these experiments, samples of water were taken from different points in the treatment stream and were hand chlorinated to give a free residual of 0.5 mg/l after 30 minutes. The formation of THMs and the decay of the free chlorine in these samples was then monitored over an extended period (the results are tabulated in Tables A24 to A28, Appendix A).

Figure 28 shows a plot of free residual against time for raw and treated water samples. This plot shows that the free residual in the raw water decayed more rapidly (reaching 0 in about 5 hours) than the treated water sample (reaching 0 in about 10 hours).

Figure 29 shows a plot of total THMs against time for the raw water and the treated water samples. The figure shows that as long as there was a free residual, THMs continued to form, but that once the free residual had decayed, THM formation ceased. There was also a significant increase in bromonated THMs over the development time (Tables A24 to A27, Appendix A).

Two samples were booster chlorinated to restore the residual to 0.5 mg/l and they show very little increase in total THMs, possibly because the booster dose was only given 30 minutes before the sample for THMs was taken.

Figure 30 shows a plot of total THMs against chlorine demand for raw and treated water samples 2. This figure shows a linear relationship between chlorine demand and total THMs formed. However, the relationship for the two samples is not the same.

(ii) **THM development with excess chlorine**

In this experiment, samples of final water were taken and given large enough chlorine doses to leave a free residual after the specified extended contact time. This method of assessment of thm potential was intended to model the situation where enough chlorine is dosed at the works to leave a free residual at the consumers tap (results are tabulated in Table A28, Appendix A).

Figure 31 is a plot of THM formation against contact time where there was a free chlorine residual throughout. The results for two samples are shown, both have been treated by DAF and two stage sand treatment, with one subject to post-treatment by ozone and F400. The figure shows that over the first 20 hours the total THMs increased in both samples, reaching a peak after about 50 to 70 hours (i.e. 2 to 3 days), followed by a decrease. It should also be noted that although the 30 minute THMs were less than the peak value, the higher 30 minute THMs produced the higher peak THMs.

The results were obtained on the 21 Jan 1991, and the peak total THM concentrations coincided with the development of brominated THMs. Brominated THMs accounted for 26% of the total in the sand treated water, and 47% in the ozone/F400 treated water; by comparison 30 minute THMs were <4% brominated in the sand treated and <7% brominated in the ozone/F400 treated waters.

Figure 32 shows the values for THMs developed after 16 to 24 hours plotted against 30 minute THMs, and figure 33 shows the same plot with expanded scales (i.e. excluding the raw water sample). From these figures it can be seen that there is a good positive correlation between long term (16 to 24 hours)THMs and 30 minute THMs. The relationship is not the same for each data set, although the gradients of three of the data sets in figure 33 appear to be very similar.

For any set of samples hand chlorinated at the same time, there is a relationship between THMs formed after 30

Fig 28. Free Chlorine Decay
Laboratory Chlorinated Samples

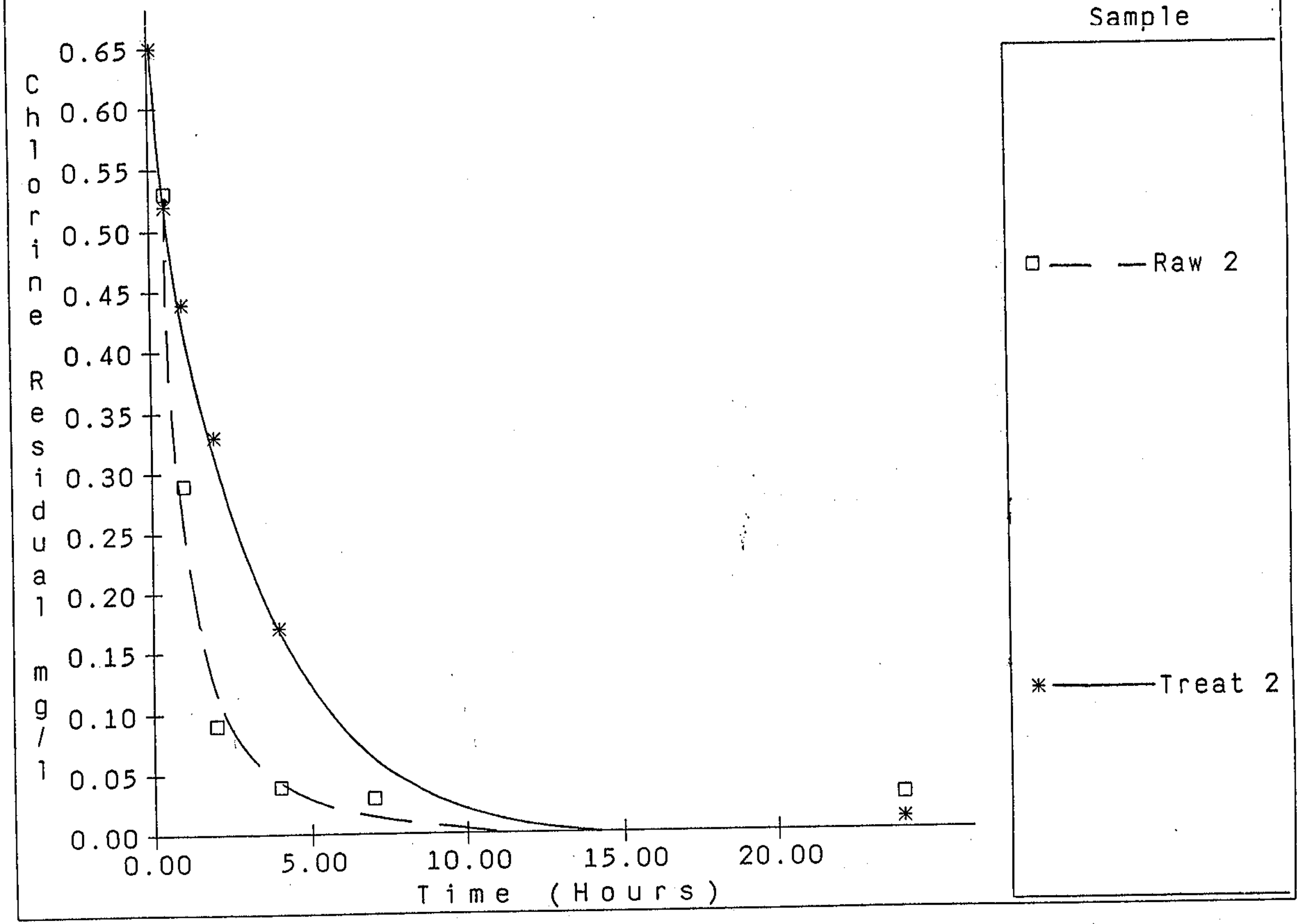


Fig 29. Total THM Development (Without Excess Chlorine)

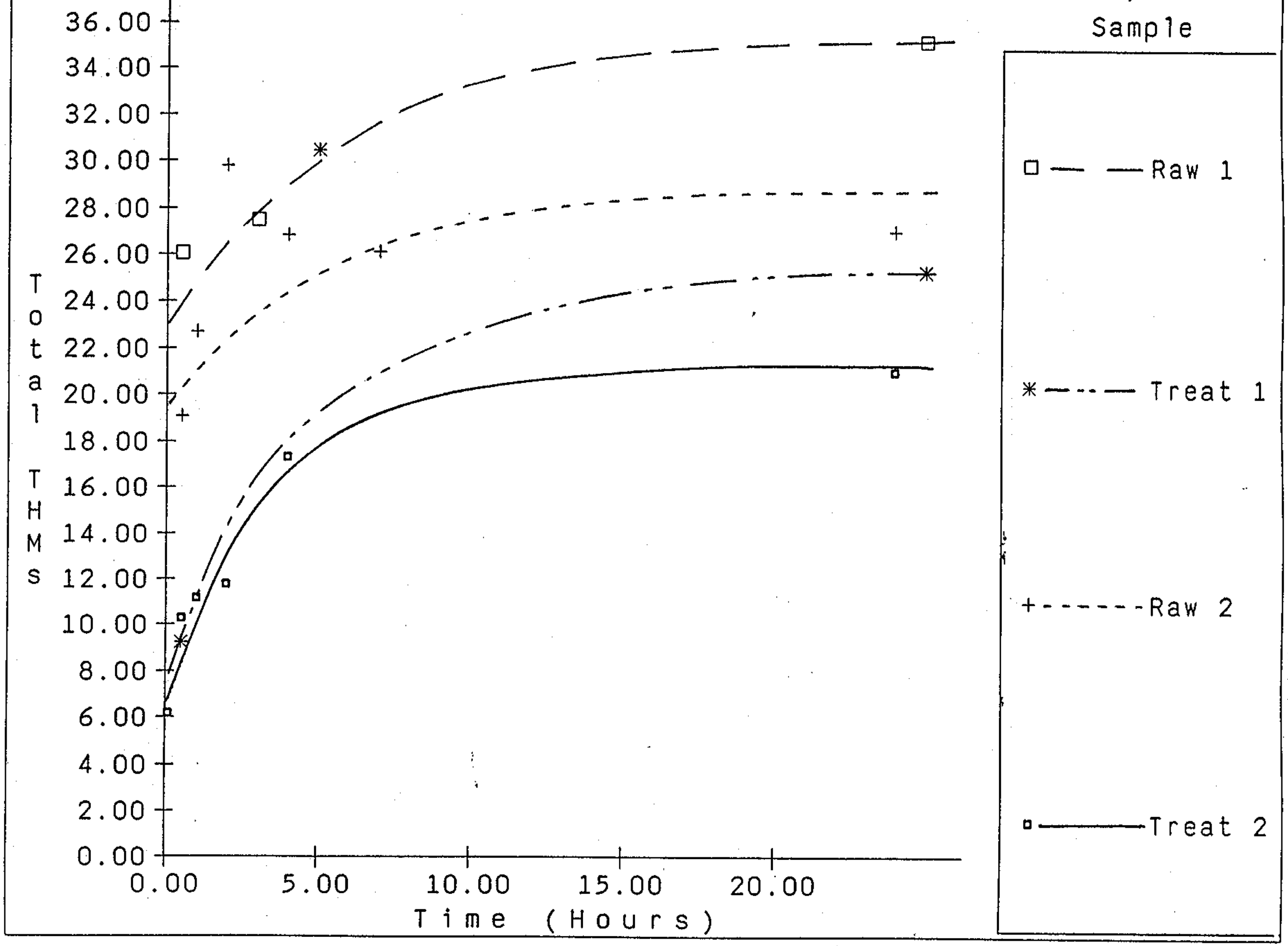
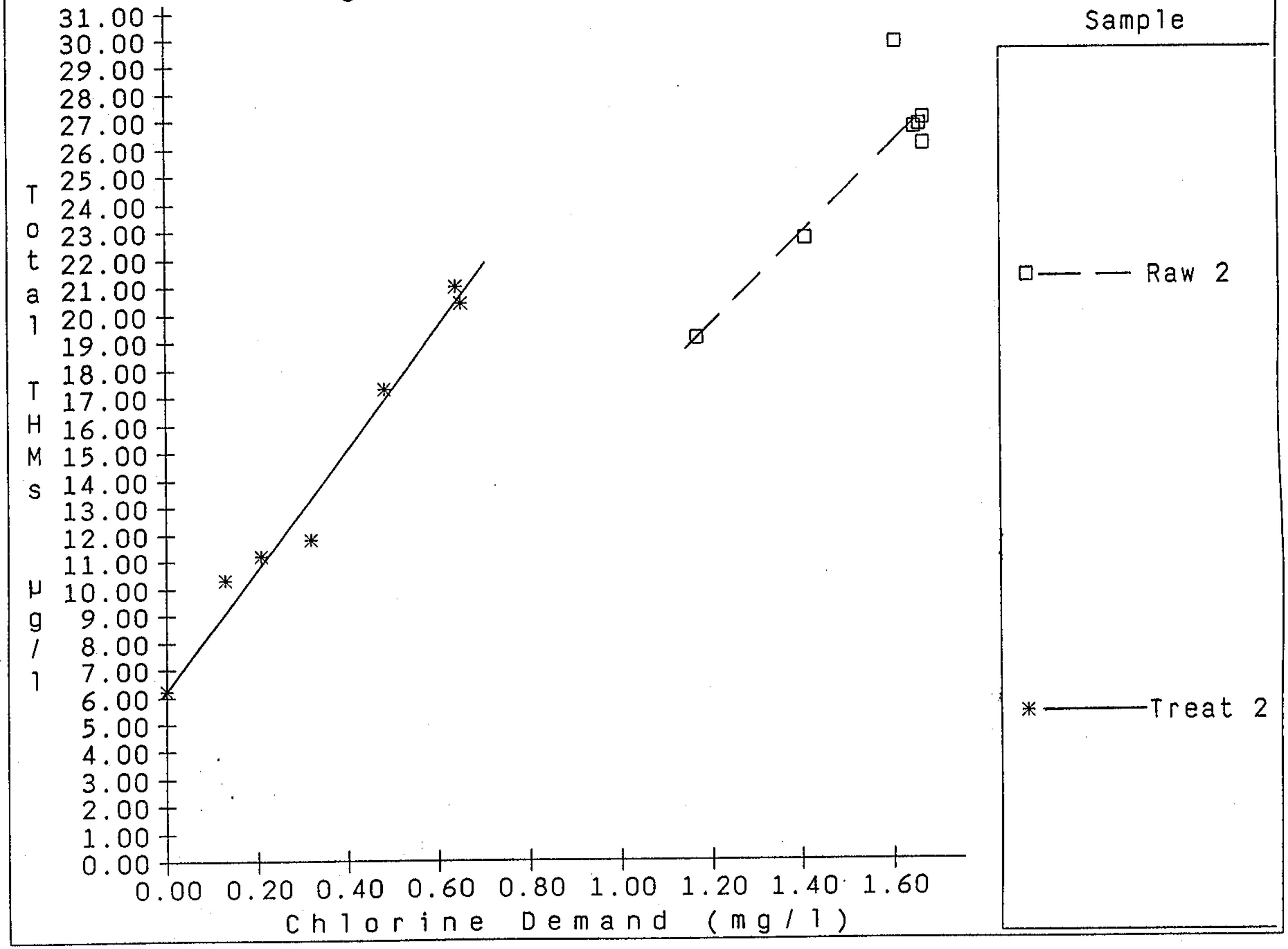


Fig 30. Total THMs vs. Chlorine Demand



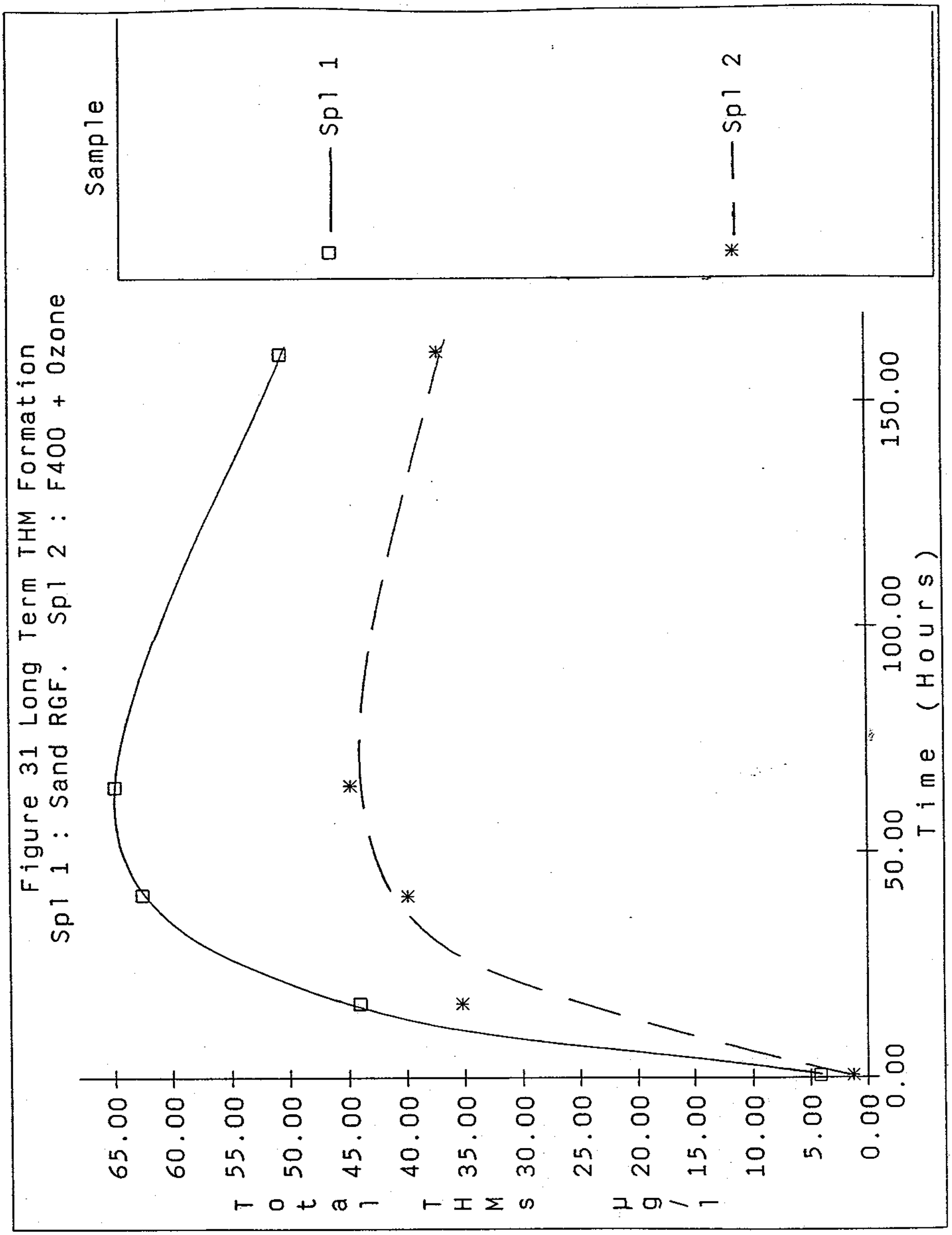


Figure 31 Long Term THM Formation
Spl 1 : Sand RGF. Spl 2 : F400 + Ozone

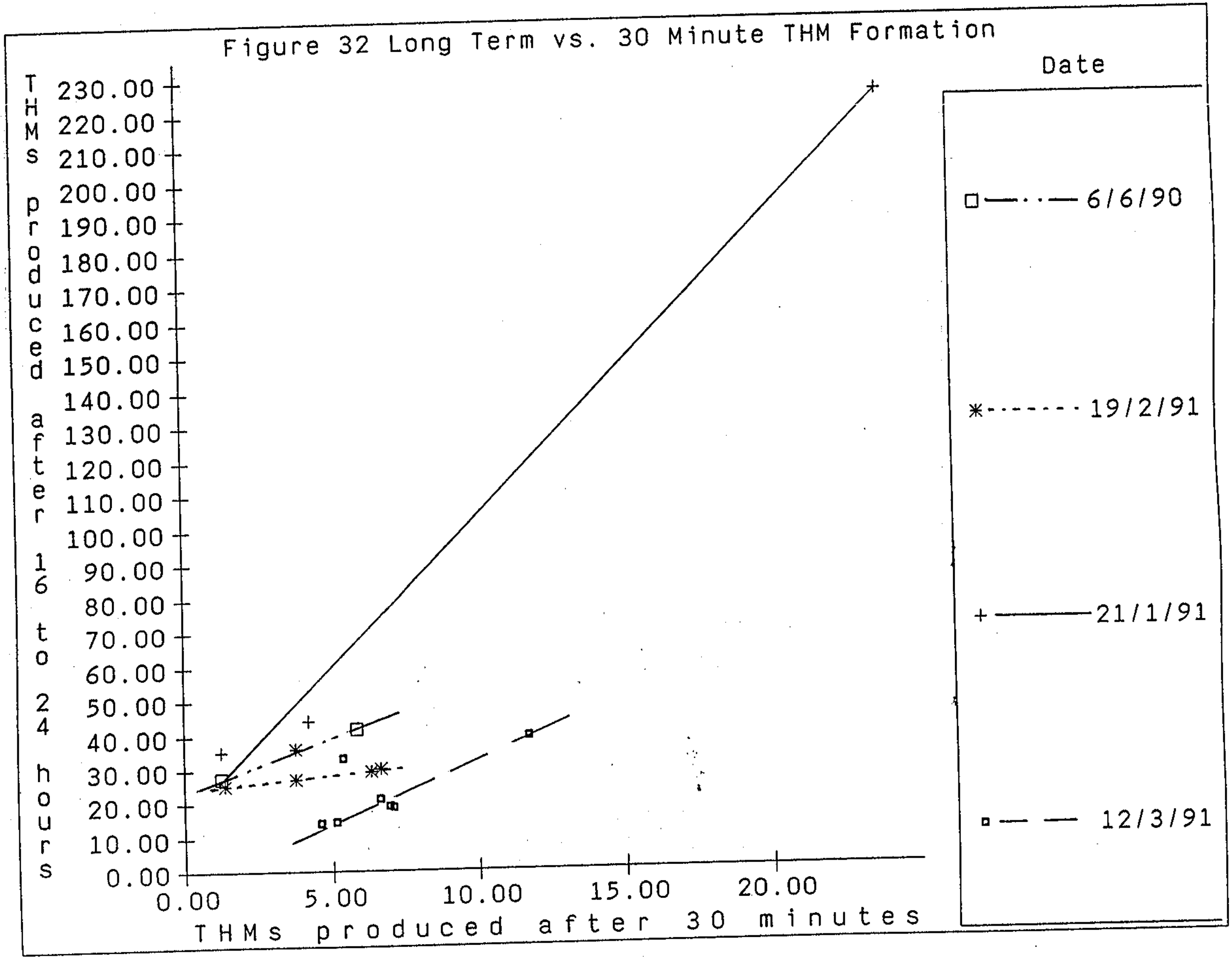
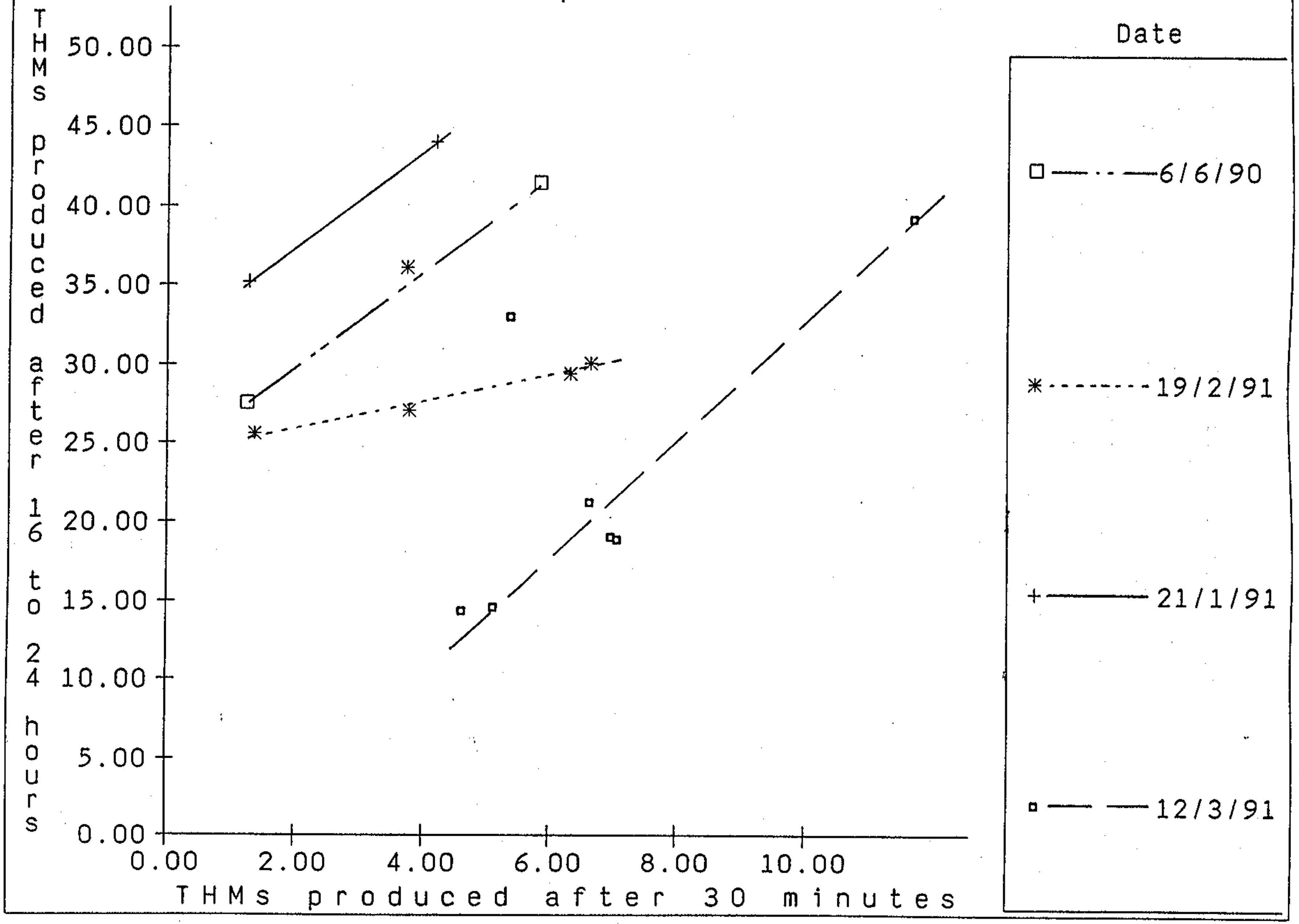


Figure 32 Long Term vs. 30 Minute THM Formation
THMs produced after 16 to 24 hours
230.00
220.00
210.00
200.00
190.00
180.00
170.00
160.00
150.00
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0.00
5.00
10.00
15.00
20.00
THMs produced after 30 minutes
Date
6/6/90
19/2/91
21/1/91
12/3/91

Figure 33 Long Term vs. 30 Minute THM Formation
Expanded Scales



minutes and THMs formed after extended periods of time but there is no simple way of establishing maximum potential THM concentrations from the 30 minute hand chlorination results. An alternative treatment process that reduces the level of THMs produced after 30 minutes should also reduce THMs produced after extended periods of chlorination.

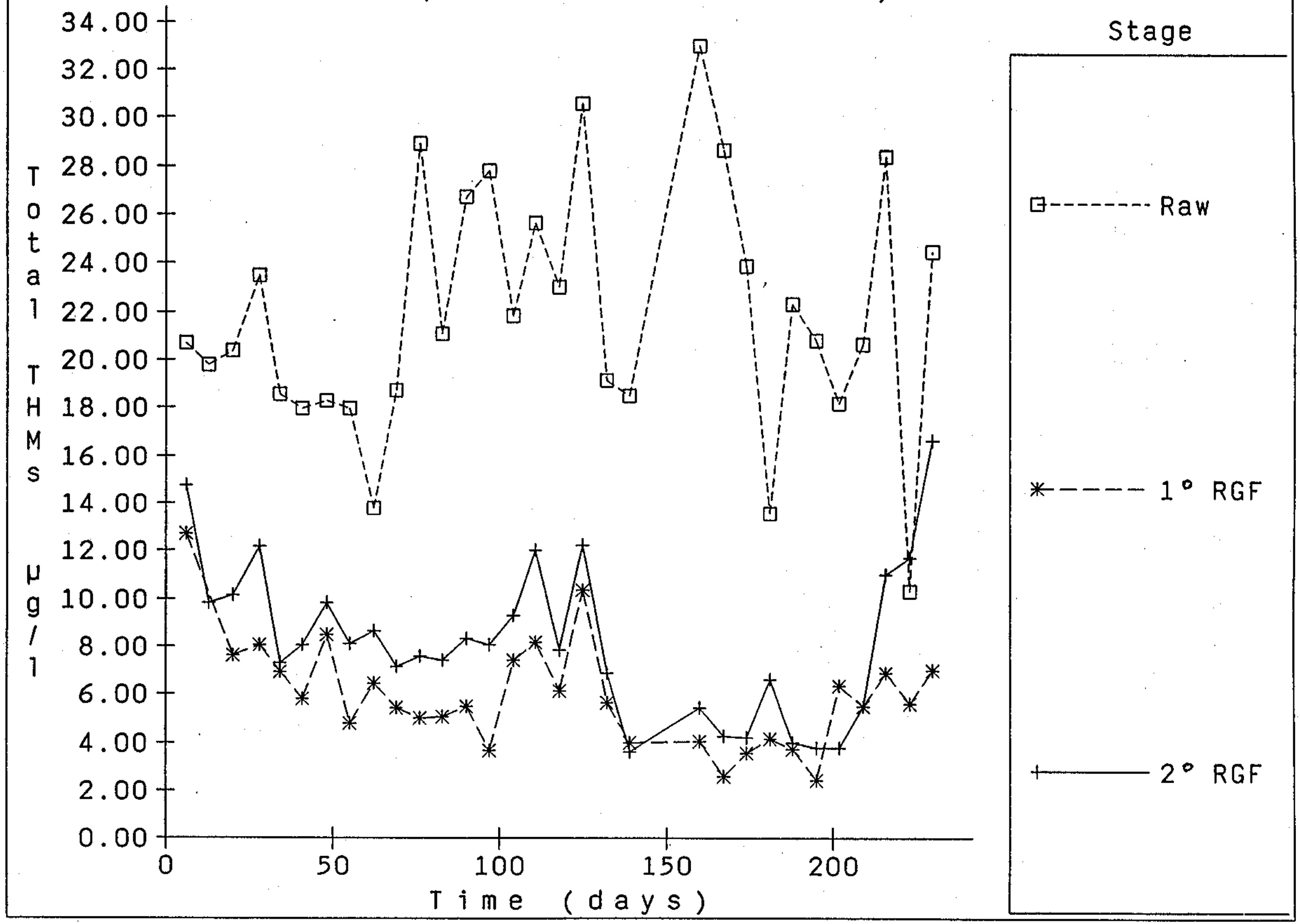
(b) **Effect of 3 stage treatment**

Figure 34 shows total THMs formed during hand chlorination in samples of water taken at various stages of three stage treatment plotted against time. There appears to be a weak trend in raw water total THM precursors, similar to the trend seen with uv absorbance. However, the total THM precursors in the sand filtered waters appear to follow a totally different trend, decreasing during the Autumn Flush, and starting to increase again as uv absorbance started to decrease. This may have been caused by temperature variations (since THM formation is slower at lower temperatures), or by the higher coagulant doses employed during the Autumn Flush. As was observed during the previous two phases (2,3), the THMs formed during passage through the 2° RGF and subsequent hand chlorination of the filtrate were consistently greater than those formed during hand chlorination of the 1° RGF filtrate (Table 21).

Table 21 - Summary total THM (30 minutes) statistics for treatment stage

Treatment Stage	RAW WATER	1° RGF	2° RGF
Mean	21.83	5.96	8.26
Std. Dev.	5.16	2.23	3.29
No. Points	31	30	31
Maximum	32.99	2.73	16.65
Minimum	10.33	2.41	3.61

Fig 34. Total THMs at Various Stages of 3 Stage Treatment (Both Filters Contain Sand)



(c) **Location of GAC**

Figure 35 shows THM precursors after treatment by carbon at different treatment stages plotted against time. For the first 104 days, there was little scatter in the data, and it is clear that increasing the EBCT resulted in more THM precursors being removed for a longer period of time. From day 111 to day 139, there is much more scatter, although the trend is consistent.

Figure 36 shows computer model predictions for THM precursor breakthrough with EBCTs of 3.75 minutes (2° RGF), and 10 minutes (1°+ 2° RGF or Post), as well as the experimental points. The model's constants (equilibrium and kinetic) were selected by reiterative calculation to give the best visual fit to the 2° GAC RGF data. These were then used to predict performance of the carbon in all positions based on the THM precursors measured in 1° sand RGF. From the figure, it can be seen that all three sets of experimental data are modelled fairly well.

Figure 37 shows the model predictions for EBCTs of 6.3 minutes (1° RGF) and 16.3 minutes (1° RGF + Post), using the same feed and model constants as in figure 31. It can be seen that the model also predicts these data reasonable well.

Since the same model constants were capable of accurately predicting breakthrough profiles for all the experimental data, this shows that the carbon position was not an important factor in carbon performance, but that EBCT was.

Table 22 gives summary statistics for the effect of carbon position on total THM precursors. The table shows that hand chlorinated filtrates from both sand 2° RGFs contained more THMs than their corresponding 1° RGF. This is the result of THM formation within the sand 2° RGF as a result of the chlorine dosed for manganese removal.

Table 22 - Summary total THM (30 minutes) statistics for effect of carbon position

	Primary Filtrates		Final Filtrates.					
	F400	SAND	1° RGF F400	1°+2° RGF F400	2° RGF F400	2° RGF sand	1°RGF + 3° F400	3° F400
Mean	3.29	5.96	4.38	3.31	5.57	8.26	1.83	3.06
Std.Dev	2.38	2.23	2.65	2.80	2.60	3.29	2.09	2.98
No.Points	31	30	31	30	31	31	31	31
Maximum	9.29	12.73	10.61	9.76	10.57	16.65	6.68	10.20
Minimum	0.22	2.41	0.22	0.22	0.51	3.61	0.18	0.22

The post adsorber (3°) and two stage (1°+2° RGF) carbon produced similar total THM precursors, although the two stage carbon, on average, removed slightly less THM precursors than the post adsorber, probably as a result of carbon loss towards the end of the trial.

Fig 35. Effect of Empty Bed Contact Time
- Total THM Precursors Breakthrough

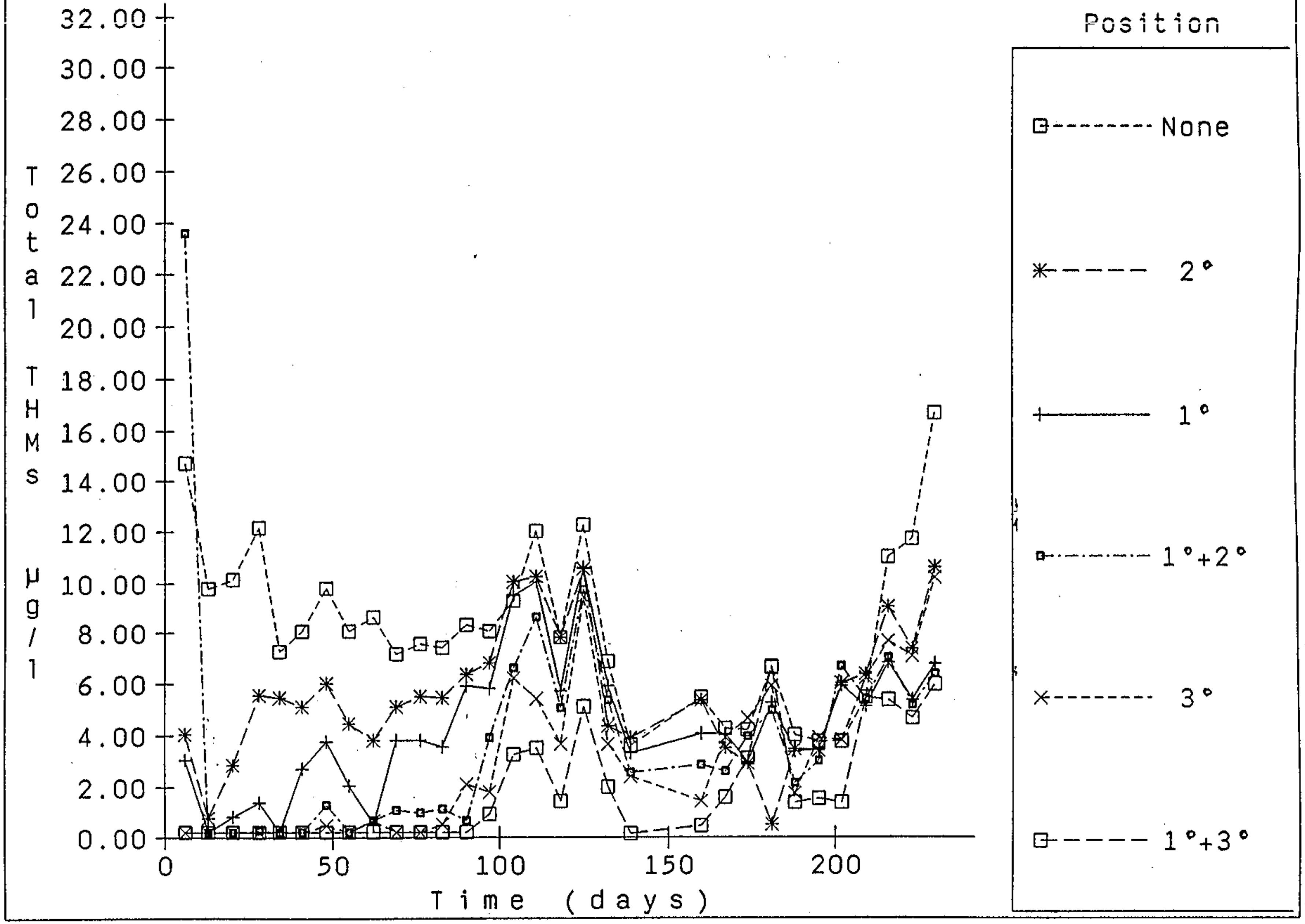


Fig 36. Model Prediction of Total THMs Precursors Breakthrough Compared to Actual Breakthrough (Dataset One)

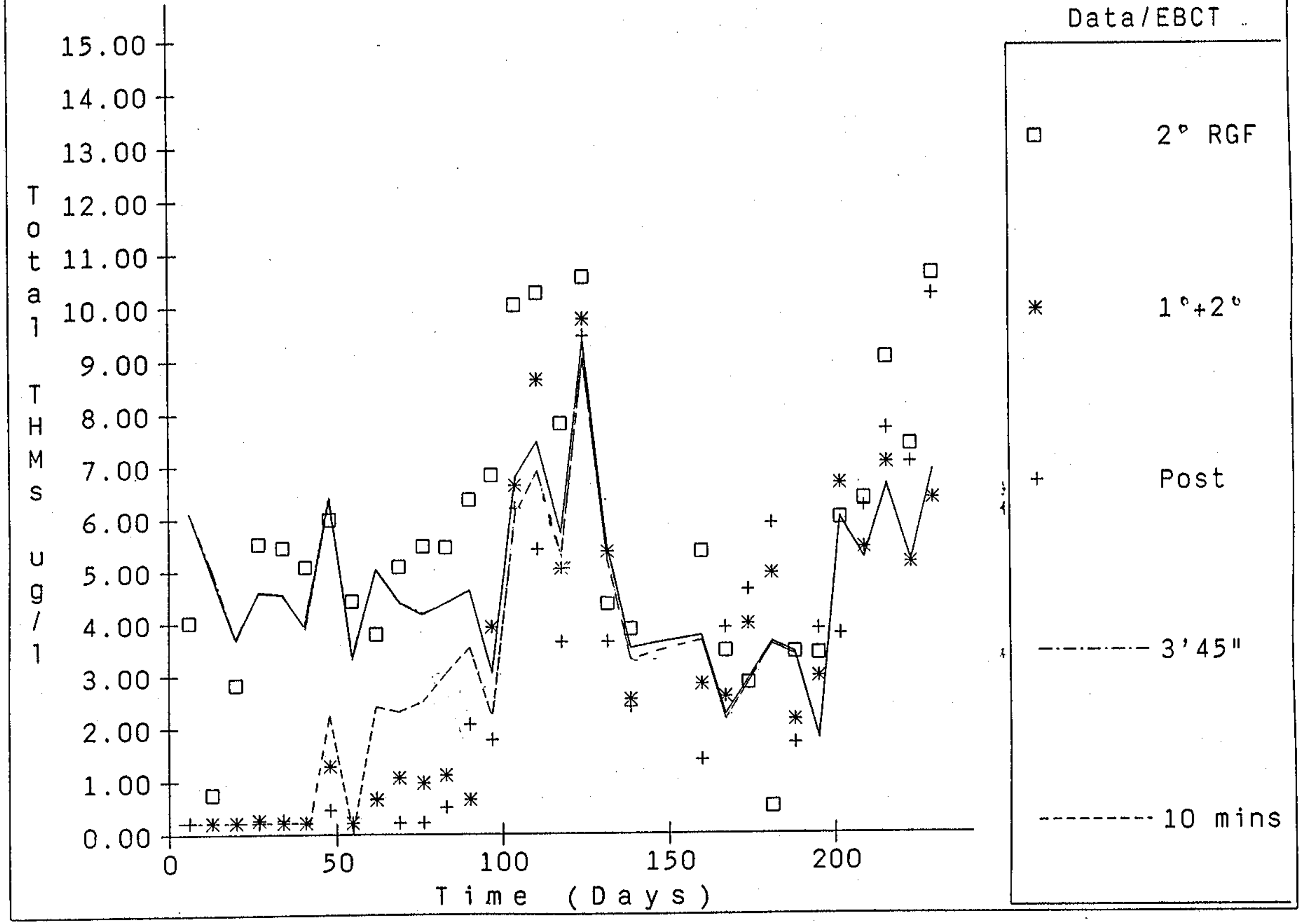
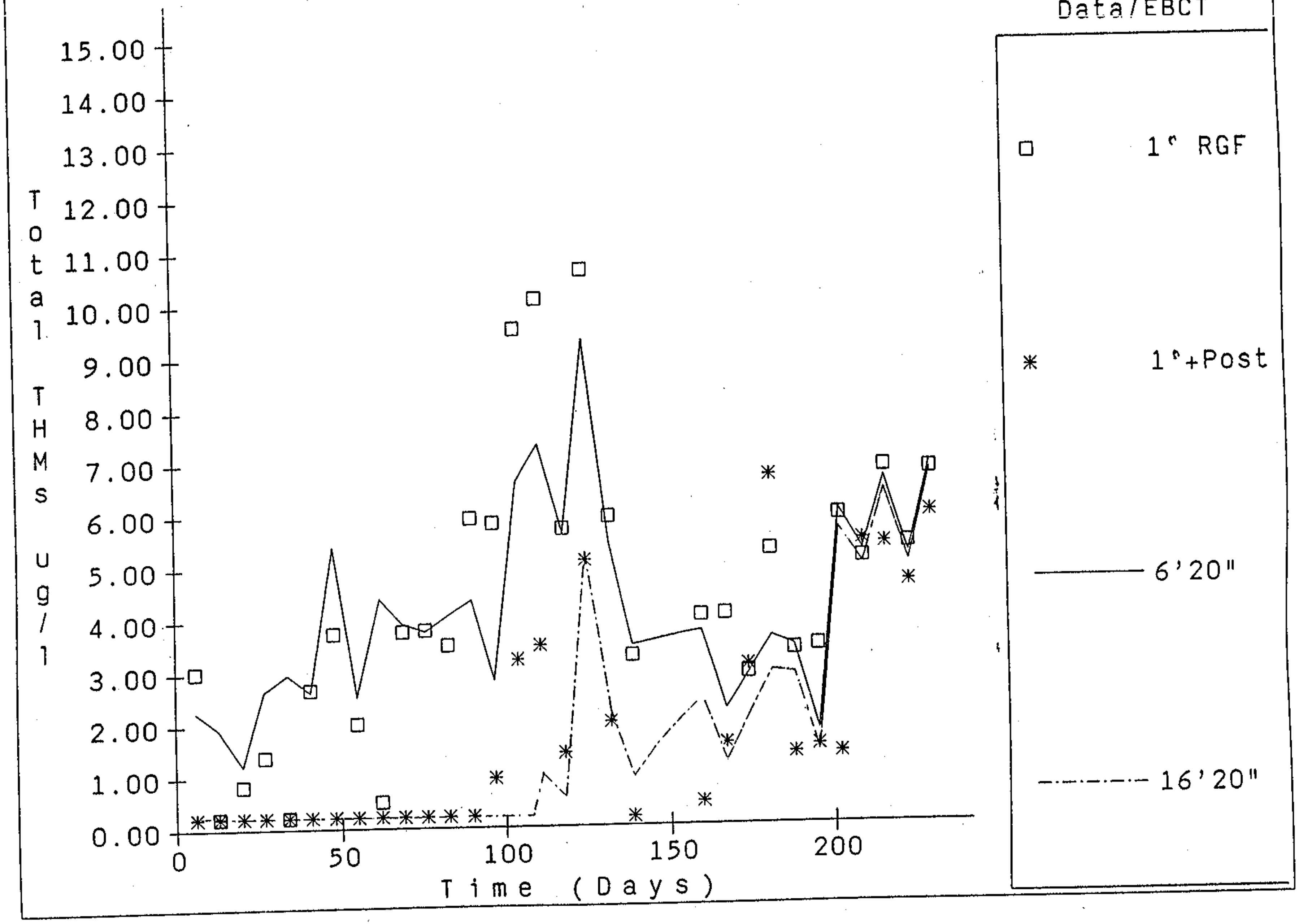


Fig 37. Model Prediction of Total THMs Precursors Breakthrough Compared to Actual Breakthrough (Dataset Two)



(d) **Carbon type and ozone**

Figure 38 shows a comparison of F400 and Norit PK for THM precursor reduction. The figure clearly shows that F400 removed more THM precursors than Norit PK.

Table 23 gives summary statistics for the effect of post treatment on total THM precursors. The table shows that THM precursors were reduced 31% by ozonation, 63% by F400, and 75% by combined ozonation and F400.

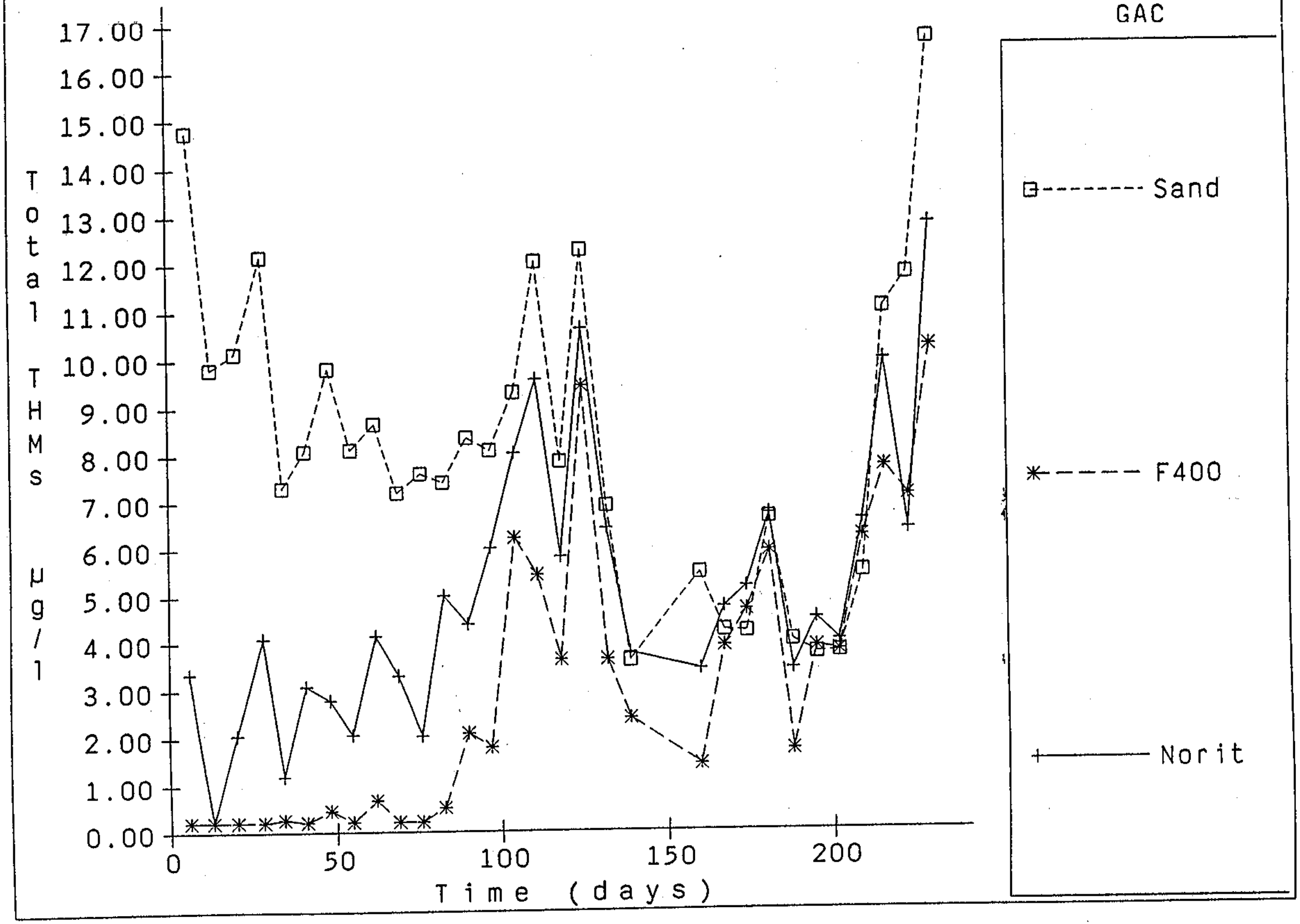
Table 23 - Summary THM (30 minutes) statistics for post treated waters

	control	Post Treatment				
	SAND 2° RGF	NORIT PK	F400	OZONE	OZONE + PICA	OZONE + F400
Mean	8.26	5.01	3.06	5.72	4.98	2.04
Std. Dev.	3.29	2.85	2.98	2.99	2.52	2.36
No.Points	31	31	31	30	30	30
Maximum	16.65	12.77	10.20	10.97	10.01	8.71
Minimum	3.61	<0.22	<0.22	0.37	0.36	<0.22

Ozone and Pica Biol only reduced total THM precursors by 40%, which was little improvement on ozone alone. Figure 39 compares F400 and Pica Biol treating ozonated water and clearly shows that F400 performed better than Pica Biol.

Comparing the two carbon 2° RGFs with their respective 1° RGFs, it can be seen that there is far less difference in total THMs (an increase of 0.02 µg/l for the carbon 1° RGF, and a decrease of only 0.39 µg/l for the sand 1° RGF) than would be expected (a reduction of from 1 to 2 µg/l would be expected taking the two 1° RGFs as guides). It would, therefore, appear that there is some formation of THMs within the carbon 2° RGFs, as a result of

Fig 38. Comparison of Norit PK and F400
- Total THM Precursors Breakthrough



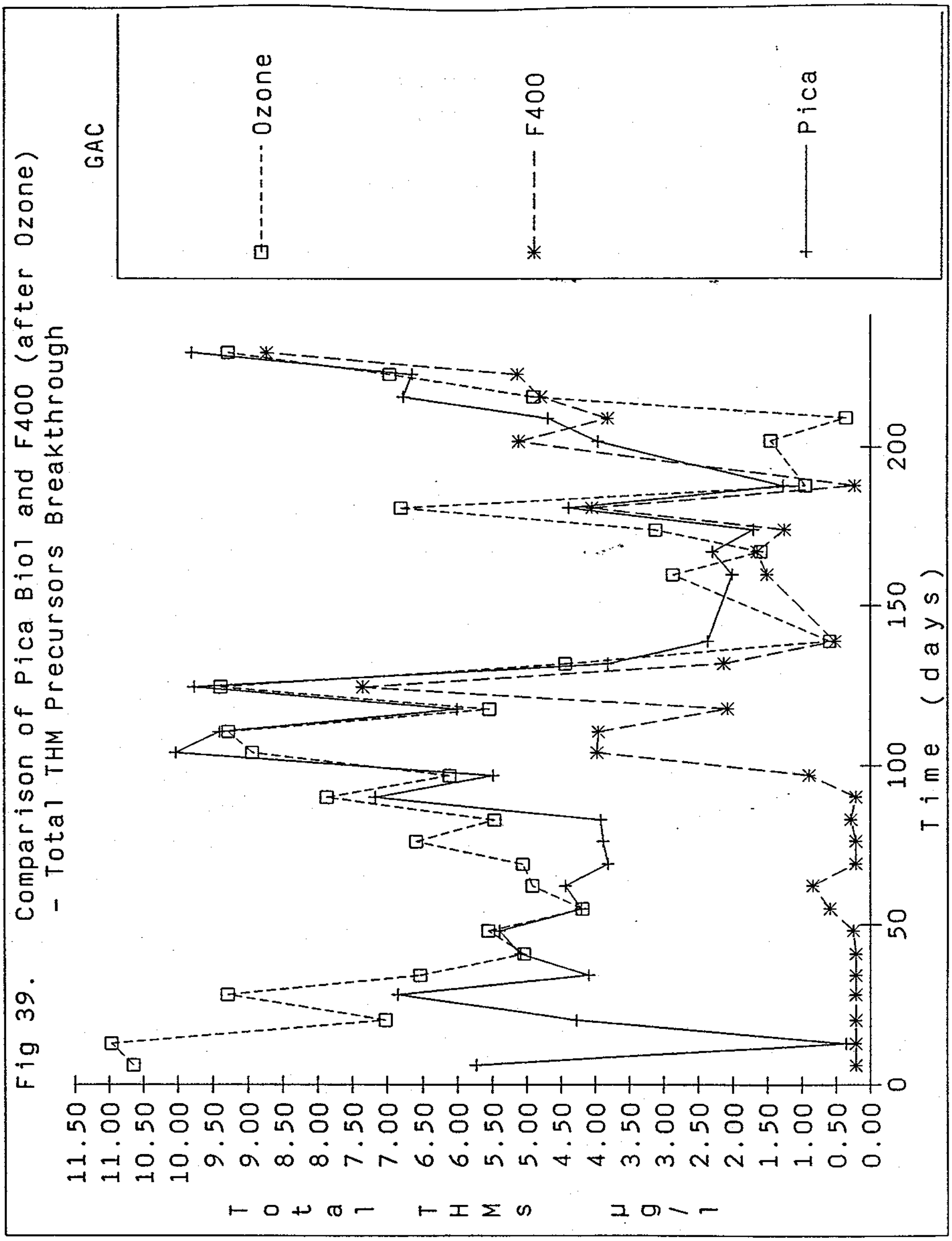


Fig 39. Comparison of Pica Biol and F400 (after Ozone) - Total THM Precursors Breakthrough

chlorine dosed for manganese oxidation, despite the absence of a free chlorine residual in the filtrates.

THMs formed within the treatment stream as a result of chlorination were removed by F400 in the 3° adsorber. However the capacity for such THMs was low and when, at the end of the trial, chlorine dosing to the 2° RGF was stopped for four weeks, THMs at low concentrations (2-6 µg/l) desorbed from the carbon. None of the other post adsorbers, or ozonation, removed THMs from the 2° RGF filtrate.

3.6.3 Adsorbable Organic Halide

(a) Effect of 3 stage treatment

Figure 40 shows AOX, resulting from chlorination, at various stages of three stage treatment plotted against time. The figure shows that AOX precursors in the raw water increased from days 60 to 90 as a result of the Autumn Flush, and then gradually decreased. The high raw water AOX on day 216 coincides with high raw water chlorine demand, which has been assumed to be the result of high raw water ammonia. The AOX precursors after each stage of sand filtration were fairly constant throughout the duration of the trial, as a result of effective coagulation dose control. The difference between the 1° and 2° RGFs was less than that seen with THMs, which supports observations made during phase 2 (3) that AOX formation is less sensitive to chlorine dose than is THM formation. Table 24 presents summary statistics of the data plotted in figure 40.

Table 24 - Summary AOX statistics at different treatment stages

Treatment Stage	RAW WATER	1° RGF	2° RGF
Mean	74.4	30.0	33.1
Std. Dev.	15.4	6.9	13.3
No. Points	16	16	16
Maximum	107.9	50.7	74.9
Minimum	50.5	18.3	8.0

(b) **Location of GAC**

Figure 41 shows AOX after carbon at different places in the treatment process plotted against time.

The same trend can be seen in figure 41 as was seen for THMs, with increasing EBCT resulting in more AOX precursors being removed for a longer period of time. A comparison of figure 41 and figure 34 shows that AOX precursor breakthroughs started at about the same time as THM precursor breakthroughs. Summary statistics for the points plotted in figure 41, as well as for the primary RGFs, are given in Table 25. The similar values obtained in the hand chlorinated 1° and 2° sand RGF filtrates indicates that the chlorine dosed for manganese oxidation made no statistical difference to AOX (at 95% confidence level).

Table 25 - Summary AOX statistics for effect of carbon position

	Primary Filtrates		Final Filtrates					
			1° RGF	1°+2° RGF	2° RGF	2° RGF	1°RGF + 3°	3°
	F400	SAND	F400	F400	F400	sand	F400	F400
Mean	19.9	30.0	20.4	17.5	23.9	33.1	11.8	19.9
Std.Dev	10.1	6.9	7.3	7.3	8.9	13.3	5.3	12.8
No.Points	15	16	16	16	16	16	16	16
Maximum	44.5	50.7	30.7	28.6	36.2	74.9	24.8	59.1
Minimum	8.0	18.3	8.0	8.0	8.0	8.0	8.0	8.0

(c) **Carbon type and ozone**

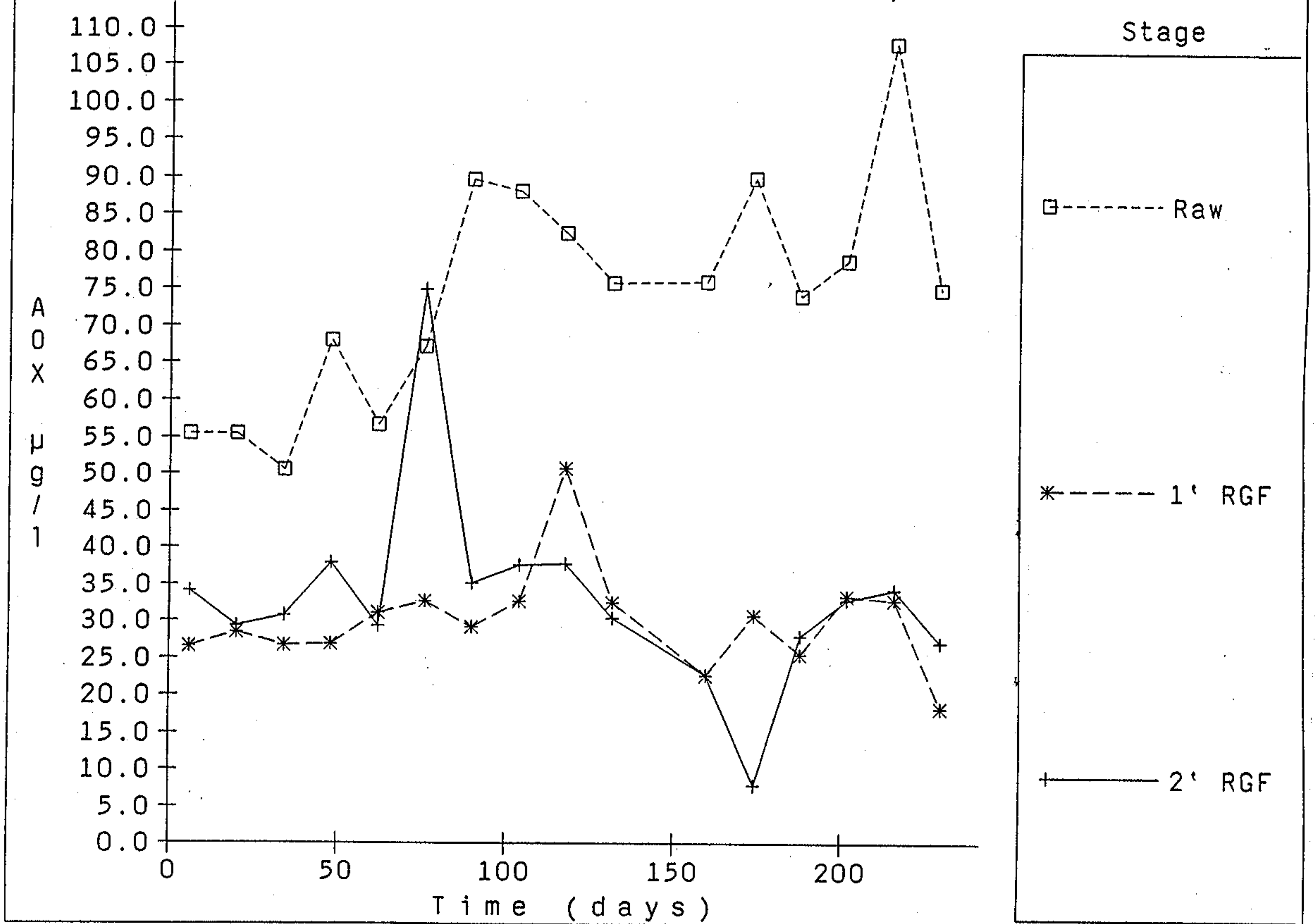
Figure 42 shows a comparison of F400 and Norit PK for AOX precursor removal; F400 removed more AOX precursor for longer than Norit PK.

Figure 43 shows a comparison of F400 and Pica Biol, both after ozonation, for AOX precursor removal. Ozonation alone greatly reduced AOX precursor, and F400 removed much more of the remaining AOX precursor for longer than Pica Biol. Summary statistics of the data in figures 42 and 43 are shown in Table 26.

Table 26 - Summary AOX statistics for post treated waters

	Control	Post Treatment				
	SAND 2° RGF	NORIT PK	F400	OZONE	OZONE + F400	OZONE + PICA
Mean	33.1	27.7	19.9	14.4	8.9	12.8
Std.Dev	13.3	7.7	12.8	6.1	2.4	3.1
No.Point	16	16	16	16	16	16
Maximum	74.9	40.4	59.1	35.3	17.2	17.5
Minimum	8.0	8.0	8.0	8.0	8.0	8.0

Fig 40. AOX Precursors at Various Stages of 3 Stage Treatment
(Both filters contain Sand)



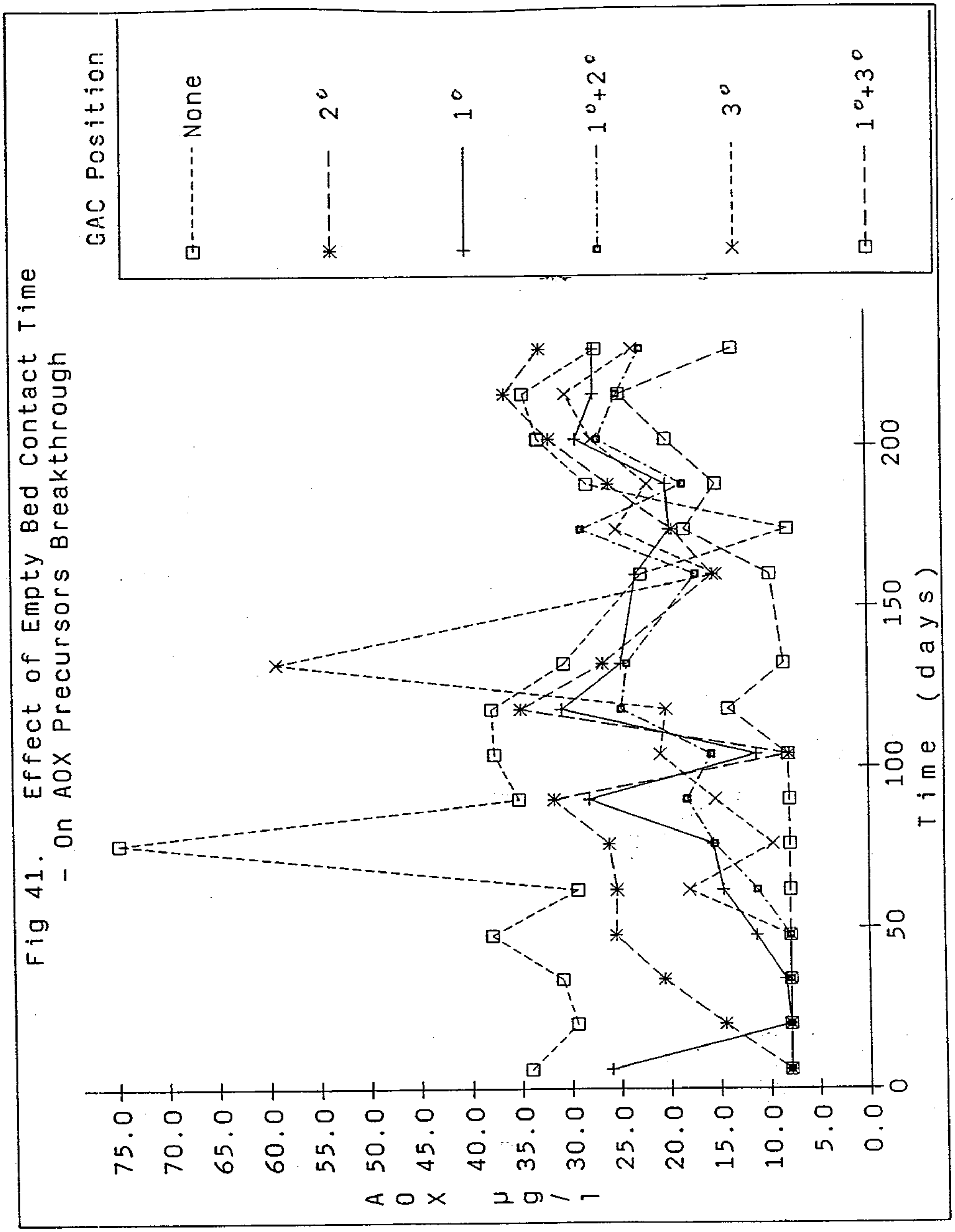


Fig 41. Effect of Empty Bed Contact Time - On AOX Precursors Breakthrough

Fig 42. Comparison of Norit PK and F400 - AOX Precursors Breakthrough

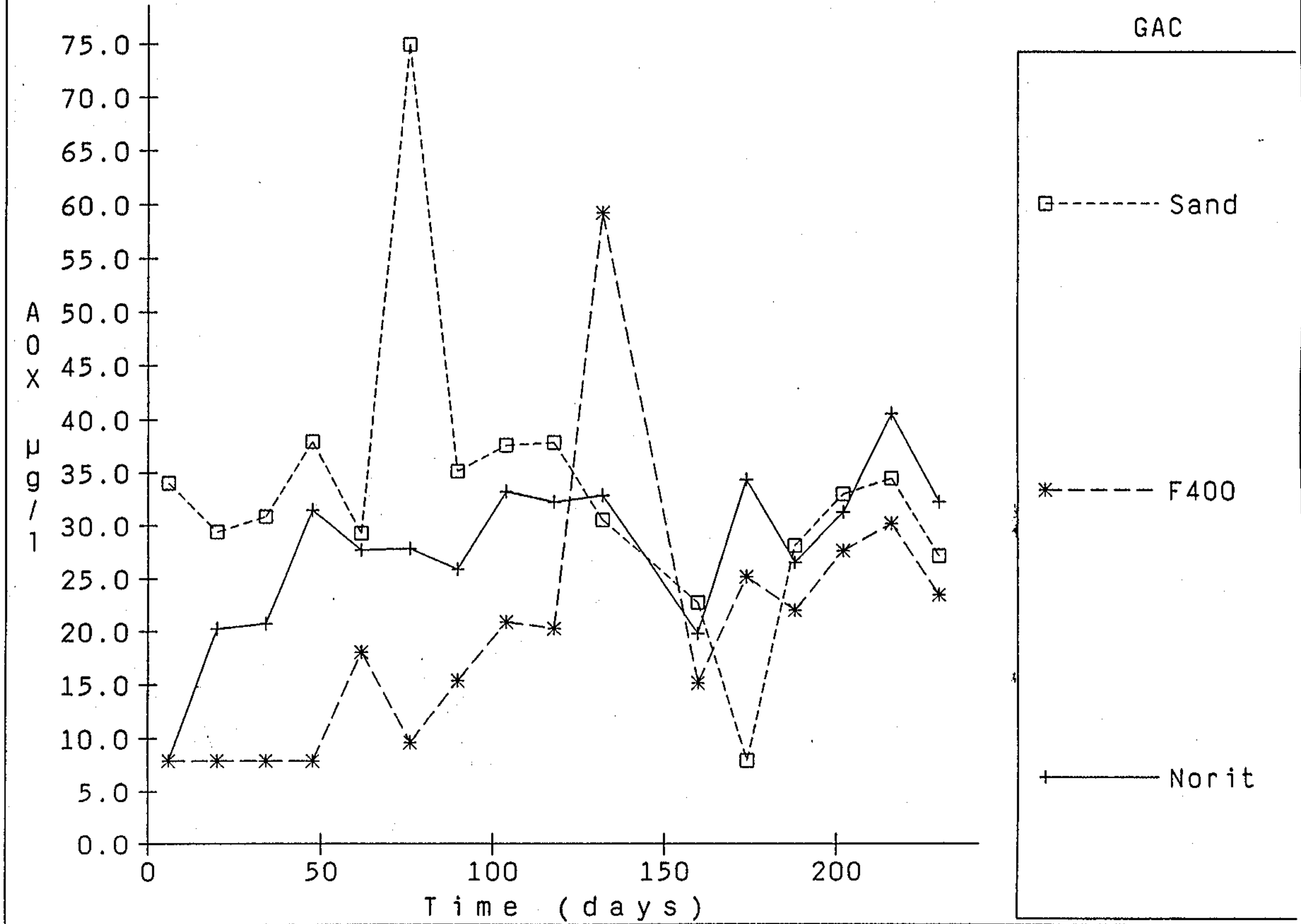
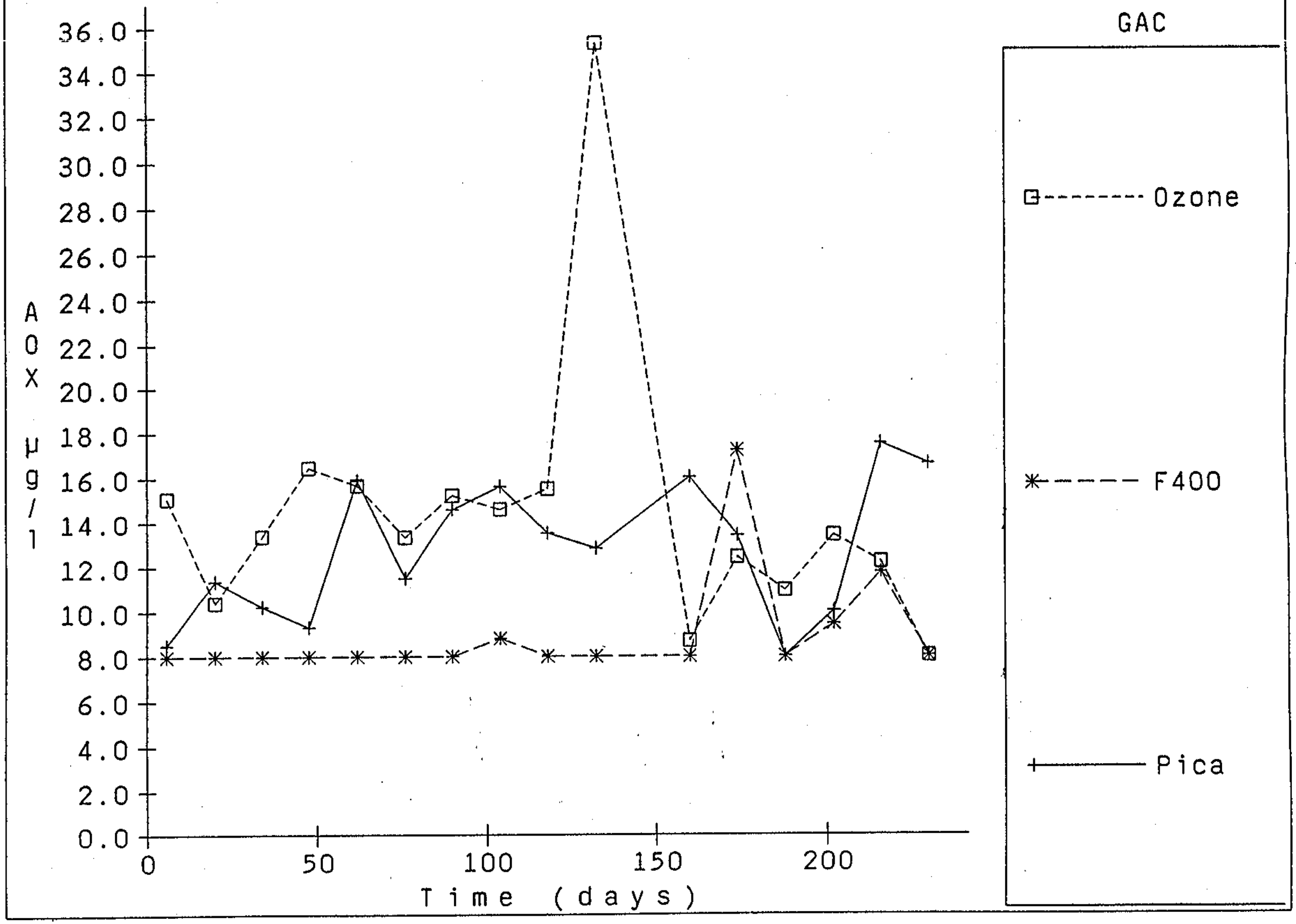


Fig 43. Comparison of Pica Biol and F400 (after Ozone) - AOX Precursors Breakthrough



3.6.4 Mutagenic activity

Figures 44 and 45 show total (pH2 + pH7) TA 98 and TA 100 mutagenic activity precursors respectively after treatment by carbon at different stages of the treatment process. The trends which were seen for uv absorbance, THMs and AOX can also be seen in figures 44 and 45. Increasing EBCT resulted in lower mutagenic activity precursor for a longer period of time. Comparing the two figures, it can be seen that carbon removed a greater proportion of TA 98 precursor than TA 100 precursor, and that the initial breakthroughs for TA 98 percursor occurred at about the same time as the initial breakthroughs for total THMs and AOX. TA 100 precursor appears to have broken through before the other disinfection by-products (but at about the same time as uv absorbance).

Tables 27 to 30 give summary statistics for TA 98 and TA 100 mutagenic activity extracted at pHs of 2 and 7.

Table 27 - Summary statistics for TA 98 mutagenic activity (at pH 2)

	CONTROL	1° RGF F400	1°+2° RGF F400	2° RGF F400	1°+3° F400	3° F400	3° NORIT	OZONE only	OZONE +F400	OZONE +PICA
Mean	2.84	1.35	1.19	1.88	0.60	0.83	1.47	0.75	0.34	0.37
Std.Dev	0.66	0.74	0.71	0.55	0.41	0.60	0.41	0.34	0.16	0.33
No.Point	7	7	7	7	7	7	7	7	7	7
Maximum	3.95	2.47	2.09	2.76	1.06	1.61	1.92	1.15	0.50	0.93
Minium	2.09	0.50	0.47	1.07	-0.03	0.17	0.91	0.13	0.05	-0.08

Table 28 - Summary statistics for TA 98 mutagenic activity (at pH 7)

	CONTROL	1° RGF F400	1°+2° RGF F400	2° RGF F400	1°+3° F400	3° F400	3° NORIT	OZONE only	OZONE +F400	OZONE +PICA
Mean	3.89	1.36	0.89	1.94	0.61	0.42	0.62	1.59	0.27	0.52
Std.Dev	0.89	0.64	0.66	0.89	0.27	0.34	0.37	0.38	0.37	0.27
No.Points	7	7	7	7	7	7	7	7	7	7
Maximum	5.33	2.14	1.76	2.91	1.00	0.79	1.16	1.95	0.84	0.98
Minium	2.73	0.53	0.00	0.43	0.27	-0.16	0.08	0.94	-0.23	0.17

Table 29 - **Summary statistics for TA 100 mutagenic activity (at pH 2)**

	CONTROL	1° RGF F400	1°+2° RGF F400	2° RGF F400	1°+3° F400	3° F400	3° NORIT	OZONE only	OZONE +F400	OZONE +PICA
Mean	11.25	7.59	6.55	9.11	5.22	3.19	5.93	8.31	3.17	5.05
Std.Dev	4.28	3.22	3.70	2.39	2.17	2.53	3.82	3.60	1.41	1.56
No.Points	7	7	7	7	7	7	7	7	7	7
Maximum	15.99	10.41	10.41	12.51	7.58	6.07	11.76	12.98	4.29	7.81
Minium	4.96	2.69	1.50	5.66	2.57	0.27	1.01	2.92	0.38	3.33

Table 30 - **Summary statistics for TA 100 mutagenic activity (at pH 7)**

	CONTROL	1° RGF F400	1°+2° RGF F400	2° RGF F400	1°+3° F400	3° F400	3° NORIT	OZONE only	OZONE +F400	OZONE +PICA
Mean	9.60	4.15	3.95	6.58	2.99	2.32	2.74	5.65	0.98	2.23
Std.Dev	4.25	2.05	1.38	3.13	1.59	1.76	1.36	2.67	0.77	1.92
No.Points	7	7	7	7	7	7	7	7	7	7
Maximum	17.97	7.15	5.56	9.93	6.30	5.50	5.38	9.40	2.04	6.27
Minium	4.96	1.94	2.03	0.69	1.73	0.96	1.82	2.69	0.08	0.28

Figures 46 and 47 show comparisons of F400 and Norit PK for total TA 98 and total TA 100 precursor reduction respectively. F400 produced a greater reduction in both types of precursor than Norit PK. Both carbons were far more effective at reducing TA 98 precursor than TA 100 precursor.

Figures 48 and 49 show comparisons of F400 after ozone and Pica Biol for total TA 98 and total TA 100 precursor reduction respectively. Ozonation alone greatly reduced both types of precursor, and F400 removed more remaining TA 100 precursor than Pica Biol. However, there is very little difference between the two GACs for TA 98 removal, mainly due to the very low level of TA 98 precursor after ozonation.

Fig 44. Effect of Empty Bed Contact Time
- Total TA 98 Mutagenic Activity Precursors Breakthrough

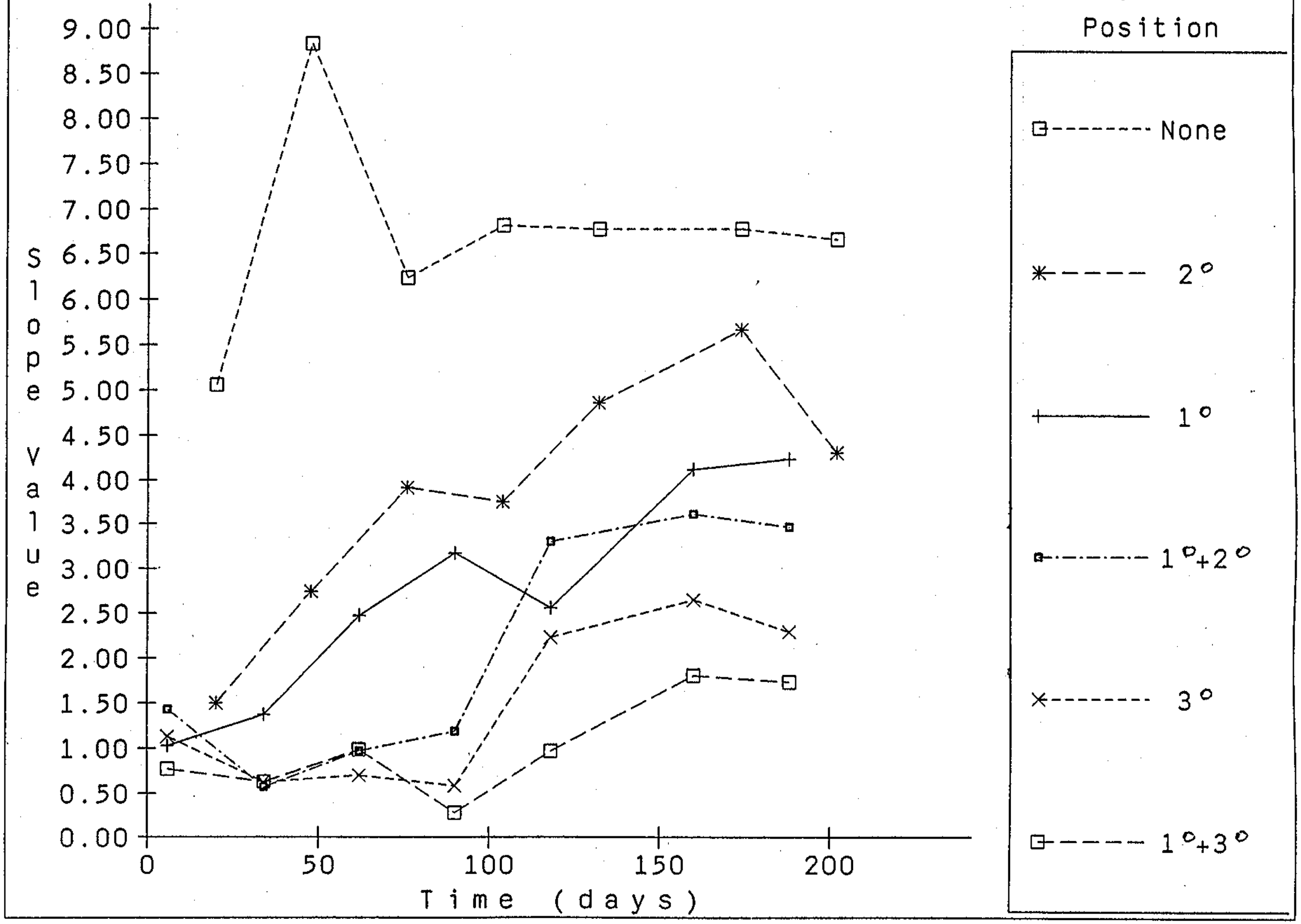
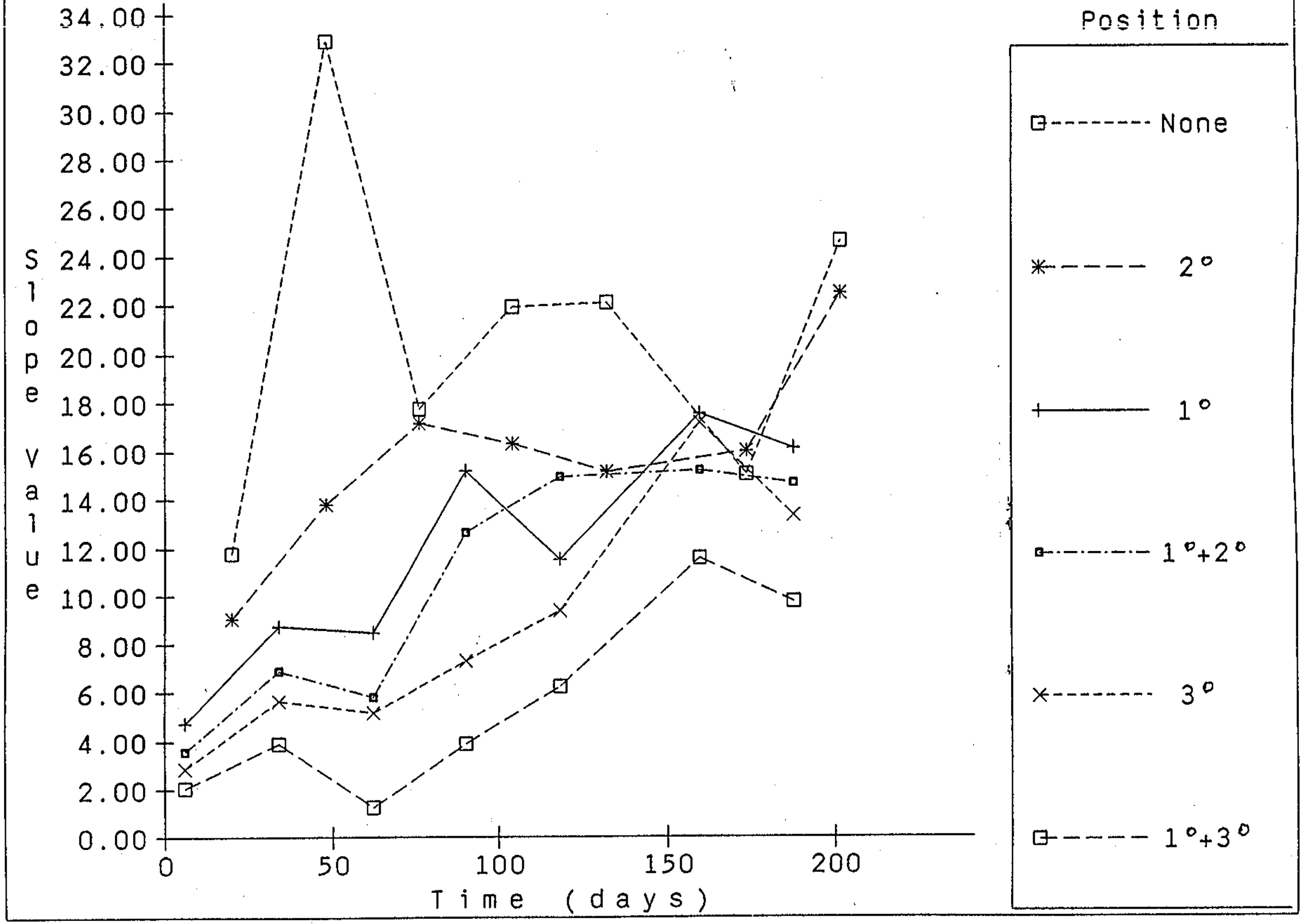


Fig 45. Effect of Empty Bed Contact Time
- Total TA 100 Mutagenic Activity Precursors Breakthrough



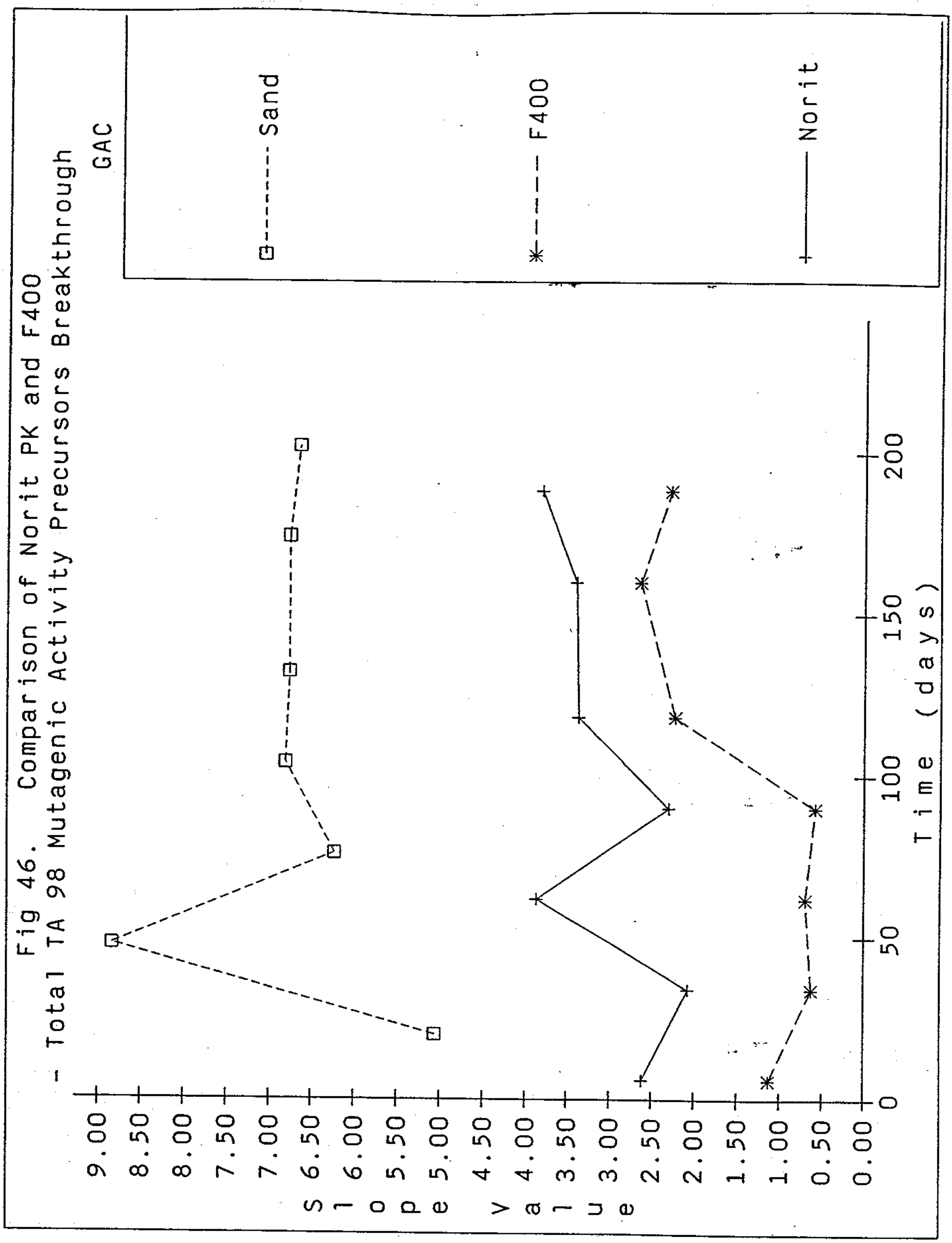


Fig 46. Comparison of Norit PK and F400
Total TA 98 Mutagenic Activity Precursors Breakthrough

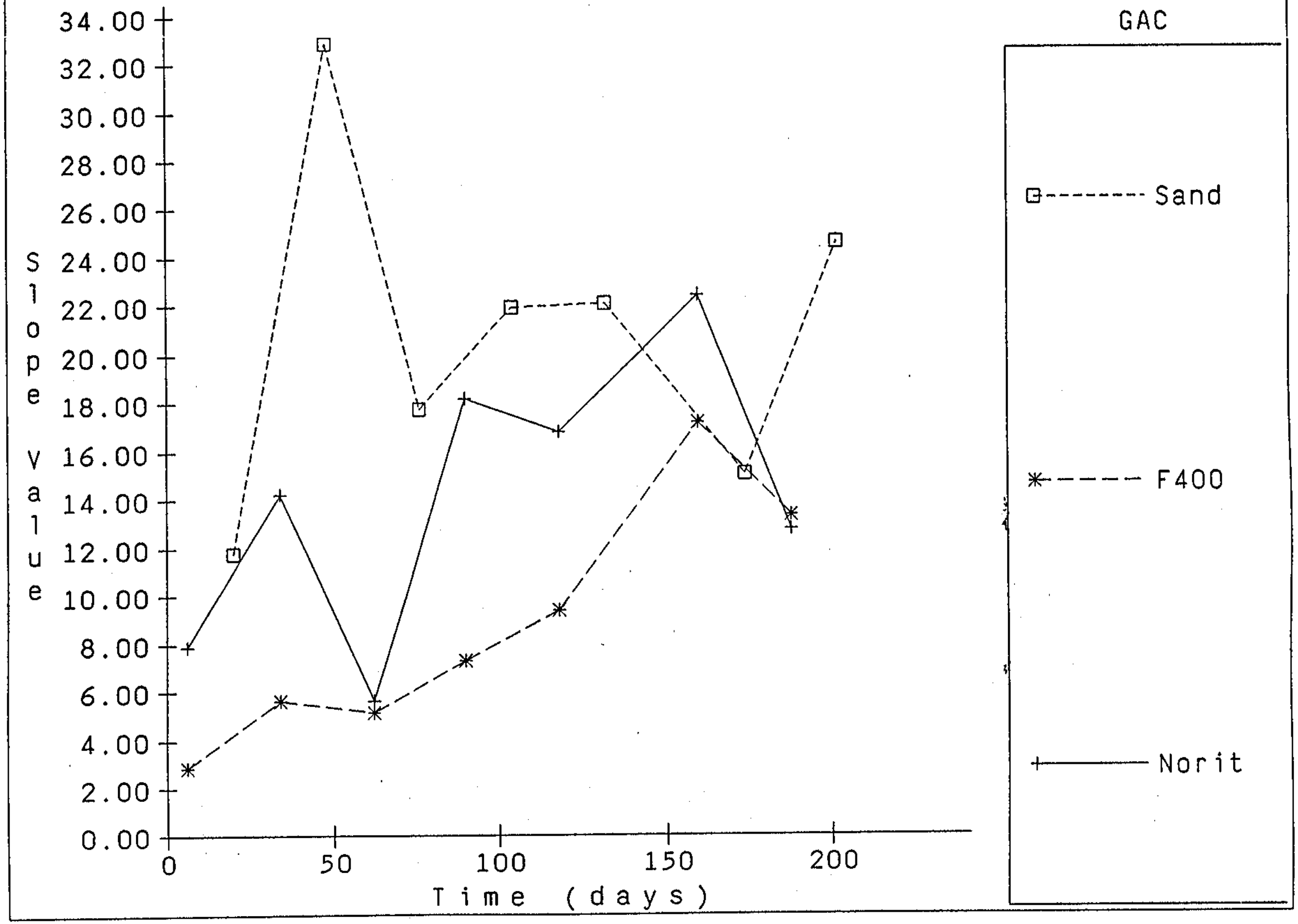


Fig 47. Comparison of Norit PK and F400 - Total TA 100 Mutagenic Activity Precursors Breakthrough

Fig 48. Comparison of Pica Biol and F400 (After Ozone) - Total TA 98 Mutagenic Activity Precursors Removal

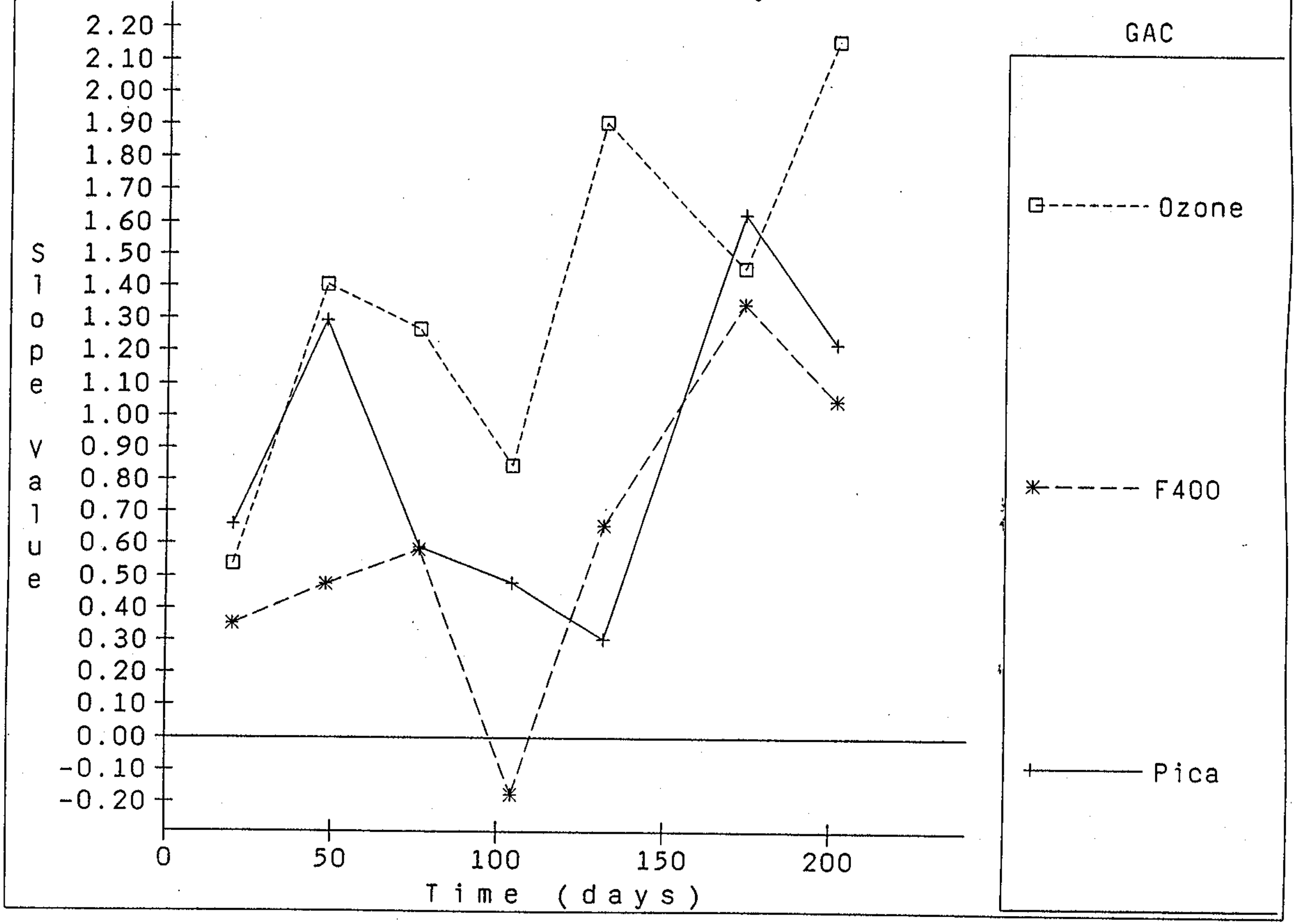
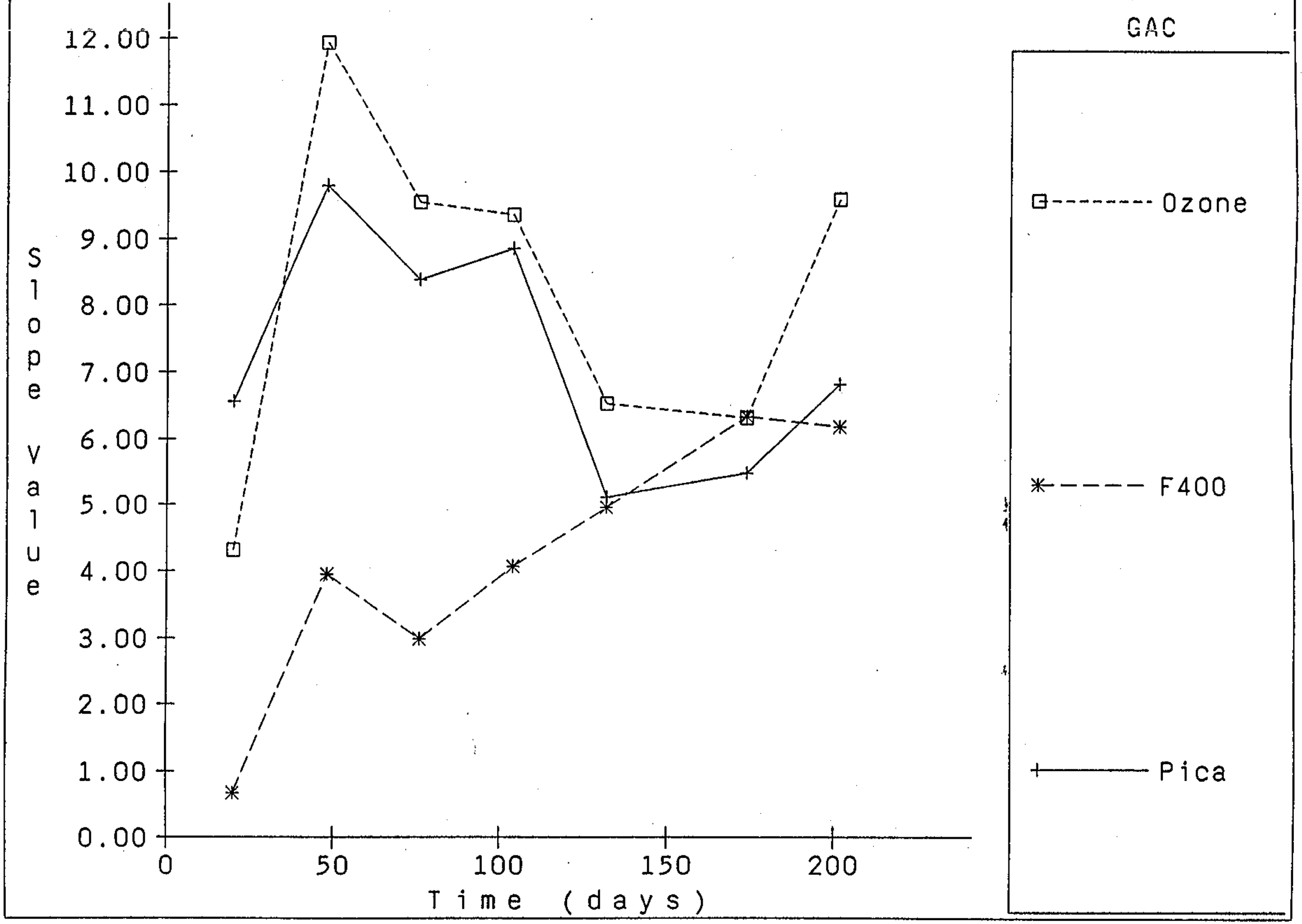


Fig 49. Comparison of Pica Biol and F400 (After Ozone) - Total TA 100 Mutagenic Activity Precursors Breakthrough



3.7 USE OF POWDERED ACTIVATED CARBON (PAC)

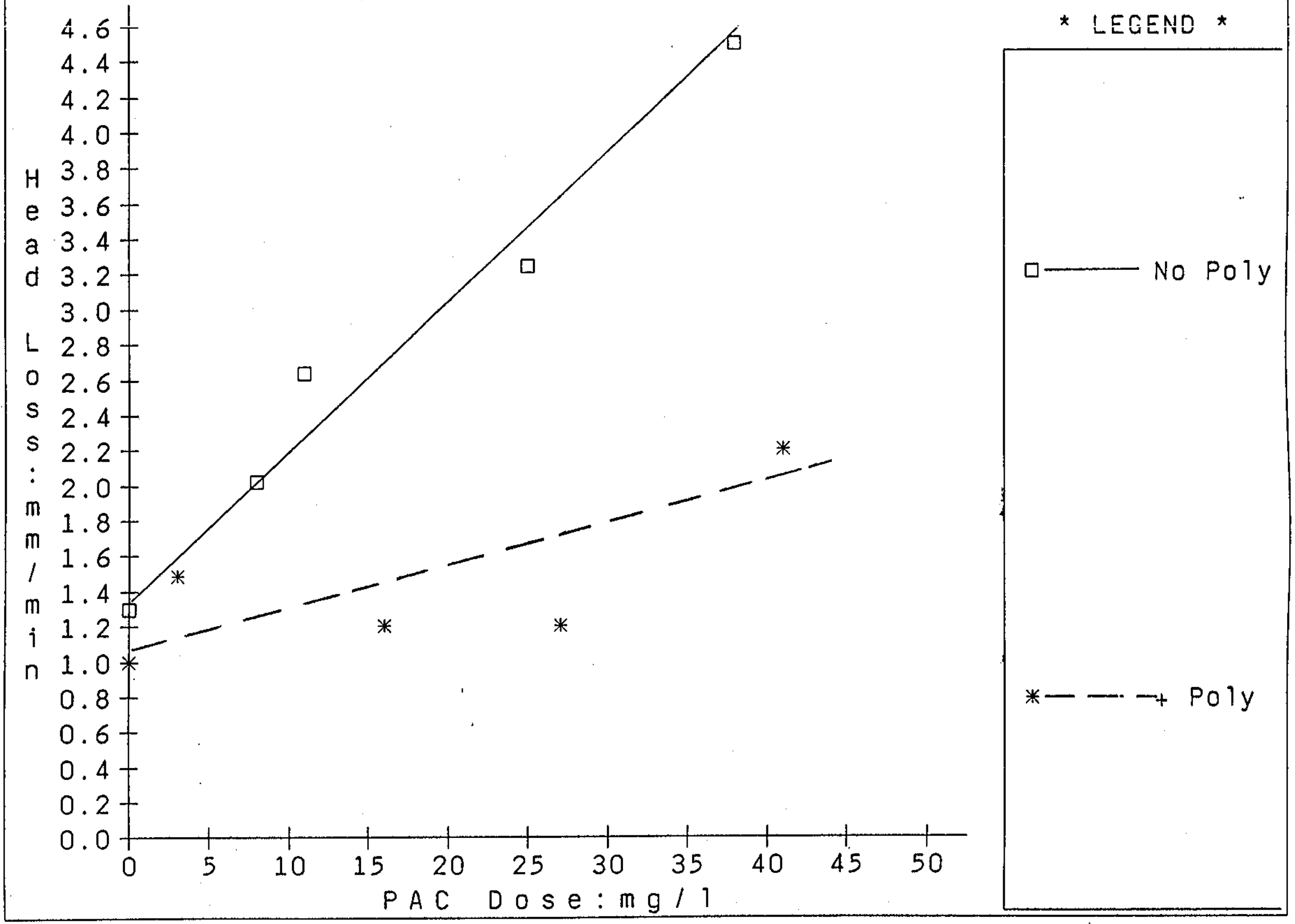
At the end of the main trial a short investigation into the use of PAC was undertaken. Only the DAF and 1° RGF were operated on one stream using ferric as the coagulant.

PAC was added to the dosed raw water prior at the beginning of the flocculation tanks at doses up to 40mg/l. No water quality measurements were made to assess the performance of the carbon but its effects on the physical behaviour of the process were recorded.

The major effect was to increase the solids loading on to the primary filters resulting in an increase in the headloss development (Figure 50) such that at a dose of 40mg/l the run length was only 6 hours compared with 12-18 hours without PAC dosing. The increased carry-over appeared to be due to the presence of heavier floc.

The addition of a polyelectrolyte (LT25) alleviated the headloss build-up somewhat (Figure 50) which may have been the result of greater removal by the DAF.

Fig. 50. Effect of PAC Dose on Filter Run Length
(Polyelectrolyte @ 0.1 mg/l: LT25)



SECTION 4 - CONCLUSIONS

(i) Solids, iron and aluminium carried over from the clarification stage can be removed as effectively by filtration through GAC as by filtration through sand. This removal does not adversely affect the performance of GAC for organics removal. (Sections 3.2 and 3.3).

(ii) Given the correct conditions, manganese can be removed on GAC and the accumulation of manganese on the GAC does not adversely affect the performance of the GAC for organics removal. (Sections 3.3.2 and 3.5.1(b)).

(iii) The removal of organics by carbon was the same at pH 6.5 and at pH 9. (Section 3.5.1(b)).

(iv) The carbon bed life is dependent on the empty bed contact time for the carbon; doubling the empty bed contact time of carbon doubles the bed life. (Section 3.5.1(b), 3.5.2(b), 3.5.3(b)).

(v) Coal based carbon (F400) performed better than peat based carbon (Norit PK) for colour, TOC, THMs, AOX and mutagenic activity reduction. (Section 3.5.2(c), 3.5.3(c), 3.6.2(d), 3.6.3(c), 3.6.4).

(vi) Ozonation of water after 3 stages of treatment had no effect on TOC but reduced, colour by 77%, THM precursors by approximately 30%, AOX by 56%, and mutagenic activity by 70%. (Section 3.5.3(c), 3.5.2(c), 3.6.2(d), 3.6.3(c), 3.6.4).

(vii) Coal based F400 after ozonation performed much better than wood based Pica Biol after ozonation for TOC, THMs, AOX and mutagenic activity reduction. (Section 3.5.3(c), 3.6.2(d), 3.6.3(c), 3.6.4).

(viii) There was no synergistic effect from using ozone and GAC, but the improvement in water quality from ozonation resulted in improved performance of the subsequent carbon adsorber. (Section 3.5.3(c), 3.6.2(d)).

(ix) During the 8 months of the trial there were very few indications of bacteriological activity within the carbon. (Section 3.4, 3.5.3(c)).

(x) Powdered activated carbon can be added prior to the DAF but it increases solids carry-over onto the 1° filter and reduces filter run length. (Section 3.7).

SECTION 5 - RECOMMENDATIONS

Activated carbon can be used to reduce disinfection by-products by removing precursor molecules. The most effective carbon is likely to be coal based. It can be used in a granular form as a media replacement in primary or secondary filters but its effective bed life will be dependent on the available contact time. Economic evaluation will be needed to decide on the best location. Bed life can be increased by using the GAC in conjunction with ozone. If used as a powder, dosed prior to the dissolved air flotation stage, shorter filter runs may have to be accepted.

SECTION 6 - REFERENCES

(1) ATTENBOROUGH A and WALKER I. Removal of Organics from Coloured Waters; Interim Progress Report No. 1. WRc Report No. 876-S, 1989.

(2) ATTENBOROUGH A and WALKER I. Removal of Organics from Coloured Water; Phase 1 Report. WRc Report UC 638, 1989.

(3) ATTENBOROUGH A and WALKER I. Removal of Organics from Coloured Water; Phase 2 Report. WRc Report No. 827, 1991.

(4) ATTENBOROUGH A and WALKER I. Removal of Organics from Coloured Water; Overview Report. WRc Report UC 1155, 1991.

(5) WHO Guidelines for Drinking Water Quality, 1984, Vol 1.

(6) BOOKER N A et al. Removal of Volatile Organics from Groundwater. June 1988. WRc Report 756-S.

(7) E & A West Ferric Data (manufacturers literature).

SECTION 7 - ACKNOWLEDGEMENT

The authors would like to thank the supply staff of North West Water, Eastern Division for their willingness to help whenever asked.

APPENDIX - TABLES OF RESULTS

A35	TA 98 Mutagenic Activity at pH 2 (slope value)
A36	TA 98 Mutagenic Activity at pH 7 (slope value)
A37	TA 100 Mutagenic Activity at pH 2 (slope value)
A38	TA 100 Mutagenic Activity at pH 7 (slope value)

Table A1 - Days Run, Chemical Doses, Residuals and Temperature

DATE	DAYS	Fe DOSE mg/l	OZONE DOSE mg/l	OZONE RESID mg/l	Str A Cl Residual Free mg/l	Str A Cl Residual Total mg/l	Str B Cl Residual Free mg/l	Str B Cl Residual Total mg/l	Cl DOSES Str A mg/l	Cl DOSES Str B mg/l	Temp Deg C
2-AUG-1990	1		1.7		0.10	0.32	0.02	0.27			16.5
3-AUG-1990	2		2.0		0.13	0.37	0.02	0.27			16.7
6-AUG-1990	5		2.0		0.03	0.33	0.04	0.34			16.4
7-AUG-1990	6	2.3	1.9		0.08	0.36	0.01	0.33	0.52	0.53	16.7
8-AUG-1990	7		2.1		0.09	0.38	0.04	0.38			16.8
9-AUG-1990	8		1.9		0.03	0.27	0.06	0.37			16.8
10-AUG-1990	9		3.3		0.13	0.34	0.09	0.34			17.0
13-AUG-1990	12		0.0		0.26	0.39	0.19	0.34			17.0
14-AUG-1990	13	2.1	1.7	0.06	0.27	0.38	0.24	0.39	0.54	0.74	17.0
15-AUG-1990	14		1.5	0.00	0.18	0.29	0.12	0.26			16.5
16-AUG-1990	15		2.2	0.00	0.02	0.19	0.12	0.32			15.6
17-AUG-1990	16		2.2		0.06	0.21	0.12	0.29			15.0
20-AUG-1990	19		3.4	0.00	0.11	0.24	0.10	0.23			15.0
21-AUG-1990	20	2.1	1.9	0.02	0.17	0.30	0.13	0.26	0.43	0.57	14.5
22-AUG-1990	21		2.0		0.16	0.26	0.10	0.25			14.8
23-AUG-1990	22		2.1		0.08	0.22	0.05	0.21			14.9
24-AUG-1990	23		2.9		0.11	0.21	0.07	0.21			14.8
28-AUG-1990	27		1.5				0.07	0.26			14.9
29-AUG-1990	28	2.4	1.5	0.00	0.11	0.27	0.07	0.26	0.35	0.47	14.8
30-AUG-1990	29		2.7		0.11	0.30	0.09	0.30			14.8
31-AUG-1990	30		2.0		0.10	0.27	0.09	0.30			14.7
3-SEP-1990	33		1.7		0.09		0.07				15.5
4-SEP-1990	34	2.2	1.7	0.00	0.10	0.24	0.10	0.25	0.37	0.63	15.5
5-SEP-1990	35		2.5		0.10	0.22	0.08	0.24			15.0
6-SEP-1990	36		1.7		0.20	0.24	0.12	0.25			14.8
7-SEP-1990	37		1.6		0.05	0.26	0.06	0.30			14.1
10-SEP-1990	40		1.6		0.02	0.24	0.03	0.28			14.2
11-SEP-1990	41	2.5	3.6	0.00	0.05	0.25	0.06	0.31	0.32	0.54	14.0
12-SEP-1990	42		1.2		0.04	0.25	0.05	0.30			14.0
13-SEP-1990	43		1.8		0.04	0.28	0.00	0.02			14.0
14-SEP-1990	44		1.9		0.05	0.29	0.07	0.35			14.0
17-SEP-1990	47		2.4		0.08	0.29	0.10	0.36			13.8
18-SEP-1990	48	2.7	2.3	0.00	0.05	0.32	0.09	0.38	0.42	0.68	13.6
19-SEP-1990	49		1.6		0.04	0.27	0.13	0.42			13.0
20-SEP-1990	50		1.6		0.37	0.73	0.53	0.83			12.0
21-SEP-1990	51		2.0		0.14	0.42	0.22	0.53			11.8
24-SEP-1990	54		2.2		0.11	0.37	0.11	0.38			11.2
25-SEP-1990	55	2.6	1.9	0.00	0.05	0.30	0.10	0.40	0.36	0.63	11.0
27-SEP-1990	57		1.7		0.04	0.32	0.04	0.33			11.0
28-SEP-1990	58		2.6		0.03	0.29	0.02	0.32			11.0
1-OCT-1990	61		1.3		0.03	0.30	0.04	0.34			11.0
2-OCT-1990	62	3.4	1.5	0.00	0.07	0.34	0.08	0.37	0.44	0.70	11.1
3-OCT-1990	63		2.0		0.10	0.36	0.14	0.46			11.2
4-OCT-1990	64		2.1		0.15	0.44	0.22	0.53			10.8

Table A1 continued

DATE	DAYS	Fe DOSE mg/l	OZONE DOSE mg/l	OZONE RESID mg/l	Str A Cl Residual Free mg/l	Str A Cl Residual Total mg/l	Str B Cl Residual Free mg/l	Str B Cl Residual Total mg/l	Cl DOSES Str A mg/l	Cl DOSES Str B mg/l	Temp Deg C
5-OCT-1990	65		1.8		0.10	0.35	0.13	0.44			10.8
8-OCT-1990	68		2.3		0.13	0.38	0.24	0.54			10.5
9-OCT-1990	69	3.6	1.8	0.02	0.14	0.40	0.14	0.42	0.49	0.64	10.3
10-OCT-1990	70		2.5		0.11	0.36	0.10	0.37			10.3
12-OCT-1990	72		2.6		0.09	0.34	0.06	0.33			10.6
15-OCT-1990	75		2.5		0.07	0.30	0.04	0.29			11.4
16-OCT-1990	76	3.6	2.1	0.01	0.10	0.33	0.12	0.37	0.47	0.66	12.0
17-OCT-1990	77		2.8		0.15	0.53	0.18	0.54			11.5
18-OCT-1990	78		1.6		0.18	0.41	0.20	0.44			11.5
19-OCT-1990	79		0.7		0.27	0.47	0.21	0.52			11.0
22-OCT-1990	82		1.3		0.15	0.42	0.10	0.37			10.5
23-OCT-1990	83	3.5	3.7	0.01	0.18	0.42	0.21	0.49	0.57	0.73	10.0
25-OCT-1990	85		1.4		0.00	0.24	0.13	0.39			9.7
26-OCT-1990	86		2.3		0.04	0.27	0.11	0.37			9.8
29-OCT-1990	89		1.8		0.02	0.21	0.06	0.24			8.5
30-OCT-1990	90	3.6	1.8	0.16	0.06	0.33	0.10	0.37	0.43	0.66	8.2
31-OCT-1990	91		3.4		0.04	0.27	0.11	0.38			8.0
1-NOV-1990	92		1.6		0.05	0.28	0.14	0.39			7.9
2-NOV-1990	93		2.0		0.10	0.33	0.18	0.44			7.7
5-NOV-1990	96		2.6		0.10	0.33	0.16	0.41			7.0
6-NOV-1990	97	3.7	1.7	0.04	0.13	0.35	0.20	0.45	0.47	0.74	7.0
7-NOV-1990	98		2.0		0.10	0.32	0.14	0.41			7.0
8-NOV-1990	99		2.3		0.02	0.26	0.12	0.39			6.8
9-NOV-1990	100		2.0		0.12	0.30	0.13	0.37			6.4
12-NOV-1990	103		1.8		0.08	0.28	0.12	0.35			7.0
13-NOV-1990	104	3.3	2.3	0.07	0.01	0.23	0.11	0.36	0.54	0.74	8.0
14-NOV-1990	105		2.5		0.05	0.28	0.01	0.27			7.4
15-NOV-1990	106		1.5		0.04	0.27	0.14	0.39			7.4
16-NOV-1990	107		1.6		0.07	0.29	0.12	0.37			7.8
19-NOV-1990	110		1.7		0.08	0.35	0.03	0.32			7.0
20-NOV-1990	111	3.6	2.3	0.54	0.07	0.35	0.07	0.32	0.58	0.79	7.0
22-NOV-1990	113		3.1		0.05	0.32	0.11	0.38			6.7

Table A1 continued

DATE	DAYS	Fe DOSE	OZONE DOSE	OZONE RESID	Str A Cl Res dual Free	Str A Cl Res dual Total	Str B Cl Residual Free	Str B Cl Residual Total	Cl DOSES Str A	Cl DOSES Str B	Temp
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	Deg C
23-NOV-1990	114		0.6		0.15	0.37	0.15	0.41			6.2
26-NOV-1990	117		0.8		0.18	0.41	0.14	0.39			5.5
27-NOV-1990	118	3.5	2.1	0.11	0.14	0.36	0.20	0.45	0.57	0.75	5.5
28-NOV-1990	119		2.1		0.45	0.92	0.63	0.96			5.5
29-NOV-1990	120		2.1		0.25	0.45	0.49	0.69			5.5
30-NOV-1990	121		2.1		0.31	0.49	0.40	0.60			5.1
3-DEC-1990	124		1.5		0.03	0.24	0.16	0.38			5.0
4-DEC-1990	125	3.2	2.4	0.02	0.11	0.32	0.18	0.41	0.53	0.72	5.0
5-DEC-1990	126		1.5		0.10	0.32	0.13	0.36			4.6
7-DEC-1990	128		2.0		0.12	0.35	0.11	0.35			4.5
10-DEC-1990	131		2.5		0.04	0.28	0.11	0.34			3.2
11-DEC-1990	132	2.9	4.2	0.09	0.12	0.32	0.14	0.37	0.59	0.68	3.3
12-DEC-1990	133		1.5		0.10	0.34	0.11	0.37			3.2
13-DEC-1990	134		1.9		0.11	0.35	0.12	0.39			3.0
14-DEC-1990	135		2.0		0.12	0.35	0.14	0.38			3.0
17-DEC-1990	138		2.0		0.09	0.34	0.11	0.37			2.8
18-DEC-1990	139	2.7	2.3	0.13	0.12	0.35	0.12	0.36	0.66	0.72	2.5
19-DEC-1990	140		1.5		0.10	0.34	0.10	0.34			2.8
21-DEC-1990	142		1.8		0.09	0.33	0.07	0.31			3.0
27-DEC-1990	148		2.0		0.07	0.36	0.00	0.01			3.7
3-JAN-1991	155		0.8		0.07	0.38	0.06	0.37			3.3
7-JAN-1991	159		1.8		0.13	0.45	0.10	0.45			2.8
8-JAN-1991	160	3.4	2.0	0.00	0.13	0.45	0.15	0.46	0.54	0.59	2.5
9-JAN-1991	161		1.8		0.53	0.70	0.11	0.51			2.0
10-JAN-1991	162		1.8		0.34	0.66	0.28	0.62			2.5
11-JAN-1991	163		2.1		0.26	0.57	0.17	0.45			2.2
14-JAN-1991	166		1.5		0.08	0.45	0.21	0.52			2.0
15-JAN-1991	167	2.8	2.1	0.10	0.09	0.42	0.17	0.50	0.49	0.60	1.9
16-JAN-1991	168		1.8		0.09	0.38	0.12	0.43			1.9
17-JAN-1991	169		2.8		0.14	0.46	0.14	0.46			1.8
18-JAN-1991	170		1.6		0.14	0.47	0.14	0.47			1.7
21-JAN-1991	173		1.1		0.12	0.45	0.10	0.42			2.2
22-JAN-1991	174	3.3	2.8	0.07	0.14	0.48	0.12	0.46	0.55	0.60	2.0
23-JAN-1991	175		1.6		0.12	0.44	0.12	0.44			2.0
24-JAN-1991	176		1.8		0.16	0.52	0.12	0.49			2.0
28-JAN-1991	180		1.6		0.13	0.50	0.12	0.48			2.0
29-JAN-1991	181	2.9	1.7	0.15	0.17	0.51	0.13	0.48	0.72	0.70	1.9
30-JAN-1991	182		2.4		0.11	0.45	0.10	0.46			2.0
31-JAN-1991	183		1.7		0.13	0.47	0.12	0.48			1.8
1-FEB-1991	184		1.8		0.12	0.47	0.12	0.46			1.7
4-FEB-1991	187		1.8		0.09	0.45	0.08	0.45			1.3
5-FEB-1991	188	3.0	2.5	0.20	0.12	0.47	0.12	0.48	0.63	0.68	1.3
6-FEB-1991	189		2.0		0.08	0.44	0.08	0.44			1.0
7-FEB-1991	190				0.10	0.45	0.13	0.48			0.8
8-FEB-1991	191				0.10	0.47	0.13	0.49			0.6
11- EB-1991	194				0.10	0.44	0.11	0.46			0.5

Table A1 continued

DATE	DAYS	Fe DOSE	OZONE DOSE	OZONE RESID	Str A Cl Residual		Str B Cl Residual		Cl DOSES		Temp
					Free	Total	Free	Total	Str A	Str B	
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	Deg C
12-FEB-1991	195	2.7			0.12	0.46	0.12	0.47	0.63	0.70	0.6
14-FEB-1991	197				0.10	0.45	0.10	0.46			0.7
15-FEB-1991	198				0.10	0.45	0.11	0.46			0.8
18-FEB-1991	201		2.2		0.10		0.08				1.0
19-FEB-1991	202	2.7	3.2	0.35	0.10	0.47	0.07	0.45	0.67	0.73	1.0
20-FEB-1991	203		2.8		0.11	0.47	0.08	0.45			1.1
21-FEB-1991	204		1.5		0.00	0.01	0.10	0.56			1.2
22-FEB-1991	205		3.4				0.07	0.61			1.2
25-FEB-1991	208		1.4				0.02	0.55			3.0
26-FEB-1991	209	2.8	2.0	0.62			0.02	0.55	0.00	0.58	3.2
27-FEB-1991	210		2.4				0.03	0.61			3.2
28-FEB-1991	211		1.8				0.05	0.64			3.3
1-MAR-1991	212		1.5				0.08	0.67			3.4
4-MAR-1991	215		1.5				0.13	0.73			3.2
5-MAR-1991	216	2.9	2.5	0.24			0.25	0.82	0.00	1.18	3.8
6-MAR-1991	217		1.5				0.10	0.69			4.0
7-MAR-1991	218		2.0				0.09	0.68			4.1
8-MAR-1991	219		2.4				0.21	0.77			4.3
11-MAR-1991	222		1.9				0.16	0.67			5.0
12-MAR-1991	223	3.1	2.0	0.52			0.09	0.60	0.00	1.17	5.3
13-MAR-1991	224		1.6				0.04	0.63			5.3
14-MAR-1991	225		2.4				0.07	0.69			5.5
15-MAR-1991	226		2.6				0.08	0.74			5.8
18-MAR-1991	229		2.4				0.14	0.79			6.4
19-MAR-1991	230	2.7	2.4	0.55			0.12	0.77	0.00	1.51	6.8

Table A2. pH

DATE	SAMPLE NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	13	14
2-AUG-1990	5.4	5.1	9.0	6.4	9.5	9.4	9.0	8.8	8.6	9.5	9.5	9.2	9.6	4.4
3-AUG-1990	5.6	4.8	7.8	6.4	9.0	9.0	8.6	8.8	8.6	9.6	9.1	8.9	8.8	5.8
6-AUG-1990	5.6	4.8	7.0	6.6	7.2	7.4	8.8	9.0	8.8	8.0	7.8	8.8	7.8	6.8
7-AUG-1990	5.6	4.7	6.6	6.3	9.0	7.8	8.7	8.8	8.7	7.6	7.8	8.8	7.6	6.8
8-AUG-1990	5.6	4.9	6.4	6.2	9.0	8.8	8.7	8.7	8.4	7.4	7.8	8.6	7.4	7.0
9-AUG-1990	5.6	4.8	6.4	6.2	9.0	8.8	8.6	8.9	8.7	7.4	7.8	8.7	7.4	7.0
10-AUG-1990	5.6	4.7	6.4	6.4	9.0	8.9	8.9	9.0	8.9	7.4	7.8	8.8	7.4	7.0
13-AUG-1990	5.8	4.8	6.6	6.7	9.3	9.2	9.4	9.2	9.2	8.7	8.8	9.0	7.8	8.3
14-AUG-1990	5.8	4.7	6.7	6.6	9.1	8.9	9.0	9.2	9.0	8.9	8.9	9.0	8.5	8.3
15-AUG-1990	5.8	4.7	6.6	6.5	9.2	9.2	9.2	9.2	8.9	8.8	8.9	9.0	8.6	8.6
16-AUG-1990	5.8	4.8	6.6	6.6	9.2	9.0	9.2	9.2	9.0	9.0	9.2	9.1	8.6	8.5
17-AUG-1990	5.7	4.8	6.6	6.6	9.2	9.2	9.2	9.3	9.0	9.0	9.1	9.2	8.6	8.6
20-AUG-1990	5.9	4.6	6.4	6.4	9.0	9.2	9.1	9.1	8.5	8.9	8.9	9.0	8.3	8.3
21-AUG-1990	5.9	4.6	6.7	7.2	9.1	9.2	9.2	9.2	9.0	8.9	8.9	9.0	8.2	8.2
22-AUG-1990	5.9	4.9	6.6	6.8	9.0	9.1	9.2	9.1	8.8	8.9	9.0	9.0	7.6	8.0
23-AUG-1990	5.9	4.7	6.5	6.2	9.0	9.0	9.0	9.0	8.6	8.7	8.8	8.8	7.4	7.8
24-AUG-1990	5.8	4.7	6.3	6.2	9.0	9.0	8.9	8.9	8.4	8.8	8.8	8.8	7.4	7.8
28-AUG-1990	5.6	4.7	6.6	6.8	9.0	8.9	8.9	9.1	9.0	8.4	7.8	8.8	7.4	8.6
29-AUG-1990	5.6	4.6	6.6	6.5	9.1	8.9	9.0	9.0	8.7	8.7	8.6	8.9	7.4	8.6
30-AUG-1990	5.6	4.8	7.2	8.3	9.0	9.0	9.2	9.2	8.8	8.8	8.8	8.9	7.4	8.4
31-AUG-1990	5.5	4.8	6.6	6.7	9.0	9.0	9.2	9.1	8.9	8.8	9.0	9.0	7.6	8.2
3-SEP-1990	5.8	4.6	6.5	6.9	9.1	9.0	9.0	9.1	9.0	8.7	8.6	8.8	7.4	7.8
4-SEP-1990	5.8	4.6	6.6	6.7	9.2	9.1	9.2	9.2	9.0	8.9	9.0	9.1	7.6	7.8
5-SEP-1990	5.9	4.6	6.5	6.6	9.0	9.1	9.1	9.0	8.9	9.0	9.0	9.0	8.2	8.2
6-SEP-1990	5.9	4.7	6.7	6.8	9.2	9.2	9.2	9.2	9.2	9.1	9.2	9.2	8.5	8.4
7-SEP-1990	5.9	4.7	6.8	6.6	9.2	9.3	9.2	9.2	9.0	9.1	9.1	9.2	8.3	8.0
10-SEP-1990	5.9	4.6	6.5	7.0	9.0	8.9	9.1	9.2	8.8	8.8	8.7	8.8	7.8	7.6
11-SEP-1990	5.8	4.6	6.6	6.2	9.2	9.2	9.2	9.2	9.0	9.0	9.0	9.0	8.0	8.0
12-SEP-1990	5.8	4.6	6.4	6.3	9.2	9.2	9.2	9.2	9.0	9.0	9.0	9.0	8.0	8.0
13-SEP-1990	5.9	4.7	6.5	6.4	9.1	9.2	9.1	9.1	8.8	9.0	9.0	9.0	8.0	7.8
14-SEP-1990	5.9	4.8	6.4	6.4	9.2	9.1	9.1	9.1	8.8	9.0	9.0	9.0	8.0	8.0
17-SEP-1990	5.9	4.7	6.4	6.8	9.0	9.0	9.1	9.2	9.0	8.8	8.8	8.8	8.2	7.3
18-SEP-1990	6.0	4.7	6.4	6.4	9.0	9.0	9.0	9.0	8.9	8.8	8.8	8.9	7.6	7.6
19-SEP-1990	6.1	5.0	6.4	7.0	9.0	9.1	9.0	9.0	9.0	8.9	9.0	9.0	8.2	7.5
20-SEP-1990	6.1	4.8	6.8	7.6	9.1	9.2	9.1	9.1	9.2	8.9	9.1	9.2	8.6	8.2
21-SEP-1990	5.9	4.7	6.8	7.8	9.4	9.6	9.6	9.4	9.4	9.0	9.2	9.3	8.9	8.7
24-SEP-1990	5.8	4.6	6.7	7.0	9.2	9.4	9.2	9.2	9.1	8.8	9.0	9.0	8.4	7.8
25-SEP-1990	6.0	4.6	6.8	6.6	9.4	9.4	9.3	9.4	9.2	9.3	9.3	9.2	8.8	8.6
27-SEP-1990	5.8	4.8	5.4	5.9	8.8	8.8	7.4	7.1	6.6	8.8	9.0	8.7	8.4	8.3
28-SEP-1990	5.9	4.7	5.9	6.5	8.8	8.8	8.4	8.5	6.8	8.6	8.7	8.4	8.0	7.8
1-OCT-1990	6.0	4.8	6.2	6.1	8.8	8.8	9.0	9.2	8.6	8.0	8.8	8.7	7.6	7.4
2-OCT-1990	6.0	4.8	6.2	6.5	8.8	8.8	9.0	9.0	8.6	7.6	8.8	8.8	7.4	7.3
3-OCT-1990	6.0	4.7	6.3	6.7	9.4	9.4	9.2	9.0	8.6	7.8	8.8	8.9	7.4	7.2
4-OCT-1990	6.1	4.7	6.5	7.0	9.0	9.1	9.2	9.3	9.0	8.0	9.0	9.2	7.4	7.4
5-OCT-1990	6.0	4.6	6.4	6.4	9.0	9.0	9.0	9.2	8.4	8.0	9.0	8.9	7.3	7.2
8-OCT-1990	5.3	4.6	6.5	6.9	9.1	9.0	9.1	9.4	7.6	8.4	8.8	8.8	7.4	7.3
9-OCT-1990	5.4	4.6	6.2	6.2	9.1	9.0	9.1	9.1	8.8	8.6	8.8	8.9	7.2	7.1
10-OCT-1990	5.5	4.8	6.2	6.3	9.1	9.0	9.2	9.2	8.5	8.6	8.9	9.0	7.2	7.1
12-OCT-1990	5.2	4.6	6.3	6.3	9.0	9.0	9.2	9.0	8.0	8.6	8.8	8.8	7.3	7.2

Table A2. pH (Continued)

DATE	SAMPLE NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	13	14
15-OCT-1990	5.2	4.7	6.0	6.2	8.9	8.8	8.3	8.4	6.6	8.4	8.5	8.5	7.0	7.0
16-OCT-1990	5.1	4.6	6.2	6.2	9.0	9.0	8.9	8.9	7.6	8.4	8.4	8.4	7.1	7.1
17-OCT-1990	5.2	4.6	6.3	6.9	9.2	9.2	9.1	9.2	8.2	8.8	8.6	8.8	7.3	7.2
18-OCT-1990	5.2	4.8	6.5	7.4	9.2	9.2	9.2	9.2	8.8	8.8	8.6	8.8	7.0	7.0
19-OCT-1990	5.2	4.8	6.7	7.4	9.2	9.2	9.2	9.2	8.9	8.9	8.8	8.9	7.0	7.0
22-OCT-1990	5.2	4.7	6.6	7.0	9.3	9.4	9.2	9.3	9.0	9.1	8.9	9.0	7.1	7.0
23-OCT-1990	5.2	4.6	6.6	6.6	9.3	9.3	9.2	9.2	8.4	9.1	8.8	9.0	7.1	7.0
25-OCT-1990	5.2	4.6	4.8	6.2	7.0	7.5	8.9	8.9	7.5	8.8	8.7	8.6	7.0	6.9
26-OCT-1990	5.2	4.6	5.4	6.3	7.8	8.8	8.9	9.0	7.4	8.7	8.7	8.7	7.0	7.0
29-OCT-1990	4.9	4.6	5.9	5.9	6.6		6.8	6.6	5.9	8.3	8.0	7.4	6.8	8.2
30-OCT-1990	4.8	4.6	6.0	6.3	9.0	8.8	8.8	8.8	6.8	8.2	7.6	7.2	6.8	6.8
31-OCT-1990	5.0	4.6	6.0	6.2	9.0	9.0	9.0	9.0	8.0	8.0	7.4	7.4	6.8	6.7
1-NOV-1990	4.8	4.5	6.1	6.3	9.1	9.2	9.2	9.1	8.6	7.8	7.6	8.3	6.8	6.7
2-NOV-1990	4.8	4.6	6.2	6.3	9.0	9.0	9.2	9.2	8.9	8.4	8.4	8.8	6.8	6.7
5-NOV-1990	4.8	4.6	6.2	6.4	9.4	9.2	9.3	9.4	9.0	8.9	8.9	9.0	7.0	7.0
6-NOV-1990	5.0	4.6	6.4	6.4	9.1	9.0	9.1	9.1	8.8	8.8	8.9	8.9	7.0	7.0
7-NOV-1990	5.0	4.5	6.2	6.2	8.9	8.9	9.0	8.9	8.6	8.8	8.8	8.9	7.0	7.0
8-NOV-1990	5.1	4.4	6.1	5.9	9.0	9.0	8.9	9.0	7.6	8.8	8.9	8.8	7.0	7.0
9-NOV-1990	5.1	4.6	6.5	6.8	9.1	9.1	9.2	9.2	8.3	9.0	8.9	8.9	7.1	7.0
12-NOV-1990	5.1	4.6	6.4	6.5	9.1	9.0	9.0	9.0	8.7	8.8	8.8	8.8	7.0	7.0
13-NOV-1990	5.2	4.6	6.4	6.4	7.0	7.6	8.9	8.6	6.3	8.8	8.8	8.6	7.0	7.0
14-NOV-1990	5.1	4.6	6.3	6.2	8.9	9.0	8.4	7.6	6.4	8.6	8.6	8.2	7.1	7.0
15-NOV-1990	5.1	4.5	6.4	6.5	8.8	8.8	9.0	9.0	8.7	8.6	8.4	8.2	7.0	7.0
16-NOV-1990	5.1	4.6	6.4	6.6	9.0	9.0	9.0	9.0	8.6	8.5	8.6	8.7	7.0	7.0
19-NOV-1990	5.0	4.6	6.4	6.4	9.0	9.0	7.1	6.8	5.9	8.9	7.8	7.2	6.8	6.7
20-NOV-1990	4.9	4.6	6.4	6.4	8.7	8.6	8.3	7.0	6.1	8.8	8.2	7.6	6.6	6.8
22-NOV-1990	4.6	4.6	6.3	6.2	9.1	9.4	8.2	7.8	6.4	8.9	7.4	7.0	6.6	6.6
23-NOV-1990	4.8	4.6	6.4	6.4	9.3	9.3	8.6	8.5	7.0	9.2	7.8	7.1	6.7	6.6
26-NOV-1990	5.1	4.6	6.5	6.6	9.2	9.3	8.8	8.8	7.0	9.0	7.4	7.2	6.7	6.6
27-NOV-1990	5.0	4.6	6.4	6.4	9.2	9.2	8.9	9.0	6.9	9.2	7.2	7.8	6.6	6.6
28-NOV-1990	4.9	4.6	6.2	6.2	9.2	9.2	9.0	9.0	7.0	9.0	7.4	7.6	6.6	6.6
29-NOV-1990	5.0	4.8	6.5	6.5	9.0	9.0	9.0	9.0	7.6	8.9	7.6	8.0	6.6	6.6
30-NOV-1990	5.0	4.8	6.4	6.4	6.6	7.4	9.0	9.0	7.6	8.8	8.0	8.4	6.6	6.6
3-DEC-1990	5.0	4.6	6.4	6.4	6.7	6.9	8.9	9.0	8.3	8.0	8.7	8.8	6.8	6.8
4-DEC-1990	5.1	4.7	6.5	6.6	9.4	9.1	9.0	9.1	8.6	7.6	8.8	8.8	7.0	6.8
5-DEC-1990	5.2	4.7	6.7	6.6	9.1	9.2	9.2	9.2	8.7	8.0	8.8	8.8	7.0	6.9
7-DEC-1990	5.2	4.7	6.4	6.3	8.8	8.9	8.9	8.9	7.2	8.5	8.7	8.8	6.9	7.0
10-DEC-1990	5.2	4.7	6.4	6.4	6.6	7.0	9.0	9.0	7.8	7.8	8.8	8.8	7.0	7.0
11-DEC-1990	5.2	4.8	6.4	6.4	9.0	8.8	9.2	9.2	8.0	8.5	8.8	8.9	6.8	6.8
12-DEC-1990	5.0	4.4	6.3	6.1	9.1	9.0	9.1	9.0	8.6	8.3	8.9	9.0	7.0	7.0
13-DEC-1990	5.1	4.7	6.3	6.3	9.0	9.0	9.0	9.0	8.5	8.6	8.8	8.9	7.1	7.0
14-DEC-1990	5.2	4.7	6.4	6.4	9.0	9.0	9.0	9.0	8.6	8.8	8.9	8.8	7.1	7.0
17-DEC-1990	5.2	4.7	6.2	6.2	9.2	9.0	9.1	9.1	8.3	8.8	8.8	8.9	7.0	7.0
18-DEC-1990	5.2	4.6	6.2	6.2	9.1	9.0	9.1	9.1	8.6	8.8	8.9	8.8	7.1	7.1
19-DEC-1990	5.2	4.6	6.3	6.2	9.0	9.0	9.0	9.0	8.3	8.8	8.8	8.8	7.0	7.0
21-DEC-1990	5.2	4.6	6.3	6.3	9.1	9.1	9.2	9.2	8.4	8.9	8.9	8.9	7.0	7.0
27-DEC-1990	4.9	4.6	6.4	6.4	9.0	9.0	9.1	9.0	8.4	8.9	8.9	8.9	7.0	7.0
3-JAN-1991	4.8	4.6	6.5	6.7	9.0	9.0	9.2	9.1	9.0	8.9	9.0	9.0	7.2	7.2
7-JAN-1991	4.8	4.5	6.4	6.4	9.1	9.2	9.4	9.3	8.9	8.9	9.1	9.2	7.3	7.3

Table A2. pH (Continued)

DATE	SAMPLE NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	13	14
8-JAN-1991	4.7	4.5	6.5	6.7	9.3	9.0	9.2	9.2	9.0	8.9	9.0	9.0	7.4	7.3
9-JAN-1991	5.0	5.0	6.4	6.4	9.3	9.3	9.2	9.1	9.0	9.0	9.0	9.0	8.0	7.4
10-JAN-1991	4.8	4.7	6.2	6.3	9.2	9.2	9.2	9.0	8.9	9.2	9.0	9.0	7.3	7.2
11-JAN-1991	4.8	4.7	6.2	6.2	9.3	9.3	9.3	9.3	9.0	9.3	9.3	9.2	7.4	7.3
14-JAN-1991	4.8	4.6	6.5	6.6	9.2	9.2	9.3	9.2	9.0	9.0	9.2	9.1	7.6	7.6
15-JAN-1991	4.9	4.7	6.5	6.4	9.0	8.9	9.1	9.0	8.8	9.0	9.0	9.0	8.3	8.3
16-JAN-1991	4.9	4.5	6.2	6.1	9.0	9.0	9.0	9.0	8.6	8.9	9.0	8.9	7.6	7.6
17-JAN-1991	5.0	4.4	6.3	6.4	9.2	9.2	9.4	9.3	8.9	9.1	9.2	9.1	7.6	7.6
18-JAN-1991	4.8	4.5	6.2	6.2	8.9	8.9	9.1	9.0	8.8	8.8	9.0	9.0	7.5	7.4
21-JAN-1991	4.8	4.6	6.2	6.2	9.3	9.1	9.1	9.0	8.5	8.9	8.9	8.8	7.4	7.3
22-JAN-1991	4.8	4.7	6.2	6.2	9.2	9.0	9.2	9.2	8.6	9.0	9.0	8.8	7.4	7.4
23-JAN-1991	4.9	4.7	6.2	6.3	9.2	9.2	9.2	9.1	8.7	8.9	8.9	8.9	7.3	7.3
24-JAN-1991	4.8	4.6	6.2	5.9	9.2	9.2	9.1	9.1	8.8	9.0	9.0	8.9	7.1	7.2
28-JAN-1991	4.8	4.5	6.2	6.1	9.2	9.2	9.2	9.2	8.6	9.0	8.9	8.9	7.2	7.1
29-JAN-1991	5.0	4.6	6.4	6.5	9.3	9.3	9.2	9.1	8.2	9.0	8.8	8.8	7.3	7.2
30-JAN-1991	5.0	4.5	5.7	5.9	8.9	9.0	9.0	8.9	6.5	9.0	8.8	8.7	7.1	7.1
31-JAN-1991	5.0	4.7	6.1	6.5	9.2	9.2	9.3	9.3	8.6	9.1	8.9	8.9	7.2	7.1
1-FEB-1991	5.0	4.6	6.2	6.4	9.1	9.1	9.1	9.0	7.8	8.9	8.9	8.8	7.2	7.1
4-FEB-1991	5.0	4.6	6.4	6.4	8.9	9.0	9.2	9.1	8.0	8.8	8.9	8.7	7.1	7.1
5-FEB-1991	5.1	4.7	6.5	6.6	9.2	9.1	9.2	9.2	8.0	8.9	8.9	8.8	7.1	7.1
6-FEB-1991	5.1	4.6	6.4	6.4	9.0	9.0	9.2	9.0	7.4	8.8	8.8	8.6	7.1	7.1
7-FEB-1991	5.1	4.7	6.5	6.6	9.2	9.2	9.3	9.2		8.9	8.9	8.9		
8-FEB-1991	5.1	4.7	6.4	6.4	9.0	9.0	9.0	9.1		8.8	8.9	8.8		
11-FEB-1991	5.1	4.7	6.5	6.6	8.9	8.9	9.1	9.0		8.8	8.8	8.7		
12-FEB-1991	4.8	4.5	6.3	6.5	9.0	9.0	9.0	9.0		8.8	8.8	8.6		
14-FEB-1991	5.1	4.6	6.3	6.2	8.9	8.8	9.0	8.8		8.6	8.7	8.4		
15-FEB-1991	5.1	4.6	6.3	6.3	9.0	8.9	9.2	9.1		8.7	8.7	8.6		
18-FEB-1991	5.1	4.6	6.2	6.3	8.8	8.8	8.8	8.8	6.6	8.6	8.6	7.6	6.8	6.8
19-FEB-1991	5.2	4.6	6.2	6.4	9.0	8.9	8.9	8.9	6.8	8.6	8.6	7.8	6.7	6.7
20-FEB-1991	5.1	4.6	6.4	6.4	8.6	8.6	8.7	8.5	6.4	8.4	8.0	7.4	6.8	6.8
21-FEB-1991	4.8	4.5	6.4	6.5	8.6	8.4	8.8	8.7	6.6	8.0	8.0	7.4	6.8	6.8
22-FEB-1991	4.9	4.6	6.4	6.5	8.4	8.0	8.6	8.3	6.4	8.0	7.8	7.2	6.8	6.7
25-FEB-1991	4.8	4.5	6.2	6.2	8.0	7.8	7.4	7.2	6.4	7.4	7.6	7.0	6.7	6.6
26-FEB-1991	4.7	4.6	6.2	6.2	7.8	7.6	7.4	7.2	6.3	7.4	7.2	6.8	6.6	6.4
27-FEB-1991	4.8	4.6	6.3	6.4	8.2	7.8	7.8	7.6	6.4	7.2	7.2	6.8	6.6	6.5
28-FEB-1991	4.8	4.6	6.5	6.8	8.7	8.3	8.7	8.6	6.7	7.2	7.3	7.0	6.5	6.5
1-MAR-1991	4.8	4.6	6.5	6.6	8.8	8.6	8.7	8.4	6.4	7.2	7.2	6.9	6.6	6.5
4-MAR-1991	4.8	4.6	6.4	6.4	8.0	7.8	8.2	7.5	6.4	7.1	7.2	6.7	6.5	6.4
5-MAR-1991	4.7	4.6	6.4	6.4	8.0	7.8	8.3	7.8	6.3	7.0	7.1	6.8	6.4	6.4
6-MAR-1991	4.8	4.5	6.4	6.3	7.6	7.8	7.3	7.0	6.6	7.0	7.0	6.8	6.4	6.4
7-MAR-1991	4.8	4.6	6.5	6.8	7.6	7.6	7.6	7.4	6.7	7.0	7.1	6.8	6.4	6.4
8-MAR-1991	4.7	4.7	6.5	6.6	7.5	7.6	7.6	7.3	6.5	6.9	7.0	6.8	6.4	6.4
11-MAR-1991	4.8	4.8	6.4	6.4	7.0	7.2	7.2	6.8	6.4	7.0	6.9	6.6	6.3	6.2
12-MAR-1991	4.8	4.7	6.2	6.0	6.9	7.2	7.0	6.8	6.3	6.8	6.8	6.6	6.3	6.3
13-MAR-1991	4.8	4.7	6.3	6.4	6.8	7.0	6.8	6.7	6.5	6.8	6.8	6.6	6.2	6.2
14-MAR-1991	4.8	4.6	6.4	6.4	6.8	6.8	6.7	6.8	6.2	6.8	6.8	6.6	6.2	6.2
15-MAR-1991	4.8	4.6	6.4	6.3	6.6	6.8	6.7	6.6	6.0	6.6	6.8	6.6	6.2	6.2
18-MAR-1991	4.8	4.6	6.3	6.3	6.6	6.7	6.5	6.4	6.0	6.8	6.7	6.5	6.2	6.1
19-MAR-1991	4.8	4.7	6.3	6.4	6.6	6.8	6.6	6.5	6.1	6.6	6.6	6.4	6.1	6.2

Table A3. Turbidity (NTU)

DATE	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	SAMPLE NUMBER													
2-AUG-1990	1.3	1.5	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.1	0.0
3-AUG-1990	1.1	0.8	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.1
6-AUG-1990	1.2	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7-AUG-1990	1.2	0.8	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.0	0.2	0.1	0.2
8-AUG-1990	1.2	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9-AUG-1990	1.2	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
10-AUG-1990	1.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13-AUG-1990	1.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14-AUG-1990	1.2	0.6	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15-AUG-1990	1.3	1.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16-AUG-1990	1.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
17-AUG-1990	1.3	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
20-AUG-1990	1.6	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
21-AUG-1990	1.4	0.7	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
22-AUG-1990	1.4	0.6	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.1
23-AUG-1990	1.3	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1
24-AUG-1990	1.3	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28-AUG-1990	1.2	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
29-AUG-1990	1.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30-AUG-1990	1.2	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
31-AUG-1990	1.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3-SEP-1990	1.2	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
4-SEP-1990	0.9	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-SEP-1990	0.9	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6-SEP-1990	1.1	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
7-SEP-1990	1.3	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10-SEP-1990	1.2	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
11-SEP-1990	1.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12-SEP-1990	1.1	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13-SEP-1990	1.2	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14-SEP-1990	1.1	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17-SEP-1990	1.4	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18-SEP-1990	1.2	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19-SEP-1990	2.4	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20-SEP-1990	2.4	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21-SEP-1990	2.4	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24-SEP-1990	2.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.2	0.3
25-SEP-1990	1.9	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27-SEP-1990	1.9	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28-SEP-1990	1.8	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.2	0.2	0.2	0.4
1-OCT-1990	1.7	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-OCT-1990	1.5	1.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
3-OCT-1990	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-OCT-1990	2.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-OCT-1990	2.2	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8-OCT-1990	2.5	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9-OCT-1990	2.2	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10-OCT-1990	2.4	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12-OCT-1990	2.4	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A3. Turbidity (NTU) (Continued)

DATE	SAMPLE NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	13	14
15-OCT-1990	2.4	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16-OCT-1990	2.6	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17-OCT-1990	2.7	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18-OCT-1990	3.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19-OCT-1990	3.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22-OCT-1990	2.2	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
23-OCT-1990	2.1	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25-OCT-1990	2.2	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26-OCT-1990	2.2	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29-OCT-1990	3.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
30-OCT-1990	3.2	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31-OCT-1990	2.8	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-NOV-1990	3.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-NOV-1990	2.8	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-NOV-1990	2.7	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6-NOV-1990	3.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7-NOV-1990	2.6	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8-NOV-1990	2.3	3.5	0.9	1.1	0.1	0.4	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.1
9-NOV-1990	2.6	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12-NOV-1990	2.4	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13-NOV-1990	2.8	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14-NOV-1990	2.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
15-NOV-1990	2.6	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16-NOV-1990	2.4	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19-NOV-1990	2.6	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20-NOV-1990	2.4	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22-NOV-1990	3.1	1.0	0.0	0.0	0.4	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
23-NOV-1990	2.4	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26-NOV-1990	2.5	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27-NOV-1990	2.9	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28-NOV-1990	2.9	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29-NOV-1990	3.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30-NOV-1990	3.9	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3-DEC-1990	2.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-DEC-1990	2.3	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-DEC-1990	2.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7-DEC-1990	2.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10-DEC-1990	2.3	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11-DEC-1990	3.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12-DEC-1990	2.6	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13-DEC-1990	2.4	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14-DEC-1990	2.6	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17-DEC-1990	2.5	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18-DEC-1990	2.4	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19-DEC-1990	2.4	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21-DEC-1990	2.6	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27-DEC-1990	3.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3-JAN-1991	3.6	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7-JAN-1991	3.7	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Sample 5 & 6 were on cont. B/W

Table A3. Turbidity (NTU) (Continued)

DATE	SAMPLE NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	13	14
8-JAN-1991	3.6	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9-JAN-1991	4.1	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10-JAN-1991	4.2	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11-JAN-1991	4.2	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14-JAN-1991	3.2	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15-JAN-1991	3.1	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16-JAN-1991	3.1	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17-JAN-1991	3.1	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18-JAN-1991	3.1	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21-JAN-1991	2.9	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22-JAN-1991	3.2	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23-JAN-1991	3.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24-JAN-1991	3.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28-JAN-1991	2.8	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29-JAN-1991	2.9	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30-JAN-1991	2.9	1.5	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0
31-JAN-1991	2.9	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-FEB-1991	3.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-FEB-1991	2.7	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-FEB-1991	2.8	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6-FEB-1991	3.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7-FEB-1991	2.8	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8-FEB-1991	2.9	1.1	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0		
11-FEB-1991	2.7	1.2	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0		
12-FEB-1991	2.8	1.4	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0		
14-FEB-1991	2.5	1.3	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0		
15-FEB-1991	2.6	1.2	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0		
18-FEB-1991	2.7	1.2	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0		
19-FEB-1991	2.6	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20-FEB-1991	2.7	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21-FEB-1991	2.8	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22-FEB-1991	2.9	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25-FEB-1991	3.8	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26-FEB-1991	3.7	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27-FEB-1991	3.8	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28-FEB-1991	3.7	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-MAR-1991	3.7	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
4-MAR-1991	3.6	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-MAR-1991	3.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6-MAR-1991	3.6	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7-MAR-1991	3.5	1.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8-MAR-1991	3.5	1.3	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
11-MAR-1991	3.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12-MAR-1991	3.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13-MAR-1991	3.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14-MAR-1991	3.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15-MAR-1991	3.1	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18-MAR-1991	2.9	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19-MAR-1991	2.7	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A4. Iron (mg/l)

DATE	SAMPLE NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	13	14
7-AUG-1990	0.45	0.67	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.04	0.03
14-AUG-1990	0.39	0.59	0.13	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.03	0.04	0.04
21-AUG-1990	0.45	0.68	0.09	0.09	0.07	0.10	0.08	0.05	0.07	0.10	0.12	0.10	0.08	0.08
29-AUG-1990	0.43	0.76	0.07	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.08	0.07	0.06	0.06
4-SEP-1990	0.31	0.74	0.06	0.06	0.03	0.04	0.06	0.06	0.06	0.03	0.03	0.03	0.04	0.06
11-SEP-1990	0.42	0.68	0.02	0.03	0.02	0.02	0.09	0.02	0.02	0.01	0.01	0.02	0.02	0.02
18-SEP-1990	0.52	0.63	0.06	0.05	0.04	0.06	0.04	0.07	0.05	0.05	0.04	0.03	0.05	0.06
25-SEP-1990	0.53	0.72	0.06	0.04	0.03	0.04	0.05	0.05	0.05	0.02	0.03	0.02	0.03	0.05
2-OCT-1990	0.51	0.76	0.14	0.09	0.06	0.06	0.05	0.06	0.06	0.04	0.05	0.03	0.07	0.08
9-OCT-1990	0.62	0.90	0.17	0.17	0.17	0.19	0.15	0.17	0.17	0.19	0.17	0.16	0.17	0.17
16-OCT-1990	0.57	0.73	0.02	0.03	0.02	0.06	0.03	0.03	0.03	0.02	0.03	0.05	0.05	0.04
23-OCT-1990	0.52	0.74	0.03	0.02	0.02	0.02	0.01	0.02	0.01	0.01	0.02	0.13	0.04	0.03
30-OCT-1990	0.60	0.72	0.06	0.01	0.01	0.02	0.01	0.02	0.02	0.00	0.01	0.00	0.01	0.02
6-NOV-1990	0.52	0.92	0.02	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02
13-NOV-1990	0.51	0.81	0.03	0.02	0.01	0.02	0.02	0.01	0.01	0.02	0.04	0.01	0.02	0.02
20-NOV-1990	0.46	0.76	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01
27-NOV-1990	0.53	0.73	0.05	0.06	0.02	0.02	0.02	0.05	0.02	0.02	0.03	0.05	0.04	0.04
4-DEC-1990	0.44	0.70	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.00	0.04	0.00	0.03	
11-DEC-1990	0.51	0.85	0.02	0.02	0.02	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.02
18-DEC-1990	0.45	0.86	0.02	0.04	0.05	0.03	0.03	0.03	0.03	0.04	0.07	0.03	0.04	0.04
8-JAN-1991	0.49	0.90		0.03	0.02	0.03		0.04	0.06	0.03	0.01	0.03		0.07
15-JAN-1991	0.44	1.09	0.03	0.02	0.04	0.01		0.03	0.04	0.02	0.03	0.05	0.04	0.07
22-JAN-1991	0.42	0.89	0.02	0.03	0.02	0.03	0.03	0.08			0.01	0.02	0.05	0.04
29-JAN-1991			0.08		0.03	0.04	0.08	0.03				0.03		
5-FEB-1991	0.38	0.83	0.05	0.02	0.03	0.03	0.04			0.03	0.02	0.01	0.05	0.06
12-FEB-1991		0.79	0.03	0.04	0.03			0.03			0.04			
19-FEB-1991	0.37	0.91	0.02	0.01	0.02	0.03		0.01	0.01	0.00	0.02	0.01	0.01	0.01
26-FEB-1991	0.39	0.73	0.02	0.01	0.02	0.02	0.02	0.02	0.03	0.01	0.02	0.02	0.03	0.04
5-MAR-1991	0.35	0.73	0.01	0.01	0.01	0.01	0.00	0.00	0.02	0.01	0.00	0.00	0.02	0.02
12-MAR-1991	0.32	0.66	0.02	0.02	0.02	0.01	0.03	0.01	0.02	0.01	0.01	0.01	0.02	0.02
19-MAR-1991	0.33	0.62	0.02	0.01	0.00	0.02	0.01	0.01	0.02	0.05	0.01	0.01	0.01	0.02

Table A5 Paired Iron 't' Tests, with respect to Sample 4

Sample No.	3	5	6	7	8	9	10	11	12	13	14
Mean	-0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01
Std.Dev.	0.02	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.03	0.01	0.02
No.Points	29	30	29	26	29	27	28	30	29	28	28
Maximum	0.02	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.06	0.02	0.02
Minimum	-0.10	-0.02	-0.03	-0.06	-0.05	-0.03	-0.04	0.03	0.11	0.03	0.05
Student's 't	-2.20	2.10	0.09	0.64	0.48	0.52	1.77	0.40	0.28	1.36	2.64

Table A6. Manganese (mg/l)

DATE	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	SAMPLE NUMBER													
7-AUG-1990	0.20	0.21	0.23	0.21	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14-AUG-1990	0.17	0.18	0.19	0.20	0.00	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.00
21-AUG-1990	0.16	0.15	0.13	0.19	0.01	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01
29-AUG-1990	0.17	0.19	0.19	0.19	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01
4-SEP-1990	0.18	0.20	0.19	0.23	0.00	0.00	0.02	0.01	0.01	0.00	0.01	0.01	0.01	0.01
11-SEP-1990	0.17	0.17	0.18	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18-SEP-1990	0.17	0.19	0.16	0.18	0.00	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.01	0.01
25-SEP-1990	0.17	0.19	0.17	0.21	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2-OCT-1990	0.17	0.18	0.19	0.19	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01
9-OCT-1990	0.16	0.18	0.18	0.19	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
16-OCT-1990	0.16	0.17	0.18	0.19	0.01	0.01	0.01	0.00	0.02	0.02	0.02	0.02	0.03	0.03
23-OCT-1990	0.15	0.17	0.17	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30-OCT-1990	0.16	0.18	0.17	0.18	0.01	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.02	0.01
6-NOV-1990	0.18	0.20	0.19	0.20	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00
13-NOV-1990	0.16	0.18	0.17	0.19	0.01	0.06	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
20-NOV-1990	0.16	0.19	0.17	0.20	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.00	0.01	0.01
27-NOV-1990	0.17	0.19	0.17	0.20	0.03	0.03	0.00	0.01	0.01	0.01	0.02	0.01	0.02	0.03
4-DEC-1990	0.17	0.19	0.18	0.18	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	
11-DEC-1990	0.16	0.18	0.18	0.19	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
18-DEC-1990	0.16	0.18	0.17	0.17	0.01	0.02	0.02	0.02	0.03	0.03	0.04	0.00	0.01	0.01
8-JAN-1991	0.15	0.17		0.20	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02		0.02
15-JAN-1991	0.17	0.18	0.19	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
22-JAN-1991	0.17	0.18	0.17	0.19	0.00	0.00	0.00	0.00			0.00	0.00	0.00	0.00
29-JAN-1991			0.17		0.00	0.01	0.01	0.00				0.00		
5-FEB-1991	0.17	0.18	0.16	0.19	0.00	0.00	0.01			0.00	0.00	0.00	0.00	0.00
12-FEB-1991		0.17	0.16	0.17	0.00			0.00			0.00			
19-FEB-1991	0.17	0.18	0.16	0.17	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.01	0.00
26-FEB-1991	0.17	0.18	0.18	0.17	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
5-MAR-1991	0.17	0.19	0.17	0.17	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12-MAR-1991	0.17	0.18	0.17	0.18			0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
19-MAR-1991	0.18	0.19	0.16	0.18				0.00	0.00		0.03	0.01	0.01	0.01

Table A7 Paired Manganese 't' Tests.

Sample Nos.	2-1	3-2	4-2	5-8	6-8	7-8	9-8	10-8	11-8	12-8	13-8	14-8
Mean	0.01	-0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Std.Dev.	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
No.Points	29	29	30	28	27	27	27	26	29	29	27	27
Maximum	0.03	0.02	0.04	0.02	0.05	0.01	0.02	0.02	0.03	0.02	0.03	0.03
Minimum	-0.01	-0.03	-0.02	-0.01	-0.01	-0.01	-0.01	0.01	0.01	0.02	0.01	0.01
Student's 't	10.18	-3.14	2.38	0.33	1.59	1.00	2.30	0.27	1.68	0.49	1.36	1.57

Table A8 - Effect of 2° RGF pH on Manganese Removal

DATE	pH SAMPLE NUMBER				MANGANESE (µg/l) SAMPLE NUMBER			
	5	6	7	8	5	6	7	8
19-FEB-1991	9	8.9	8.9	8.9	4	0		3
20-FEB-1991	8.6	8.6	8.7	8.5	0	0	0	0
21-FEB-1991	8.6	8.4	8.8	8.7	0	0	3	1
22-FEB-1991	8.4	8	8.6	8.3		0	0	0
25-FEB-1991	8	7.8	7.4	7.2	0	0	3	0
26-FEB-1991	7.8	7.6	7.4	7.2	1	8	7	3
27-FEB-1991	8.2	7.8	7.8	7.6	3	9		
28-FEB-1991	8.7	8.3	8.7	8.6		22	4	
1-MAR-1991	8.8	8.6	8.7	8.4				2
4-MAR-1991	8	7.8	8.2	7.5		23	18	
5-MAR-1991	8	7.8	8.3	7.8	10	24	2	0
6-MAR-1991	7.6	7.8	7.3	7	24	59	0	0
7-MAR-1991	7.6	7.6	7.6	7.4	36	80	10	11
8-MAR-1991	7.5	7.6	7.6	7.3	41	93	2	0
11-MAR-1991	7	7.2	7.2	6.8	113	171	0	0
12-MAR-1991	6.9	7.2	7	6.8	171	196	4	3
13-MAR-1991	6.8	7	6.8	6.7	211	239	7	114
14-MAR-1991	6.8	6.8	6.7	6.8	230	255	20	0
15-MAR-1991	6.6	6.8	6.7	6.6	272	340	78	1
18-MAR-1991	6.6	6.7	6.5	6.4	230	321	138	3
19-MAR-1991	6.6	6.8	6.6	6.5	207	303	143	2

Table A9. Aluminium (mg/l)

DATE	SAMPLE NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	13	14
7-AUG-1990	0.18	0.10	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.02	0.03	0.03	0.03	0.02
14-AUG-1990	0.17	0.06	0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.02	0.03	0.03
21-AUG-1990	0.15	0.08	0.00	0.02	0.00	0.02	0.00	0.00	0.01	0.02	0.02	0.02	0.01	0.01
29-AUG-1990	0.09	0.05	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.02	0.01	0.00	0.00
4-SEP-1990	0.07	0.06	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.02	0.01	0.00
11-SEP-1990	0.09	0.04	0.00	0.00	0.00	0.00	0.03	0.01	0.01	0.00	0.02	0.01	0.03	0.00
18-SEP-1990	0.11	0.04	0.00	0.00	0.00	0.03	0.02			0.01		0.01	0.01	0.01
25-SEP-1990	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.01	0.01	0.02	0.02	0.02
2-OCT-1990	0.09	0.05	0.04	0.04	0.00	0.02	0.00	0.00	0.02	0.00	0.01	0.00	0.02	0.03
9-OCT-1990														
16-OCT-1990		0.17	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.05	0.02	
23-OCT-1990	0.24	0.16	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
30-OCT-1990	0.39	0.25	0.01	0.00	0.02	0.00	0.00	0.02	0.01	0.02	0.02	0.02	0.00	0.01
6-NOV-1990	0.37	0.28	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.04	0.03	0.04	0.03
13-NOV-1990	0.36	0.29	0.03	0.02	0.02	0.03	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.03
20-NOV-1990			0.03	0.02	0.03	0.02	0.03	0.03	0.02	0.05	0.02	0.02	0.02	0.03
27-NOV-1990	0.35	0.20	0.00	0.01	0.00	0.03	0.01	0.01	0.02	0.00	0.01	0.00	0.00	0.00
4-DEC-1990	0.32	0.21	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05
11-DEC-1990	0.31	0.26	0.07	0.05	0.07	0.05	0.08	0.07	0.07	0.08	0.07	0.08	0.07	0.07
18-DEC-1990														
8-JAN-1991	0.51	0.33		0.03	0.03	0.03	0.05	0.06	0.09	0.03	0.05	0.05		0.09
15-JAN-1991	0.46	0.34	0.04	0.04	0.04	0.03	0.04	0.05	0.04	0.05	0.04	0.04	0.06	0.07
22-JAN-1991	0.42	0.38	0.01	0.01	0.01	0.01	0.01	0.01			0.03	0.03	0.03	0.03
29-JAN-1991		0.33	0.02		0.02	0.02	0.02	0.03				0.03		
5-FEB-1991	0.41	0.31	0.02	0.03	0.01	0.02	0.03			0.02	0.02	0.03	0.02	0.02
12-FEB-1991	0.42	0.26	0.03	0.03	0.02	0.02		0.03			0.03			
19-FEB-1991	0.38	0.31	0.02	0.01	0.02	0.01		0.01	0.01	0.02	0.01	0.01	0.01	0.01
26-FEB-1991	0.52	0.26	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
5-MAR-1991	0.44	0.32	0.03	0.02	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
12-MAR-1991	0.45	0.31	0.03	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
19-MAR-1991	0.40	0.28	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Table A10 Paired Aluminium 't' Tests with respect to Sample 4

Sample No	3	5	6	7	8	9	10	11	12	13	14
Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
Std.Dev.	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
No.Points	27	28	28	26	26	24	26	27	27	26	26
Maximum	0.02	0.04	0.03	0.04	0.04	0.03	0.04	0.03	0.04	0.03	0.03
Minimum	-0.02	-0.02	-0.03	-0.03	-0.03	-0.06	-0.03	0.03	0.03	0.03	0.06
Student's 't	-1.15	0.72	0.29	-0.50	-0.52	-0.98	-0.88	1.66	1.63	1.29	2.13

Table A11 - Total Coliforms (per 100 ml)

(All Samples Except No. 9 Hand Chlorinated)

DATE	SAMPLE NUMBER 5	6	7	8	9	10	11	12	13	14
7-AUG-1990	0	0	0	0		0	0	0	0	0
14-AUG-1990	0	0	0	0	0	0	0	0	0	0
21-AUG-1990	0	0	0	0	0	0	0	0	0	0
29-AUG-1990	0	0	0	0	0	0	0	0	0	0
4-SEP-1990	0	0	0	0	0	0	0	0	0	0
11-SEP-1990	0	0	0	0	0	0	0	0	0	0
18-SEP-1990	0	0	0	0	0	0	0	0	0	0
25-SEP-1990	0	0	0	0	0	0	0	0	0	0
2-OCT-1990	0	0	0	0	0	0	0	0	0	0
9-OCT-1990	0	0	0	0	0	0	0	0	0	0
16-OCT-1990	0	0	0	0	0	0	0	0	0	0
23-OCT-1990	0	0	0	0	0	0	0	0	0	0
30-OCT-1990	0	0	0	0	0	0	0	0	0	0
6-NOV-1990	0	0	0	0	0	0	0	0	0	0
13-NOV-1990	0	0	0	0	0	0	0	0	0	0
20-NOV-1990	0	0	0	0	0	0	0	0	0	0
27-NOV-1990	0	0	0	0	0	0	0	0	0	0
4-DEC-1990	0	0	0	0	0	0	0	0	0	0
11-DEC-1990	0	0	0	0	0	0	0	0	0	0
18-DEC-1990	0	0	0	0	0	0	0	0	0	0
8-JAN-1991	0	0	0	0	0	0	0	0	0	0
15-JAN-1991	0	0	0	0	0	0	0	0	0	0
22-JAN-1991	0	0	0	0	0	0	0	0	0	0
29-JAN-1991	0	0	0	0	0	0	0	0	0	0
5-FEB-1991	0	0	0	0	0	0	0	0	0	0
12-FEB-1991	0	0	0	0		0	0	0		
19-FEB-1991	0	0	0	0	0	0	0	0	0	0
26-FEB-1991	0	0	0	0	0	0	0	0	0	0
5-MAR-1991	0	0	0	0	0	0	0	0	0	0
12-MAR-1991	0	0	0	0	0	0	0	0	0	0
19-MAR-1991	0	0	0	0	0	0	0	0	0	0

Table A12 - Total Coliforms (per 100 ml): Non-Chlorinated

(Only Sample No. 9 Hand Chlorinated)

DATE	SAMPLE NUMBER 5	6	7	8	9	10	11	12	13	14
11-DEC-1990	0	0	0	0	0	0	0	0	0	0
18-DEC-1990	0	0	0	0	0	0	0	0	0	0
8-JAN-1991	0	0	0	0	0	0	0	0	0	0
15-JAN-1991	0	0	0	0	0	0	0	0	0	0

Table A13 - E-Coli (per 100 ml): Non-Chlorinated

(All Samples Except No. 9 Hand Chlorinated)

DATE	SAMPLE NUMBER 5	6	7	8	9	10	11	12	13	14
7-AUG-1990	0	0	0	0		0	0	0	0	0
14-AUG-1990	0	0	0	0	0	0	0	0	0	0
21-AUG-1990	0	0	0	0	0	0	0	0	0	0
29-AUG-1990	0	0	0	0	0	0	0	0	0	0
4-SEP-1990	0	0	0	0	0	0	0	0	0	0
11-SEP-1990	0	0	0	0	0	0	0	0	0	0
18-SEP-1990	0	0	0	0	0	0	0	0	0	0
25-SEP-1990	0	0	0	0	0	0	0	0	0	0
2-OCT-1990	0	0	0	0	0	0	0	0	0	0
9-OCT-1990	0	0	0	0	0	0	0	0	0	0
16-OCT-1990	0	0	0	0	0	0	0	0	0	0
23-OCT-1990	0	0	0	0	0	0	0	0	0	0
30-OCT-1990	0	0	0	0	0	0	0	0	0	0
6-NOV-1990	0	0	0	0	0	0	0	0	0	0
13-NOV-1990	0	0	0	0	0	0	0	0	0	0
20-NOV-1990	0	0	0	0	0	0	0	0	0	0
27-NOV-1990	0	0	0	0	0	0	0	0	0	0
4-DEC-1990	0	0	0	0	0	0	0	0	0	0
11-DEC-1990	0	0	0	0	0	0	0	0	0	0
18-DEC-1990	0	0	0	0	0	0	0	0	0	0
8-JAN-1991	0	0	0	0	0	0	0	0	0	0
15-JAN-1991	0	0	0	0	0	0	0	0	0	0
22-JAN-1991	0	0	0	0	0	0	0	0	0	0
29-JAN-1991	0	0	0	0	0	0	0	0	0	0
5-FEB-1991	0	0	0	0	0	0	0	0	0	0
12-FEB-1991	0	0	0	0		0	0	0		
19-FEB-1991	0	0	0	0	0	0	0	0	0	0
26-FEB-1991	0	0	0	0	0	0	0	0	0	0
5-MAR-1991	0	0	0	0	0	0	0	0	0	0
12-MAR-1991	0	0	0	0	0	0	0	0	0	0
19-MAR-1991	0	0	0	0	0	0	0	0	0	0

Table A14 - E-Coli (per 100 ml)

(Only Sample No. 9 Hand Chlorinated)

DATE	SAMPLE NUMBER									
	5	6	7	8	9	10	11	12	13	14
11-DEC-1990	0	0	0	0	0	0	0	0	0	0
18-DEC-1990	0	0	0	0	0	0	0	0	0	0
8-JAN-1991	0	0	0	0	0	0	0	0	0	0
15-JAN-1991	0	0	0	0	0	0	0	0	0	0

Table A15 - 1 Day Colony Counts (at 22° C)

(All Samples Except No. 9 Hand Chlorinated)

DATE	SAMPLE NUMBER 5	6	7	8	9	10	11	12	13	14
7-AUG-1990	6	0	5	0		2	0	0	1	3
14-AUG-1990										
21-AUG-1990	1	0	0	0	0	0	0	4	0	5
29-AUG-1990	1	0	3	4	6	0	1	1	3	1
4-SEP-1990	1	22	0	0	1	1	10	26	1	5
11-SEP-1990	0	1	1	1	10	3	1	1	1	8
18-SEP-1990	3	5	14	1	1	4	1	0	10	6
25-SEP-1990	0	1		0	0	0	0	0	1	1
2-OCT-1990	3	3	0	0	1	1	1	5	1	1
9-OCT-1990	10	3	1	1	3	3	0	3	3	0
16-OCT-1990	4	0	6	4	5	1	4	4	0	4
23-OCT-1990	0	0	3	1	3	1	0	3	4	0
30-OCT-1990	4	5	1	0	3	0	0	5	1	1
6-NOV-1990	1	0	1	1	1	0	3	0	0	1
13-NOV-1990	1	0	0	0	1	1	0	1	1	0
20-NOV-1990	4	1	0	9	0	8	1	1	0	1
27-NOV-1990	18	0	0	0	0	1	7	2	0	1
4-DEC-1990	0	0	0	1	0	0	1	0	0	1
11-DEC-1990	0	1	1	0	0	1	1	0	0	3
18-DEC-1990	1	2	0	2	0	0	0	0	0	2
8-JAN-1991	0	0	0	1	1	3	0	1	2	1
15-JAN-1991	0	0	1	1	1	1	1	0	1	1
22-JAN-1991	5	0	1	0	0	2	1	0	0	1
29-JAN-1991	0	1	2	0	1	0	1	1		0
5-FEB-1991	1	5	1	0	1	27	2	3	1	2
12-FEB-1991	0	1	1	2		0	0	0		
19-FEB-1991	0	2	0	0	2	1	1	2	6	5
26-FEB-1991	29	2	0	3	2	14	3	8	7	7
5-MAR-1991	1	1	0	1	0	0	2	2	2	0
12-MAR-1991	1	0	0	2	2	0	3	1	0	0
19-MAR-1991	1	2	5	1	1	3	0	6	1	0

Table A16 - Paired 1 Day Colony Count 't' Test Data wrt Sample 8

(All Samples Except No. 9 Hand Chlorinated)

Sample No.	5	6	7	9	10	11	12	13	14
Mean	-2	-1	0	0	-1	0	-1	0	-1
Std.Dev.	6	5	3	3	5	3	5	3	3
No.Points	30	30	29	28	30	30	30	28	29
Maximum	5	8	9	9	4	8	8	9	8
Minimum	-26	-22	-13	-9	-27	-10	-26	-9	-7
Student's	-1.78	-0.84	-0.60	-0.84	-1.40	-0.56	-1.49	-0.80	-1.69

Table A17 - 't' values for unchlorinated colony counts w.r.t. sample 5 (only sample 9 hand chlorinated)

Sample	6	7	8	9	10	11	12	13	14
1 Day	0.50	0.88	0.00	0.58	0.00	0.00	1.44	1.36	0.85
3 Day	1.57	-0.86	0.81	-0.99	0.30	1.73	1.85	1.78	1.49

Table A18 - 3 Day Colony Counts (at 22°C)

(All Samples Except No. 9 Hand Chlorinated)

DATE	SAMPLE NUMBER 5	6	7	8	9	10	11	12	13	14
7-AUG-1990	4	3	5	4		1	1	1	21	9
14-AUG-1990										
21-AUG-1990	17	15	12	4	228	14	50	19	10	19
29-AUG-1990	9	4	1	10	392	10	51	51	51	51
4-SEP-1990	4	30	6	6	722	72	15	196	9	19
11-SEP-1990	13	1	1	3	130	10	1	1	5	3
18-SEP-1990	8	17	23	22	35	1	18	66	17	33
25-SEP-1990	18	5		131	109	6	63	18	4	1
2-OCT-1990	8	0	4	5	187	4	1	6	17	3
9-OCT-1990	49	8	5	4	60	10	3	10	21	5
16-OCT-1990	10	5	15	4	28	22	44	9	18	8
23-OCT-1990	28	44	1	50	53	12	1	15	9	5
30-OCT-1990	5	20	15	6	1	3	5	0	33	3
6-NOV-1990	1	5	0	32	257	0	3	12	4	30
13-NOV-1990	53	3	9	12	57	3	26	19	3	3
20-NOV-1990	157	4	19	1	3	8	8	117	5	2
27-NOV-1990	9	7	2	15	3	3	2	5	15	43
4-DEC-1990	5	14	2	3	9	6	207	2	27	5
11-DEC-1990	2	29	3	0	2	67	6	64	21	3
18-DEC-1990	0	69	11	32	2	227	2	18	14	0
8-JAN-1991	20	0	2	1	21	0	2	2	18	12
15-JAN-1991	0	6	2	20	28	2	3	12	6	0
22-JAN-1991	2	7	1	1	0	2	1	11	7	1
29-JAN-1991	2	1	1	3	3	6	3	5		2
5-FEB-1991	2	3	0	3	3	11	0	3	16	10
12-FEB-1991	1	10	0	2		0	8	6		
19-FEB-1991	18	9	1	0	1	7	6	1	0	1
26-FEB-1991	109	3	6	9	1	9	1	12	10	14
5-MAR-1991	9	5	7	11	5	2	8	11	5	6
12-MAR-1991	5	15	5	6	5	14	3	8	2	2
19-MAR-1991	5	3	2	0	78	2	1	1	14	1

Table A19 - Paired 3 Day Colony Count 't' Test Data wrt Sample 8

(All Samples Except No. 9 Hand Chlorinated)

Sample No.	5	6	7	9	10	11	12	13	14
Mean	-6	2	4	-72	-4	-5	-10	0	4
Std.Dev.	43	27	13	158	48	44	49	30	29
No.Points	30	30	29	28	30	30	30	28	29
Maximum	113	126	49	30	125	68	113	127	130
Minimum	-156	-37	-18	-716	-195	-204	-190	-41	-41
Student's	-0.73	0.38	1.55	-2.42	-0.51	-0.59	-1.12	0.08	0.67

Table A20. Ultraviolet Absorbance (per meter at 254nm)

DATE	SAMPLE NUMBER 1	1F	2	2F	3	4	5	6	7	8	9	10	11	12	13	14
2-AUG-1990	13.3	11.3	16.9	3.5	-0.5	2.7	-0.4	-0.4	-0.7	3.0	2.0	-0.6	-0.8	-0.6	-0.7	-0.4
3-AUG-1990	13.0	10.7	7.7	3.0	-0.6	2.5	-0.6	-0.7	-0.8	2.7	1.6	-0.8	-0.8	-0.5	-0.6	0.2
6-AUG-1990	15.2	12.6	9.3	3.8	0.1	3.3	0.2	0.1	0.4	3.6	2.3	0.0	0.0	0.4	0.1	1.2
7-AUG-1990	15.0	12.0	8.9	3.9	0.2	3.4	0.3	0.0	0.6	3.5	2.1	0.0	0.1	0.7	0.2	1.4
8-AUG-1990	14.8	12.1	8.5	3.6	0.0	3.2	0.1	0.0	0.3	3.2	2.0	-0.1	-0.2	0.5	-0.2	1.1
9-AUG-1990	14.7	12.1	8.9	3.4	0.0	3.3	0.1	-0.2	0.0	3.2	1.8	-0.2	-0.2	0.7	-0.1	1.0
10-AUG-1990	13.6	11.3	8.4	3.7	0.1	3.4	0.1	-0.1	0.9	3.3	2.1	-0.1	-0.1	1.2	0.0	1.3
13-AUG-1990	13.3	10.9	7.6	3.3	0.1	3.5	0.3	-0.1	1.2	3.3	3.5	-0.2	-0.1	1.8	-0.2	2.0
14-AUG-1990	13.2	11.0	10.2	3.7	0.4	3.6	0.4	0.2	1.3	3.5	1.7	0.1	0.2	1.8	0.4	1.7
15-AUG-1990	13.6	11.0	8.1	3.6	0.4	3.6	0.4	0.2	1.2	3.6	1.5	1.0	0.1	1.8	0.1	1.4
16-AUG-1990	13.9	11.0	8.1	3.5	0.5	3.7	0.6	0.2	1.5	3.6	1.6	0.1	0.2	2.0	0.3	1.4
17-AUG-1990	14.1	11.1	8.4	3.6	0.6	3.7	0.6	0.2	1.2	3.7	1.6	0.0	0.2	2.0	0.3	1.4
20-AUG-1990	14.3		8.1	3.5	0.4	3.5	0.5	0.1	1.1	3.4	1.3	-0.1	0.0	1.8	0.0	0.9
21-AUG-1990	14.3	11.2	8.6	3.6	1.2	4.7	1.1	0.7	2.3	4.0	1.9	0.7	0.9	2.9	0.5	1.6
22-AUG-1990	14.2	11.2	8.5	3.4	0.9	4.2	0.9	0.4	2.2	3.9	1.7	0.0	0.3	2.2	0.0	1.1
23-AUG-1990	14.1	11.1	8.5	3.8	0.9	3.5	0.9	0.4	2.0	3.5	1.5	0.1	0.3	2.3	0.3	1.5
24-AUG-1990	14.0	11.1	8.5	4.0	0.8	3.5	0.9	0.3	1.9	3.5	1.4	0.1	0.3	2.0	0.1	1.2
28-AUG-1990	13.0	10.9	8.1	3.3	0.4	3.5	0.5	0.0	1.7	3.3	1.7	-0.3	-0.1	1.7	-0.1	1.2
29-AUG-1990	13.8	11.4	8.0	3.5	0.7	3.4	0.7	0.3	1.9	3.6	1.8	0.0	0.2	2.0	0.1	1.3
30-AUG-1990	13.7	11.7	8.9	3.6	1.8	5.0	1.3	0.9	3.0	4.5	1.9	0.6	0.5	2.3	0.2	1.2
31-AUG-1990	13.4	11.4	8.3	3.4	1.1	3.7	1.0	0.5	2.3	3.7	1.7	0.0	0.5	2.3	0.2	1.3
3-SEP-1990	13.3	12.2	8.3	4.1	1.0	4.1	0.9	0.5	2.6	4.1	2.2	0.0	0.4	2.3	0.4	1.9
4-SEP-1990	13.3	11.7	8.2	3.5	1.1	4.0	0.9	0.5	2.8	4.3	2.2	-0.1	0.3	2.3	0.3	1.5
5-SEP-1990	13.4	12.0	8.8	4.2	1.6	4.7	1.3	0.9	3.1	4.4	1.7	0.1	0.8	2.8	0.5	1.4
6-SEP-1990	13.6	11.9	8.5	3.8	1.7	4.5	1.6	1.0	3.1	4.4	2.2	0.1	1.0	3.0	0.6	1.7
7-SEP-1990	14.0	12.2	8.4	3.7	1.1	3.5	1.1	0.5	2.3	3.6	1.5	0.0	0.7	2.4	0.3	1.2
10-SEP-1990	14.3	12.7	8.7	3.9	1.3	4.0	1.4	0.8	2.9	4.4	3.4	0.6	1.1	3.4	1.2	3.5
11-SEP-1990	14.1	12.1	8.3	3.6	1.1	3.6	1.3	0.7	2.4	3.9	1.5	0.0	0.6	2.3	0.3	1.2
12-SEP-1990	14.0	12.3	8.5	3.6	1.2	3.9	1.3	0.7	2.6	3.9	1.9	0.0	0.6	2.6	0.4	1.4
13-SEP-1990	14.1	12.3	8.1	3.7	1.4	3.9	1.4	0.8	2.6	3.9	1.6	0.0	0.5	2.4	0.3	1.2
14-SEP-1990	14.1	12.4	8.7	3.7	1.3	3.8	1.3	0.8	2.5	3.7	1.5	0.0	0.6	2.3	0.3	1.1
17-SEP-1990	14.0	12.1	8.3	3.5	1.2	3.7	1.2	0.7	2.6	3.8	1.8	0.1	0.6	2.4	0.4	1.3
18-SEP-1990	14.0	12.0	7.8	3.5	1.4	3.9	1.4	0.9	2.6	3.8	1.6	0.2	0.5	2.3	0.5	1.4
19-SEP-1990	14.8	12.4	7.8	3.6	2.0	5.2	1.6	1.3	3.6	4.8	2.5	0.2	1.0	3.1	0.6	1.7
20-SEP-1990	17.9	12.3	7.9	6.6	2.3	5.1	2.1	1.5	3.7	4.6	2.5	2.9	1.2	3.3	1.0	1.8
21-SEP-1990	15.8	13.4	8.7	3.6	2.3	5.2	2.0	1.5	3.8	4.7	2.4	0.3	1.3	3.4	1.2	2.0
24-SEP-1990	15.7	13.2	9.0	3.9	1.8	4.6	1.7	1.2	3.2	4.4	2.9	0.5	1.4	3.1	1.8	3.2
25-SEP-1990	15.5	13.1	8.4	3.6	1.6	3.6	1.6	1.0	2.7	3.9	2.1	0.2	0.9	2.8	0.8	1.7
27-SEP-1990	15.5	13.1	8.8	3.7	1.3	3.2	1.3	0.6	2.2	3.2	1.3	-0.2	0.2	1.8	0.0	1.1
28-SEP-1990	15.6	13.3	9.4	4.5	1.6	3.9	1.7	1.1	3.1	3.4	5.1	1.5	2.5	4.9	2.1	4.3
1-OCT-1990	15.3	13.1	8.8	3.9	1.7	3.6	1.7	1.0	2.7	3.6	1.6	0.0	0.7	2.5	0.2	1.2
2-OCT-1990	15.3	13.0	9.7	4.1	2.8	5.4	2.2	1.4	3.4	4.4	2.0	0.1	1.0	3.0	0.6	1.7
3-OCT-1990	16.7	14.2	9.4	4.2	2.4	4.8	2.3	1.9	3.7	4.6	1.8	0.2	1.3	3.4	0.5	1.3
4-OCT-1990	16.9	14.2	9.5	4.3	2.6	5.1	2.4	1.6	3.8	4.7	2.3	0.4	1.5	3.6	0.7	1.7
5-OCT-1990	17.3	14.5	9.4	3.8	1.8	3.6	1.9	1.3	2.8	3.6	1.5	0.2	1.1	2.8	0.4	1.2
8-OCT-1990	19.2	15.6	9.5	4.3	1.5	4.0	1.5	1.0	2.9	3.9	1.7	0.1	1.1	2.6	0.2	0.9
9-OCT-1990	19.0	15.4	9.6	3.9	1.7	3.8	2.2	1.3	3.0	4.2	2.1	0.2	1.2	3.1	0.5	1.3
10-OCT-1990	18.9	15.7	9.3	3.9	1.7	3.5	1.7	1.2	2.7	3.5	1.5	0.1	1.1	2.7	0.3	1.0
12-OCT-1990	21.1	17.2	9.9	4.4	1.9	3.7	1.9	1.3	2.9	3.7	1.5	0.2	1.1	2.9	0.3	1.2

Table A20. Ultraviolet Absorbance (per meter at 254nm) (Continued)

DATE	SAMPLE NUMBER															
	1	1F	2	2F	3	4	5	6	7	8	9	10	11	12	13	14
15-OCT-1990	20.8	17.0	9.6	4.4	1.7	3.7	1.7	1.1	2.7	3.7	1.6	0.2	1.1	2.9	0.3	1.2
16-OCT-1990	21.0	15.4	8.9	4.3	2.0	3.8	2.1	1.5	3.1	3.8	1.3	0.2	1.1	2.9	0.2	1.0
17-OCT-1990	20.3	16.5	9.2	4.3	2.6	5.9	2.5	1.8	4.4	5.1	1.7	0.4	1.5	3.6	0.2	1.0
18-OCT-1990	21.0	16.3	9.6	4.4	3.0	5.7	2.8	2.2	4.4	5.2	2.8	0.5	1.7	4.0	0.5	2.0
19-OCT-1990	21.2	17.0	9.7	4.6	3.0	5.2	2.8	2.2	4.2	4.9	2.9	0.6	1.8	3.8	0.6	1.8
22-OCT-1990	20.4	16.8	9.5	4.5	2.7	4.6	2.6	2.0	3.7	4.5	2.3	0.7	1.8	3.5	0.5	1.5
23-OCT-1990	19.9	15.7	9.0	4.0	2.3	3.7	2.3	1.7	3.2	3.9	1.1	0.5	1.4	3.1	0.5	1.2
25-OCT-1990	20.2	16.1	9.6	4.3	1.9	3.7	1.8	1.2	2.9	3.6	1.5	0.2	1.3	2.8	0.3	1.1
26-OCT-1990	20.1	16.2	9.8	4.3	2.2	3.7	2.1	1.5	3.1	3.7	1.2	0.2	1.3	2.9	0.3	1.0
29-OCT-1990	24.6	18.8	10.9	4.6	2.3	3.7	2.2	1.3	2.7	3.5	2.1	0.3	1.0	2.5	0.2	1.1
30-OCT-1990	24.3	18.8	10.3	4.6	2.6	3.9	2.6	2.1	3.3	4.0	1.5	0.5	1.3	3.0	0.4	1.3
31-OCT-1990	24.4	19.4	10.8	5.1	2.6	4.0	2.6	2.1	3.4	4.0	1.6	0.5	1.4	3.2	0.3	1.1
1-NOV-1990	25.3	20.3	10.9	4.7	2.6	3.9	2.6	2.0	3.4	3.9	1.6	0.6	1.5	3.3	0.3	1.1
2-NOV-1990	24.6	19.9	10.6	4.8	2.6	3.9	2.6	2.1	3.5	3.9	1.5	0.7	1.7	3.4	0.3	1.1
5-NOV-1990	23.9	19.4	11.1	4.4	2.6	3.8	2.6	2.1	3.3	3.8	1.6	0.7	1.9	3.4	0.5	1.2
6-NOV-1990	24.3	16.5	11.3	4.4	2.8	4.1	2.8	2.3	3.5	4.0	1.7	0.9	2.1	3.5	0.7	1.3
7-NOV-1990	24.0	19.1	16.1	4.8	3.1	4.3	3.0	2.5	3.8	4.3	1.5	1.0	2.2	3.5	0.8	1.2
8-NOV-1990	23.5	18.9	20.7	5.0	8.5	8.2	6.7	6.8	6.3	5.7	2.8	2.3	3.2	5.2	2.6	1.3
9-NOV-1990	23.5	18.7	10.7	4.6	2.9	4.8	3.0	2.4	4.2	4.9	3.1	1.3	3.0	4.9	2.0	3.1
12-NOV-1990	23.2	18.7	10.5	4.7	2.9	3.9	3.0	2.5	3.6	4.0	1.8	1.1	2.2	3.5	0.9	1.4
13-NOV-1990	23.6	17.3	10.5	4.4	2.9	4.0	2.8	2.2	3.4	3.8	1.4	0.8	2.1	3.3	0.7	1.3
14-NOV-1990	23.6	18.8	10.7	4.8	2.9	4.0	2.9	2.6	3.4	3.9	1.7	0.8	1.5	3.0	0.9	1.3
15-NOV-1990	23.6	18.9	10.6	4.8	3.0	4.1	3.0	2.3	3.7	4.1	2.0	0.9	2.0	3.5	0.7	1.5
16-NOV-1990	23.3	18.7	10.2	4.6	2.8	3.9	2.8	2.4	3.5	3.9	1.7	0.9	2.0	3.5	0.6	1.2
19-NOV-1990	26.0	20.8	10.6	4.8	3.1	3.9	3.1	2.5	3.1	3.8	2.7	1.3	1.6	3.0	0.5	1.2
20-NOV-1990	26.0	20.8	10.2	4.3	2.8	3.7	2.8	2.2	3.2	3.7	1.1	1.0	1.5	2.9	0.3	1.1
22-NOV-1990	25.9	19.8	10.1	4.5	2.8	3.7	3.8	2.5	3.1	3.6	1.6	0.9	1.6	2.9	0.3	1.2
23-NOV-1990	25.3	20.2	10.4	4.5	2.9	3.8	2.9	2.5	3.3	3.8	1.9	1.3	1.6	3.2	0.5	1.3
26-NOV-1990	25.1	20.1	10.6	4.5	3.0	3.9	3.0	2.6	3.4	3.9	1.4	1.4	2.0	3.4	0.5	1.2
27-NOV-1990	25.3	19.3	10.0	4.7	3.2	4.2	3.2	2.9	3.6	4.1	1.6	1.3	2.2	3.5	0.7	1.3
28-NOV-1990	25.4	19.8	10.6	4.5	3.1	4.2	3.0	2.8	3.6	4.0	1.1	1.3	2.1	3.4	0.4	0.9
29-NOV-1990	25.1	19.3	11.2	4.6	3.7	4.1	3.2	2.6	3.8	4.0	1.4	1.3	2.2	3.6	0.7	1.2
30-NOV-1990	25.4	17.5	10.7	4.9	3.3	4.2	3.1	2.4	3.7	4.2	1.5	1.2	2.4	3.8	0.7	1.3
3-DEC-1990	24.5	19.5	10.6	4.6	3.1	3.9	2.9	2.4	3.5	3.8	1.2	0.7	2.2	3.4	0.5	1.2
4-DEC-1990	24.4	18.9	10.4	4.3	3.2	4.0	3.3	2.9	3.7	4.1	1.7	1.3	2.6	3.7	0.9	1.2
5-DEC-1990	24.5	19.6	11.0	4.6	3.2	3.9	3.2	2.8	3.6	3.9	1.8	1.3	2.6	3.7	1.0	1.4
7-DEC-1990	24.4	19.6	11.0	4.7	3.2	4.2	3.1	2.8	3.7	4.1	1.2	1.4	2.6	3.5	0.7	1.0
10-DEC-1990	24.1	19.4	11.1	4.7	3.2	3.9	2.9	2.5	3.6	3.9	1.1	1.0	2.5	3.5	0.7	0.9
11-DEC-1990	24.6	19.0	10.8	4.5	3.3	4.0	3.4	2.8	3.7	4.1	1.2	1.5	3.0	3.6	0.7	1.1
12-DEC-1990	27.0	21.8	12.5	5.9	3.2	3.7	3.2	2.8	3.5	3.8	1.4	1.6	2.5	3.5	0.8	1.2
13-DEC-1990	25.5	20.4	11.4	5.2	3.2	3.9	3.2	2.9	3.6	3.9	1.4	1.6	2.7	3.6	0.9	1.2
14-DEC-1990	25.4	20.2	11.3	5.0	3.2	3.8	3.2	2.8	3.6	3.9	1.4	1.7	2.6	3.6	0.8	1.2
17-DEC-1990	25.1	20.1	11.8	4.9	3.2	3.8	3.2	2.9	3.5	3.8	1.2	1.7	2.5	3.5	0.7	1.0
18-DEC-1990	25.0	19.1	11.4	4.7	3.2	3.9	3.1	2.9	3.6	3.8	1.4	1.6	2.5	3.6	0.9	1.2
19-DEC-1990	25.0	19.4	11.2	4.7	3.2	3.8	3.1	2.9	3.5	3.9	1.4	1.5	2.5	3.5	0.9	1.2
21-DEC-1990	22.2	17.8	10.3	4.7	3.2	3.8	3.1	2.9	3.6	3.8	1.4	1.7	2.1	3.4	0.8	1.1
27-DEC-1990	24.3	19.5	9.7	4.2	3.0	3.7	3.0	2.8	3.5	3.7	1.3	1.7	2.5	3.4	0.7	1.0
3-JAN-1991	25.0	20.5	9.9	4.1	3.1	4.2	3.2	2.9	3.9	4.2	2.1	1.8	2.9	3.9	1.6	1.9
7-JAN-1991	24.7	20.0	9.8	4.1	2.7	3.3	2.8	2.6	3.2	3.4	1.2	1.5	2.4	3.2	1.0	1.1

5 & 6 B/W Continuously

Table A20. Ultraviolet Absorbance (per meter at 254nm) (Continued)

DATE	SAMPLE NUMBER															
	1	1F	2	2F	3	4	5	6	7	8	9	10	11	12	13	14
8-JAN-1991	25.0	19.8	10.3	4.9	3.3	4.0	3.2	2.9	3.8	4.1	2.0	2.0	2.8	3.6	1.7	2.0
9-JAN-1991	24.5	19.7	10.6	4.3	3.0	3.4	3.0	2.9	3.3	3.5	1.5	2.0	2.5	3.2	1.1	1.2
10-JAN-1991	24.3	19.4	11.1	4.3	2.8	3.3	2.9	2.7	3.0	3.3	1.1	1.9	2.3	2.9	0.9	1.1
11-JAN-1991	24.4	19.8	11.2	4.8	3.1	4.2		2.8	3.2	3.6	1.8	2.1	2.6	3.5	1.1	1.4
14-JAN-1991	23.9	19.9	10.5	4.4	3.2	3.7	3.3	3.0	3.6	3.8	1.9	2.0	2.9	3.7	1.7	1.6
15-JAN-1991	23.6	19.0	10.3	4.2	3.0	3.4	3.1	2.8	3.3	3.5	1.4	1.9	2.6	3.3	1.4	1.4
16-JAN-1991	23.7	19.6	10.7	4.4	2.9	3.3	2.9	2.7	3.2	3.3	1.2	1.7	2.4	3.1	1.0	1.1
17-JAN-1991	23.5	19.1	10.6	4.5	3.0	3.2	2.8	2.7	3.2	3.3	1.2	1.7	3.4	3.1	1.0	1.1
18-JAN-1991	23.4	19.1	10.8	4.5	2.8	3.2	2.8	2.6	3.1	3.3	1.3	1.7	2.4	3.2	1.1	1.2
21-JAN-1991	22.6	18.3	9.6	3.7	2.6	3.1	2.6	2.4	2.9	3.1	1.1	1.4	2.1	2.7	0.7	0.9
22-JAN-1991	23.0	16.3	9.7	4.2	2.9	3.3	2.9	2.7	3.2	3.3	1.2	1.8	2.4	3.2	1.0	1.2
23-JAN-1991	26.9	21.2	10.7	4.5	3.2	3.6	3.1	3.0	3.4	3.6	1.3	1.8	2.5	3.2	0.9	1.1
24-JAN-1991	27.3	22.1	11.7	5.1	3.3	3.7	3.3	3.1	3.7	3.8	1.5	3.1	2.8	3.5	1.2	1.3
28-JAN-1991	26.8	21.1	11.5	4.7	3.2	3.7	3.3	2.9	3.4	3.7	1.4	2.0	2.7	3.3	0.9	1.0
29-JAN-1991	27.0	20.4	11.8	5.1	3.5	4.0	3.5	3.3	3.9	4.2	1.7	2.2	2.9	3.7	1.2	1.6
30-JAN-1991	26.5	20.8	11.7	5.1	3.2	3.6	3.1	2.8	3.2	3.5	1.6	1.8	2.3	3.2	0.8	1.2
31-JAN-1991	26.5	21.2	11.2	4.8	3.5	3.9	3.4	3.2	3.7	4.0	1.4	2.1	2.8	3.7	1.1	1.3
1-FEB-1991	26.4	21.2	11.3	4.6	3.3	3.6	3.2	3.0	3.4	3.7	1.2	1.9	3.6	3.4	1.0	1.2
4-FEB-1991	26.0	20.9	11.2	4.5	3.5	4.0	3.5	3.3	3.7	4.0	1.6	2.2	2.8	3.7	1.1	1.4
5-FEB-1991	25.9	20.4	10.9	4.7	3.7	4.0	3.7	3.3	4.0	4.3	1.8	2.2	2.9	3.8	1.5	1.8
6-FEB-1991	26.0	20.6	11.5	4.9	3.4	3.7	3.4	3.2	3.6	3.8	1.3	2.2	2.8	3.6	1.0	1.4
7-FEB-1991	25.8	20.8	10.3	4.3	3.4	3.9	3.5	3.2	3.7	3.9		2.2	2.9	3.7		
8-FEB-1991	25.7	20.2	10.8	4.6	3.3	3.7	3.4	3.2	3.5	3.8		2.1	2.7	3.5		
11-FEB-1991	25.3	21.2	10.9	4.5	3.4	3.8	3.3	3.1	3.6	3.9		2.1	2.9	3.6		
12-FEB-1991	25.7	20.1	11.6	5.3	3.4	3.7	3.5	3.2	3.6	3.9		2.2	3.0	3.8		
14-FEB-1991	25.3	20.2	11.4	4.7	3.3	3.9	3.3	3.2	3.4	3.6		2.1	2.6	3.7		
15-FEB-1991	25.3	19.9	10.9	4.8	3.3	3.7	3.3	3.1	3.5	3.7		2.1	2.6	3.4		
18-FEB-1991	25.2	20.2	10.9	4.4	3.2	3.8	3.2	2.9	3.2	3.5	2.2	1.8	2.3	3.0	0.6	1.1
19-FEB-1991	24.8	18.4	10.9	4.3	3.3	3.5	3.1	2.8	3.3	3.6	0.8	1.7	2.2	3.0	0.4	0.8
20-FEB-1991	25.4	19.9	11.7	4.7	3.6	4.1	3.6	3.4	3.8	4.1	3.1	2.3	2.9	3.6	1.0	1.5
21-FEB-1991	26.1	20.4	12.4	5.1	3.9	4.3	3.9	3.7	4.1	4.4	2.1	2.4	3.2	4.2	1.5	2.1
22-FEB-1991	26.0	20.2	10.7	4.2	3.7	4.1	3.7	3.4	3.8	4.2	2.2	2.3	2.9	3.7	1.3	1.9
25-FEB-1991	25.6	19.8	11.1	4.6	3.3	3.5	3.1	2.8	3.2	3.7	2.1	1.9	2.4	3.2	0.8	1.3
26-FEB-1991	25.7	19.5	10.4	4.5	3.2	3.7	3.3	2.9	3.3	3.7	1.2	2.0	2.4	3.2	0.9	1.6
27-FEB-1991	25.6	19.7	10.5	4.3	3.4	3.8	3.3	3.1	3.5	3.9	2.9	2.0	2.5	3.3	0.9	1.5
28-FEB-1991	25.1	19.2	10.2	4.3	3.8	5.1	3.9	3.7	4.7	5.0	2.6	2.3	3.5	4.4	1.4	2.2
1-MAR-1991	25.3	19.4	10.1	4.2	3.6	4.1	3.7	3.5	3.9	4.1	2.3	2.2	2.8	3.6	1.1	1.6
4-MAR-1991	24.9	19.0	10.6	4.3	3.3	3.6	3.2	2.9	3.3	3.5	2.8	1.7	2.2	3.0	0.7	1.7
5-MAR-1991	25.2	19.0	10.1	4.1	3.3	3.6	3.3	3.0	3.4	3.6	1.4	2.0	2.4	3.1	0.8	1.6
6-MAR-1991	25.4	19.7	11.2	4.9	3.6	4.2	3.9	3.6	3.8	3.9	2.4	2.2	2.7	3.5	1.3	1.9
7-MAR-1991	25.3	19.3	10.0	4.3	4.1	5.2	4.1	3.9	4.7	4.9	2.4	2.5	3.2	4.0	1.5	2.3
8-MAR-1991	25.4	19.3	10.2	4.4	3.7	4.2	3.9	3.7	3.9	4.2	3.1	2.3	2.8	3.5	1.2	1.8
11-MAR-1991	24.4	18.8	9.5	4.0	3.3	3.7	3.3	3.0	3.3	3.5	1.6	1.9	2.3	3.0	0.9	1.6
12-MAR-1991	24.4	18.3	10.0	4.1	3.2	3.5	3.1	2.8	3.2	3.4	1.5	1.8	2.2	2.9	0.9	1.6
13-MAR-1991	23.8	18.2	9.5	3.9	3.2	3.5	3.1	2.8	3.0	3.4	1.6	1.7	2.1	2.8	0.8	1.4
14-MAR-1991	24.2	18.1	9.9	4.2	3.3	3.6	3.2	2.8	3.0	3.4	2.0	1.5	2.0	2.8	0.7	1.3
15-MAR-1991	24.2	18.1	9.8	4.4	3.3	3.6	3.4	2.9	3.1	3.5	2.4	1.7	2.2	2.9	0.9	1.5
18-MAR-1991	23.7	17.5	9.5	4.1	3.2	3.5	3.1	2.7	2.7	3.2	2.2	1.5	1.8	2.6	0.7	1.4
19-MAR-1991	23.5	17.1	9.5	4.1	3.3	3.6	3.2	2.7	2.8	3.2	1.1	1.6	1.9	2.8	0.8	1.6

Table A21. Colour (Hazen)

DATE	1	1F	2	2F	3	4	5	6	7	8	9	10	11	12	13	14
	SAMPLE NUMBER															
2-AUG-1990	21	14	50	3	0	1	0	0	0	1	0	0	0	0	0	0
3-AUG-1990	20	14	14	4	1	2	1	1	0	3	2	1	1	1	1	2
6-AUG-1990	24	14	15	1	0	1	0	0	0	1	0	0	0	0	0	0
7-AUG-1990	26	15	15	2	2	3	0	0	0	2	1	0	0	0	0	1
8-AUG-1990	24	14	13	2	0	1	0	0	0	1	0	0	0	0	0	0
9-AUG-1990	24	15	14	2	0	2	0	0	0	2	1	0	0	0	0	0
10-AUG-1990	22	14	13	3	0	2	0	0	0	2	1	0	0	0	1	0
13-AUG-1990	21	14	12	2	0	2	0	0	1	3	3	0	0	1	0	1
14-AUG-1990	22	12	12	1	0	1	0	0	0	1	0	0	0	1	0	0
15-AUG-1990	22	13	12	3	0	2	0	0	0	2	1	0	0	1	0	1
16-AUG-1990	24	13	12	2	0	2	0	0	1	2	1	0	0	1	1	1
17-AUG-1990	24	13	13	2	0	2	0	0	1	2	1	0	0	1	0	1
20-AUG-1990	25	14	13	3	1	3	1	1	2	3	2	1	1	2	1	1
21-AUG-1990	25	13	13	3	2	4	2	2	2	4	2	1	2	1	1	2
22-AUG-1990	26	14	14	3	1	4	2	2	3	6	3	1	1	3	1	1
23-AUG-1990	24	12	13	2	0	2	0	0	1	2	1	0	0	1	0	1
24-AUG-1990	24	13	14	3	1	3	2	2	2	3	2	1	1	2	1	1
28-AUG-1990	22	14	13	3	1	3	1	1	2	4	1	0	0	1	0	1
29-AUG-1990	23	14	12	3	1	2	1	0	1	3	1	0	0	1	0	1
30-AUG-1990	23	13	14	2	2	4	1	1	3	4	1	1	1	1	0	1
31-AUG-1990	21	13	13	3	2	3	2	2	3	4	2	1	2	3	1	3
3-SEP-1990	20	17	12	6	1	3	0	0	2	3	1	0	0	1	1	1
4-SEP-1990	18	12	11	1	0	1	0	1	0	1	0	-1	-1	0	-1	0
5-SEP-1990	18	13	12	2	0	1	0	0	0	1	0	-1	0	0	-1	0
6-SEP-1990	20	14	13	3	2	3	2	1	3	3	1	1	2	3	1	1
7-SEP-1990	22	15	13	4	1	2	1	1	2	3	1	0	1	1	0	1
10-SEP-1990	22	15	13	3	0	2	0	0	2	3	1	0	0	2	1	2
11-SEP-1990	20	13	12	2	0	1	0	0	1	2	0	0	0	0	0	0
12-SEP-1990	22	14	13	3	1	3	1	1	2	3	1	0	1	2	0	1
13-SEP-1990	22	15	13	2	1	2	1	0	2	3	0	0	0	1	0	1
14-SEP-1990	22	15	14	3	1	3	1	1	2	3	1	0	1	2	0	1
17-SEP-1990	23	14	13	2	0	2	1	0	1	2	0	0	0	0	0	0
18-SEP-1990	23	14	12	2	1	2	1	0	2	2	1	1	1	1	0	1
19-SEP-1990	25	14	11	1	0	2	0	0	1	2	0	-1	0	0	-1	-1
20-SEP-1990	23	14	12	9	0	1	0	0	0	0	1	0	1	2	0	0
21-SEP-1990	29	17	13	2	1	4	1	1	3	4	1	0	2	3	2	3
24-SEP-1990	28	15	14	2	1	3	1	1	3	3	3	1	2	3	3	4
25-SEP-1990	28	17	13	2	1	2	1	1	2	3	2	1	1	2	1	1
27-SEP-1990	26	15	13	2	0	1	0	0	0	1	0	0	0	0	0	0
28-SEP-1990	25	15	14	4	0	2	0	0	1	2	6	2	3	4	3	6
1-OCT-1990	25	17	14	2	1	2	0	0	1	2	0	0	0	1	0	0
2-OCT-1990	25	17	15	3	2	4	1	1	2	3	0	0	0	1	1	1
3-OCT-1990	29	18	14	3	2	3	2	2	3	4	1	0	2	3	1	1
4-OCT-1990	29	18	15	4	2	4	2	2	4	4	2	1	2	3	1	2
5-OCT-1990	30	18	15	3	1	3	2	2	3	3	2	1	2	3	1	2
8-OCT-1990	33	18	14	3	0	2	0	0	1	1	0	0	0	1	0	0
9-OCT-1990	32	19	14	2	0	2	1	0	2	2	0	0	0	1	0	0
10-OCT-1990	32	20	14	3	0	1	0	0	2	2	0	0	1	2	0	0
12-OCT-1990	35	20	17	3	1	2	1	0	2	2	0	0	1	2	0	0

Table A21. Colour (Hazen) (Continued)

DATE	1	1F	2	2F	3	4	5	6	7	8	9	10	11	12	13	14
	SAMPLE NUMBER															
15-OCT-1990	35	20	14	3	0	2	0	0	1	2	0	0	0	1	0	1
16-OCT-1990	36	18	13	3	0	1	0	0	0	1	0	0	0	0	0	0
17-OCT-1990	36	20	13	3	1	3	1	0	2	2	1	0	1	2	0	0
18-OCT-1990	36	19	14	4	2	6	2	2	4	4	2	0	1	2	0	0
19-OCT-1990	37	21	14	7	2	4	1	0	3	3	1	0	1	3	1	2
22-OCT-1990	34	21	14	6	1	3	1	1	3	3	2	0	1	2	0	0
23-OCT-1990	32	18	13	2	1	2	1	1	2	2	0	0	1	2	0	0
25-OCT-1990	32	19	13	2	0	1	0	0	1	1	0	0	0	0	0	0
26-OCT-1990	33	20	14	3	0	1	0	0	1	2	0	0	0	1	0	0
29-OCT-1990	42	21	17	2	0	1	0	0	0	1	0	0	0	0	0	0
30-OCT-1990	43	22	15	2	0	1	0	0	1	2	0	0	0	1	0	0
31-OCT-1990	42	23	15	3	1	2	1	1	2	2	0	0	0	1	0	0
1-NOV-1990	43	24	15	2	1	1	0	0	2	2	0	0	0	0	0	0
2-NOV-1990	42	24	15	2	1	1	1	0	1	2	0	0	0	1	0	0
5-NOV-1990	41	23	18	2	1	1	1	1	2	2	0	0	0	1	0	0
6-NOV-1990	43	17	19	2	1	2	1	1	2	2	0	0	1	2	0	0
7-NOV-1990	40	23	30	2	0	1	1	0	1	2	0	0	0	1	0	0
8-NOV-1990	40	23	48	3	21	17	8	10	7	7	2	3	3	6	2	2
9-NOV-1990	40	23	17	2	2	2	2	1	2	3	1	0	2	3	1	2
12-NOV-1990	39	22	14	2	1	1	0	0	2	1	-1	-1	0	0	-1	-1
13-NOV-1990	41	20	15	2	0	1	0	0	1	1	0	0	0	1	0	0
14-NOV-1990	39	23	14	2	0	1	0	0	1	1	0	0	0	1	0	0
15-NOV-1990	41	23	15	2	1	2	0	0	2	2	0	0	0	1	-1	0
16-NOV-1990	39	22	14	2	1	2	1	1	2	2	0	0	1	2	0	0
19-NOV-1990	43	24	13	0	0	0	0	0	0	0	-1	-1	-1	0	-1	-1
20-NOV-1990	44	26	14	1	0	1	0	0	0	0	0	0	0	0	0	0
22-NOV-1990	44	22	13	0	0	0	3	0	0	0	-1	-1	0	0	-1	-1
23-NOV-1990	42	24	14	1	0	0	0	0	0	0	-1	0	0	0	-1	-1
26-NOV-1990	42	24	14	1	0	0	0	0	0	0	-1	0	0	0	-1	-1
27-NOV-1990	45	23	13	1	0	0	0	0	1	2	0	0	0	0	0	0
28-NOV-1990	45	25	13	1	0	1	0	1	1	0	0	0	0	0	-1	-1
29-NOV-1990	45	23	17	1	0	0	0	0	0	0	-2	0	0	0	-2	-2
30-NOV-1990	45	20	14	2	0	1	0	0	0	0	-1	-1	0	0	-1	-1
3-DEC-1990	43	25	15	2	1	1	0	0	2	2	0	0	1	1	0	0
4-DEC-1990	42	23	15	2	1	2	2	2	2	3	1	0	1	2	0	0
5-DEC-1990	42	25	17	3	2	2	2	3	2	2	1	1	2	2	0	0
7-DEC-1990	42	25	17	2	1	1	1	1	2	2	0	0	0	2	0	0
10-DEC-1990	43	25	19	3	2	2	1	1	2	2	0	0	1	2	0	0
11-DEC-1990	44	23	18	2	0	0	1	-2	-1	-1	-3	-3	-3	0	-2	-2
12-DEC-1990	50	31	22	6	3	3	3	2	3	3	1	1	2	3	1	2
13-DEC-1990	45	26	19	4	1	2	1	1	1	1	0	0	0	1	0	0
14-DEC-1990	45	26	18	3	1	2	1	1	2	2	0	0	1	2	0	0
17-DEC-1990	45	26	19	3	2	2	2	2	3	3	0	1	2	2	0	0
18-DEC-1990	44	24	19	2	1	1	1	1	2	2	0	0	1	2	1	1
19-DEC-1990	43	24	19	3	1	2	1	1	2	1	0	0	1	1	0	0
21-DEC-1990	39	22	14	0	-1	-1	-1	-1	-1	-1	-2	-2	-1	-1	-2	-2
27-DEC-1990	50	28	17	2	1	1	1	1	2	2	0	0	1	2	0	0
3-JAN-1991	51	30	17	2	1	2	1	1	2	2	0	0	1	2	0	0
7-JAN-1991	51	29	17	2	1	2	1	1	2	2	0	0	0	1	-1	-1

Table A21. Colour (Hazen) (Continued)

DATE	SAMPLE NUMBER 1	1F	2	2F	3	4	5	6	7	8	9	10	11	12	13	14
8-JAN-1991	51	28	19	3	1	2	1	1	2	2	1	1	2	2	0	0
9-JAN-1991	51	29	17	2	0	1	0	0	0	0	-2	-1	0	0	-2	-2
10-JAN-1991	51	29	22	3	1	0	1	1	2	0	0	0	1	0	0	1
11-JAN-1991	51	29	22	2	0	1	2	1	2	2	0	1	1	2	2	1
14-JAN-1991	48	32	18	3	2	2	2	2	3	2	0	1	2	2	0	1
15-JAN-1991	46	26	18	2	1	2	2	2	2	2	0	0	1	2	0	0
16-JAN-1991	47	29	19	3	1	1	2	2	2	2	0	1	1	2	0	1
17-JAN-1991	46	28	18	3	1	1	1	1	2	2	1	1	2	2	0	0
18-JAN-1991	46	29	19	3	2	2	2	2	2	2	0	2	2	3	0	0
21-JAN-1991	44	25	17	2	1	1	1	1	2	1	0	0	1	1	0	0
22-JAN-1991	44	20	17	2	1	2	2	2	3	2	0	1	1	2	0	0
23-JAN-1991	45	26	17	2	1	1	1	1	1	1	0	0	1	1	0	0
24-JAN-1991	50	29	19	3	1	1	1	1	2	2	0	1	2	2	0	0
28-JAN-1991	50	29	21	3	2	2	2	2	2	2	0	1	2	2	0	0
29-JAN-1991	50	26	20	3	2	2	2	2	2	2	0	1	2	2	0	0
30-JAN-1991	48	26	20	3	1	1	1	1	1	1	0	0	0	1	0	0
31-JAN-1991	48	29	18	3	1	2	1	1	2	2	0	0	1	2	0	0
1-FEB-1991	48	29	19	3	1	1	1	1	1	1	0	0	1	1	0	0
4-FEB-1991	47	29	20	3	2	2	2	2	2	2	0	1	2	2	0	0
5-FEB-1991	47	26	19	3	2	2	2	2	3	3	0	1	2	2	0	0
6-FEB-1991	47	28	20	3	2	2	2	2	2	2	1	2	2	2	1	1
7-FEB-1991	47	28	17	3	2	2	2	2	2	2	0	1	2	2	0	0
8-FEB-1991	47	26	18	3	2	2	2	2	2	2		1	2	2		
11-FEB-1991	46	30	18	2	1	1	1	1	2	1		0	1	1		
12-FEB-1991	47	28	20	3	1	2	2	2	2	2		2	2	2		
14-FEB-1991	45	28	20	3	1	1	1	2	2	2		1	1	2		
15-FEB-1991	46	26	20	4	1	1	1	1	1	1		0	1	1		
18-FEB-1991	46	26	18	2	1	1	0	0	0	0	-1	0	0	0	-1	-1
19-FEB-1991	45	24	19	3	2	0	1	0	0	0	-1	0	0	0	-1	0
20-FEB-1991	47	29	22	4	2	2	2	2	3	2	0	1	2	2	1	1
21-FEB-1991	48	29	24	4	3	3	3	3	4	3	2	2	3	4	2	2
22-FEB-1991	47	26	19	2	2	2	3	2	2	2	1	1	2	3	1	1
25-FEB-1991	50	25	20	3	2	2	2	2	2	2	1	1	2	2	0	0
26-FEB-1991	50	25	18	3	1	2	2	1	1	1	0	0	1	1	0	0
27-FEB-1991	51	26	19	3	2	2	2	2	2	2	0	1	2	2	0	0
28-FEB-1991	51	26	20	4	4	7	4	6	7	7	3	3	6	6	3	4
1-MAR-1991	50	25	18	3	3	3	3	4	4	4	1	2	2	3	1	1
4-MAR-1991	50	25	19	3	2	3	2	2	2	2	0	1	1	2	0	1
5-MAR-1991	47	24	17	2	1	2	2	2	2	1	0	0	1	2	0	0
6-MAR-1991	50	26	22	4	4	6	6	4	3	3	2	1	2	3	2	2
7-MAR-1991	50	28	19	4	3	4	3	2	3	3	1	1	2	3	1	1
8-MAR-1991	48	28	19	6	4	4	4	6	4	4	2	2	3	3	2	2
11-MAR-1991	48	28	17	4	1	3	3	4	3	3	2	2	2	2	2	2
12-MAR-1991	46	23	18	2	2	2	1	1	1	1	0	1	1	1	0	1
13-MAR-1991	45	24	17	2	2	2	2	1	2	1	0	1	1	1	0	0
14-MAR-1991	46	24	18	3	3	4	4	4	4	4	2	3	2	3	2	2
15-MAR-1991	46	24	18	4	3	3	3	3	3	3	1	2	2	2	1	1
18-MAR-1991	44	22	15	3	3	2	2	2	2	2	0	0	1	1	0	1
19-MAR-1991	43	22	17	3	2	2	2	2	2	2	0	1	1	2	1	1

Table A22 - Total Organic Carbon (mg/l)

DATE	SAMPLE NUMBER										
	1	5	6	7	8	9	10	11	12	13	14
7-AUG-1990	3.03	0.38	0.24	0.51	1.57	1.64	0.22	0.33	0.43	0.16	1.10
14-AUG-1990	2.54	0.23	0.00	0.51	1.26	1.19	0.95	0.13	1.01	0.28	1.33
21-AUG-1990	3.80	0.65	0.35	1.05	1.60	1.45	0.15	0.25	1.45	0.20	1.10
29-AUG-1990	3.65	1.54	1.28	1.90	2.37	2.99	0.90	1.02	1.93	0.93	6.18
4-SEP-1990	2.96	0.67	0.37	1.68	1.62	1.69	0.29	0.59	1.50	0.41	1.19
11-SEP-1990		1.07	0.85	1.45	2.10	1.98	0.45	0.97	1.60	1.01	1.45
18-SEP-1990											
25-SEP-1990	3.23	1.07	0.74	1.53	1.83	1.75	0.56	1.05	1.76	0.93	1.55
2-OCT-1990		2.35	2.01	2.81	3.47	3.19	1.74	2.15	3.92	1.92	2.91
9-OCT-1990	6.26	1.86	1.33	2.20	2.60	2.45	1.27	1.75	3.19	1.69	2.40
16-OCT-1990	4.89	2.34	2.15	2.69	3.12	2.93	1.66	2.06	3.03	1.80	2.97
23-OCT-1990	3.33	1.52	1.26	1.90	1.82	1.73	0.90	1.22	1.63	1.12	1.49
30-OCT-1990	6.30	2.20	2.00	2.10	3.90	2.90	1.00	2.00	2.50	1.50	2.90
6-NOV-1990	5.70	1.90	1.40	2.20	2.60	2.30	0.80	1.80	2.20	1.20	1.80
13-NOV-1990	5.50	2.40	1.80	2.40	2.50	1.90	1.50	1.50	2.90	1.10	1.90
20-NOV-1990	6.20	2.10	2.30	2.70	2.80	2.90	1.70	1.50	2.40	1.50	2.30
27-NOV-1990	7.80	4.15	3.30	3.70	3.75	3.65	2.90	3.00	4.20	2.70	3.90
4-DEC-1990	7.80	3.75	4.30	4.15	4.80	4.00	4.50	5.05	4.45	5.25	6.15
11-DEC-1990	5.15	2.80	2.10	2.90	2.70	2.90	2.45	2.60	3.85	2.60	2.60
18-DEC-1990	6.35	3.50	3.10	4.05	3.60	3.60	2.80	2.55	3.80	2.55	3.30
8-JAN-1991	6.73	3.95	3.90	4.73	3.18	4.90	3.45	4.10	4.60	3.73	3.90
15-JAN-1991	6.83	3.53	3.65	4.65	3.35	4.00	3.83	4.55	4.50	3.08	4.08
22-JAN-1991	6.00	3.05	2.60	2.65	2.88	2.60	2.38	2.48	2.88	2.33	2.45
29-JAN-1991	6.15	3.45	2.43	2.58	3.00	2.63	2.13	2.02	2.63	2.28	2.43
5-FEB-1991	7.18	3.48	3.05	3.38	3.25	3.10	2.75	2.75	3.13	3.00	2.90
12-FEB-1991	5.58	3.10	2.80	3.13	3.03		2.58	3.28	3.13		
19-FEB-1991	4.90	2.30	2.10	2.20	2.35	2.25	1.85	1.85	2.30	3.00	2.05
26-FEB-1991	5.05	2.38	2.20	2.43	2.70	2.35	1.98	2.08	2.35	1.78	2.20
5-MAR-1991	5.40	2.30	2.20	2.50	2.60	2.50	1.90	2.00	2.30	1.30	2.10
12-MAR-1991	4.20	2.60	1.70	2.50	1.90	2.10	1.40	2.90	2.20	1.50	2.10
19-MAR-1991	4.40	2.10	1.90	1.90	2.00	1.90	1.30	1.40	2.00	1.40	1.70

Table A23. Chlorine Demand (mg/l)

DATE	SAMPLE NUMBER 1	3	4	5	6	7	8	9	10	11	12	13	14
7-AUG-1990	0.98	0.19	0.59	0.43	0.30	0.22	0.17	0.16	0.18	0.25	0.36	0.10	0.23
14-AUG-1990	0.83	0.01		-0.02	-0.02	0.07	0.14	0.10	-0.03	-0.03	0.10	-0.05	0.06
21-AUG-1990	0.72	0.15	0.47	-0.02	0.06	0.17	0.27	0.24	0.07	0.07	0.18	0.06	0.16
29-AUG-1990	0.98	0.19	0.54	0.02	0.15	0.23	0.22	0.24	0.10	0.12	0.24	0.07	0.16
4-SEP-1990	0.92	0.11	0.41	0.07	0.13	0.19	0.14	0.15	0.08	0.09	0.14	0.00	0.11
11-SEP-1990	0.94	0.21	0.44	0.03	0.15	0.23	0.13	0.14	0.10	0.15	0.21	0.05	0.12
18-SEP-1990	0.89	0.24	0.54	0.01	0.19	0.34	0.19	0.18	0.18	0.22	0.26	0.14	0.20
25-SEP-1990	1.01	0.31	0.55	0.01	0.20	0.29	0.14	0.11	0.15	0.21	0.28	0.17	0.21
2-OCT-1990	0.87	0.29	0.51	0.07	0.22	0.24	0.11	0.17	0.18	0.25	0.34	0.10	0.24
9-OCT-1990	0.91	0.22	0.41	0.00	0.09	0.20	0.09	0.11	0.06	0.14	0.25	0.04	0.12
16-OCT-1990	0.96	0.25	0.39	0.01	0.11	0.19	0.14	0.20	0.07	0.10	0.11	0.07	0.17
23-OCT-1990	0.94	0.23	0.37	0.03	0.11	0.19	0.08	0.12	0.06	0.11	0.12	0.08	0.13
30-OCT-1990	1.10	0.25	0.37	0.04	0.16	0.20	0.08	0.13	0.10	0.15	0.13	0.06	0.10
6-NOV-1990	1.10	0.23	0.37	0.00	0.10	0.14	0.05	0.03	0.05	0.13	0.07	0.08	0.10
13-NOV-1990	1.08	0.30	0.40	0.04	0.16	0.24	0.16	0.16	0.17	0.15	0.13	0.18	0.23
20-NOV-1990	1.21	0.33	0.45	0.07	0.18	0.22	0.10	0.20	0.14	0.17	0.12	0.10	0.22
27-NOV-1990	1.14	0.33	0.44	0.13	0.19	0.19	0.13	0.13	0.17	0.21	0.13	0.11	0.19
4-DEC-1990	1.17	0.35	0.45	0.05	0.14	0.17	0.11	0.12	0.13	0.19	0.13	0.16	0.15
11-DEC-1990	1.10	0.36	0.43	0.05	0.14	0.23	0.12	0.12	0.17	0.19	0.13	0.18	0.21
18-DEC-1990	1.23	0.44	0.53	0.10	0.20	0.24	0.13	0.14	0.23	0.23	0.15	0.22	0.24
8-JAN-1991	1.21	0.33	0.42	0.11	0.22	0.14	0.08	0.06	0.26	0.34	0.20	0.21	0.18
15-JAN-1991	1.17	0.35	0.41	0.01	0.08	0.09	0.03	-0.03	0.16	0.19	0.08	0.17	0.15
22-JAN-1991	1.10	0.38	0.46	0.03	0.13	0.22	0.10	0.14	0.24	0.23	0.12	0.22	0.20
29-JAN-1991	1.21	0.46	0.53	0.07	0.15	0.16	0.05	0.11	0.26	0.29	0.14	0.21	0.16
5-FEB-1991	1.21	0.45	0.48	0.14	0.21	0.18	0.08	0.04	0.27	0.32	0.23	0.17	0.13
12-FEB-1991	1.19	0.46	0.51	0.09	0.17	0.15	0.08		0.30	0.33	0.11		
19-FEB-1991	1.29	0.56	0.57	0.11	0.19	0.26	0.19	0.14	0.32	0.36	0.18	0.20	0.27
26-FEB-1991	1.50	0.80	0.89	0.77	0.76	0.52	0.23	0.26	0.65	0.59	0.26	0.36	0.37
5-MAR-1991	1.60	0.77	0.84	0.76	0.73	0.32	0.18	0.14	0.59	0.48	0.22	0.29	0.28
12-MAR-1991	1.46	0.64	0.70	0.64	0.61	0.17	0.11	0.12	0.51	0.37	0.15	0.26	0.26
19-MAR-1991	1.37	0.62	0.68	0.64	0.53	0.21	0.02	0.12	0.45	0.22	0.11	0.18	0.22

Table A24 - THM development/Chlorine Residual Decay in Raw Water sample 1

TIME (hrs)	C13 ug/l	C12Br ug/l	ClBr2 ug/l	Br3 ug/l	Total ug/l
0.5	24.92	0.88	0.25	<0.03	26.08
3	26.14	1.01	0.33	<0.03	27.51
25	33.87	0.73	0.53	<0.03	35.16
48	30.31	0.70	0.42	<0.03	31.46

Table A25 - THM development/Chlorine Residual Decay in Treated Water sample 1

TIME (hrs)	C13 ug/l	C12Br ug/l	ClBr2 ug/l	Br3 ug/l	Total ug/l
0.5	8.13	0.94	0.15	<0.03	9.25
5	27.67	2.30	0.44	<0.03	30.44
25	23.56	1.45	0.26	<0.03	25.30
48	13.62	2.60	0.57	<0.03	16.82

Table A26 - THM development/Chlorine Residual Decay in Raw Water sample 2

TIME (hrs)	RESID mg/l	C13 ug/l	C12Br ug/l	ClBr2 ug/l	Br3 ug/l	Total ug/l
0.5	0.53	18.8	0.3	<0.1	<0.2	19.1
1	0.29	22.3	0.4	<0.1	<0.2	22.7
2	0.09	29.3	0.5	<0.1	<0.2	29.8
4	0.04	26.3	0.5	<0.1	<0.2	26.8
7	0.03	25.6	0.5	<0.1	<0.2	26.1
24	0.03	26.5	0.5	<0.1	<0.2	27.0
168*	0.05	26.2	0.5	<0.1	<0.2	26.7

*This sample was given a booster chlorine dose of 0.5 mg/l half an hour before sampling.

Table A27 - THM development/Chlorine Residual Decay in Treated Water sample 2

TIME (hrs)	RESID mg/l	Cl3 ug/l	Cl2Br ug/l	ClBr2 ug/l	Br3 ug/l	Total ug/l
0.1	0.65	5.9	0.3	<0.1	<0.2	6.2
0.5	0.52	9.7	0.6	<0.1	<0.2	10.3
1	0.44	10.2	0.8	0.2	<0.2	11.2
2	0.33	11.8	1.2	0.3	<0.2	11.8
4	0.17	15.2	2.1	0.5	<0.2	17.3
24	0.01	17.8	3.2	0.9	<0.2	21.0
168	0.00	17.1	2.5	0.8	<0.2	20.4
168*	0.26	17.8	3.6	1.1	<0.2	22.5

*This sample was given a booster chlorine dose of 0.5 mg/l half an hour before sampling.

Table A28 - THM Development with Excess Chlorine

Date Chlorine Added	Sample Number	Chlorination			T H M s				
		Time hrs	Demand mg/l	Resid mg/l	Cl3 ug/l	Cl2Br ug/l	ClBr2 ug/l	Br3 ug/l	Total ug/l
5 Jun 90	8	0.5	0.10	0.62	5.33	0.44	<0.05	<0.03	5.85
5 Jun 90	8	16.3	0.72	0.50	30.71	8.04	2.68	<0.03	41.46
5 Jun 90	*	0.5	0.38	0.69	<0.13	0.70	0.39	<0.03	1.25
5 Jun 90	*	16.3	0.79	0.51	15.10	7.88	4.54	<0.03	27.55
21 Jan 91	1	0.5	1.10	0.57	23.34	0.42	<0.05	<0.03	23.84
21 Jan 91	1	16.3	5.87	1.13	210.78	13.38	0.63	<0.03	224.80
21 Jan 91	8	0.5	0.10	0.47	4.03	0.09	<0.05	<0.03	4.20
21 Jan 91	8	16.5	0.95	0.65	30.21	9.91	3.50	0.34	43.96
21 Jan 91	8	40.8	1.14	0.46	46.26	12.19	3.87	0.21	62.53
21 Jan 91	8	64.7	1.19	0.41	47.73	12.92	4.03	0.24	64.92
21 Jan 91	8	161.0	1.47	0.13	38.72	9.13	2.64	<0.03	50.52
21 Jan 91	13	0.5	0.22	0.50	1.17	<0.01	<0.05	<0.03	1.26
21 Jan 91	13	16.5	0.82	0.78	17.55	10.00	6.94	0.72	35.21
21 Jan 91	13	41.0	0.94	0.66	19.54	11.76	7.85	0.70	39.85
21 Jan 91	13	64.8	0.94	0.66	23.54	12.56	7.95	0.74	44.79
21 Jan 91	13	161.5	1.03	0.47	22.91	8.19	5.42	0.64	37.16
19 Feb 91	4	0.5	0.62	0.39	6.04	0.21	<0.05	<0.03	6.33
19 Feb 91	4	22.7	1.70	0.27	19.92	7.26	2.16	<0.03	29.40
19 Feb 91	6	0.5	0.19	0.53	6.32	0.26	<0.05	<0.03	6.66
19 Feb 91	6	23.5	1.12	0.45	18.56	8.06	3.22	0.26	30.10
19 Feb 91	8	0.5	0.19	0.43	3.45	0.23	<0.05	<0.03	3.76
19 Feb 91	8	21.0	1.24	0.23	24.44	8.81	2.80	<0.03	36.08
19 Feb 91	10	0.5	0.32	0.53	1.12	0.17	<0.05	<0.03	1.37
19 Feb 91	10	23.3	1.06	0.64	13.15	8.01	4.19	0.23	25.58
19 Feb 91	11	0.5	0.36	0.49	3.50	0.21	<0.05	<0.03	3.79
19 Feb 91	11	22.0	1.15	0.55	15.78	7.72	3.48	0.08	27.06
12 Mar 91	5	0.5	0.64	0.51	4.79	0.49	<0.05	<0.03	5.36
12 Mar 91	5	24.0	1.79	0.16	20.00	8.80	3.93	0.30	33.03
12 Mar 91	8	0.5	0.11	0.54	9.40	1.95	0.33	<0.03	11.71
12 Mar 91	8	24.0	1.16	0.29	23.00	12.10	3.82	0.28	39.20
12 Mar 91	9	0.5	0.12	0.52	5.22	1.19	0.22	<0.03	6.96
12 Mar 91	9	24.0	1.00	0.44	10.50	5.30	2.80	0.44	19.04

Table A28 continued

Date Chlorine Added	Sample Number	Chlorination			T H M s				
		Time hrs	Demand mg/l	Resid mg/l	Cl3 ug/l	Cl2Br ug/l	ClBr2 ug/l	Br3 ug/l	Total ug/l
12 Mar 91	10	0.5	0.51	0.49	4.16	0.39	<0.05	<0.03	4.63
12 Mar 91	10	24.0	1.44	0.36	5.17	5.70	2.85	0.62	14.34
12 Mar 91	11	0.5	0.37	0.53	6.30	0.68	<0.05	<0.03	7.06
12 Mar 91	11	24.0	1.25	0.45	9.81	4.60	4.10	0.33	18.84
12 Mar 91	13	0.5	0.26	0.49	4.55	0.49	<0.05	<0.05	5.12
12 Mar 91	13	24.0	0.89	0.66	5.92	5.30	3.30	<0.03	14.55
12 Mar 91	14	0.5	0.26	0.49	5.81	0.75	<0.05	<0.03	6.64
12 Mar 91	14	24.0	1.22	0.33	10.64	5.20	4.95	0.41	21.20

* = sample treated by pre and interfiltration ozonation
£ see figure 2 for a description of sample numbers

Table A29. Chloroform (ug/l)

DATE	SAMPLE NUMBER 1	3	4	5	6	7	8	9	10	11	12	13	14
7-AUG-1990	19.89	1.90	11.70	2.41	23.19	3.28	13.39	9.29	0.13	0.13	2.41	0.13	4.08
14-AUG-1990	19.41	0.13		0.13	0.13	0.67	9.67	10.20	0.13	0.13	0.13	0.13	0.27
21-AUG-1990	20.07	0.13	7.24	0.75	0.13	2.71	9.69	6.54	0.13	0.13	1.94	0.13	4.07
29-AUG-1990	22.37	0.63	7.45	1.13	0.13	4.96	11.36	8.30	0.13	0.13	3.41	0.13	6.13
4-SEP-1990	18.25	0.13	6.82	0.13	0.13	5.38	7.20	6.34	0.13	0.13	1.10	0.13	3.99
11-SEP-1990	17.30	0.13	5.70	2.60	0.13	5.00	7.70	4.50	0.13	0.13	3.00	0.13	5.00
18-SEP-1990	17.68	1.73	7.85	3.32	0.96	5.49	9.19	4.99	0.13	0.13	2.41	0.13	4.87
25-SEP-1990	17.38	0.93	4.48	1.94	0.13	4.29	7.90	4.03	0.13	0.13	1.97	0.13	3.76
2-OCT-1990	13.46	1.34	5.98	0.13	0.13	3.59	8.28	4.64	0.13	0.13	3.27	0.13	3.64
9-OCT-1990	18.26	1.73	5.16	3.49	0.89	4.89	6.95	4.65	0.13	0.13	2.91	0.13	3.61
16-OCT-1990	28.40	1.87	4.78	3.72	0.90	5.40	7.18	6.40	0.13	0.13	1.89	0.13	3.78
23-OCT-1990	20.50	3.24	4.87	3.42	1.03	5.27	6.90	5.04	0.13	0.29	4.90	0.13	3.31
30-OCT-1990	26.00	4.30	5.00	5.40	0.13	5.70	7.70	7.30	0.13	2.00	4.30	0.13	6.60
6-NOV-1990	27.12	3.74	3.34	5.47	3.59	6.48	7.77	5.73	0.64	1.53	5.65	0.74	5.00
13-NOV-1990	21.27	6.98	7.01	8.76	6.21	9.23	8.64	8.43	2.88	5.70	7.56	3.64	9.28
20-NOV-1990	24.96	6.73	7.65	8.35	7.47	9.43	10.96	8.11	3.08	4.95	8.93	3.44	8.35
27-NOV-1990	22.53	5.06	5.86	5.43	4.78	7.27	7.47	5.28	1.30	3.51	5.59	1.96	5.44
4-DEC-1990	29.30	8.43	9.49	9.77	8.82	9.68	11.41	8.61	5.01	8.56	9.70	6.56	8.64
11-DEC-1990	18.78	3.12	5.57	5.84	5.12	4.28	6.78	4.33	1.91	3.55	6.29	2.04	3.72
18-DEC-1990	18.01	2.24	3.60	3.05	2.30	3.69	3.45	0.50	0.09	2.28	3.56	0.38	1.99
8-JAN-1991	32.11	3.93	3.81	3.80	2.64	5.23	5.35	2.73	0.36	1.32	3.31	1.26	1.69
15-JAN-1991	27.70	1.83	2.27	3.84	2.43	3.39	4.08	1.50	1.48	3.70	4.41	1.31	1.97
22-JAN-1991	23.34	2.36	2.96	2.77	3.69	2.73	4.03	3.01	2.89	4.31	4.94	1.17	1.56
29-JAN-1991	12.97	3.66	3.66	4.72	3.74	0.13	5.84	6.27	6.09	5.35	6.05	3.50	3.83
5-FEB-1991	21.70	2.23	3.46	2.17	1.85	3.24	3.78	0.87	1.23	1.51	3.20	0.15	1.10
12-FEB-1991	20.18	2.07	1.82	2.94	2.46	2.96	3.30		1.18	3.45	4.00		
19-FEB-1991	17.60	2.45	6.04	5.55	6.32	5.67	3.45	1.34	1.12	3.50	3.65	4.88	3.58
26-FEB-1991	20.51	0.96	5.26	4.88	5.16	6.12	5.30	0.28	5.22	6.03	6.34	3.64	4.39
5-MAR-1991	27.78	6.42	6.64	6.50	6.62	8.45	10.33	4.58	5.07	7.33	9.35	4.49	6.15
12-MAR-1991	10.01	4.67	5.19	4.79	4.56	6.57	9.40	5.52	4.16	6.30	5.17	4.55	5.81
19-MAR-1991	24.25	6.55	6.92	6.70	6.21	9.10	12.53	6.96	5.87	9.20	10.94	7.42	8.50

Table A30. Bromo, Dichloromethane (ug/l)

DATE	SAMPLE NUMBER 1	3	4	5	6	7	8	9	10	11	12	13	14
7-AUG-1990	0.73	0.22	0.95	0.38	0.32	0.50	1.14	1.04	0.01	0.01	0.63	0.01	1.06
4-AUG-1990	0.28	0.01		0.01	0.01	0.01	0.06	0.63	0.01	0.01	0.01	0.01	0.01
1-AUG-1990	0.23	0.01	0.33	0.01	0.01	0.04	0.36	0.40	0.01	0.01	0.06	0.01	0.12
9-AUG-1990	1.01	0.20	0.51	0.19	0.08	0.50	0.72	0.90	0.01	0.01	0.60	0.01	0.64
4-SEP-1990	0.24	0.01	0.03	0.01	0.01	0.01	0.01	0.11	0.01	0.01	0.01	0.01	0.01
1-SEP-1990	0.60	0.01	0.01	0.01	0.01	0.01	0.30	0.45	0.01	0.01	0.01	0.01	0.01
8-SEP-1990	0.53	0.24	0.55	0.37	0.25	0.42	0.53	0.48	0.01	0.27	0.32	0.05	0.43
5-SEP-1990	0.50	0.08	0.21	0.01	0.01	0.07	0.12	0.07	0.01	0.01	0.01	0.21	0.35
2-OCT-1990	0.24	0.43	0.32	0.23	0.28	0.14	0.28	0.18	0.01	0.27	0.67	0.22	0.50
9-OCT-1990	0.37	0.12	0.20	0.21	0.11	0.14	0.14	0.31	0.01	0.01	0.31	0.01	0.11
6-OCT-1990	0.41	0.01	0.12	0.01	0.01	0.01	0.31	0.10	0.01	0.01	0.01	0.01	0.01
3-OCT-1990	0.47	0.02	0.10	0.02	0.01	0.12	0.42	0.34	0.01	0.13	0.01	0.01	0.42
30-OCT-1990	0.63	0.40	0.39	0.44	0.47	0.58	0.57	0.49	0.01	0.01	0.01	0.01	0.49
6-NOV-1990	0.59	0.30	0.24	0.27	0.25	0.27	0.23	0.29	0.23	0.19	0.25	0.07	0.39
13-NOV-1990	0.45	0.45	0.31	0.66	0.35	0.71	0.57	0.43	0.26	0.42	0.37	0.25	0.65
20-NOV-1990	0.57	0.52	0.44	1.44	0.97	0.74	0.97	0.99	0.33	0.39	0.54	0.36	0.89
27-NOV-1990	0.38	0.28	0.21	0.21	0.18	0.46	0.28	0.17	0.04	0.05	0.13	0.03	0.45
4-DEC-1990	1.18	0.78	0.78	0.76	0.86	0.77	0.76	0.69	0.01	0.79	0.84	0.71	1.03
11-DEC-1990	0.27	0.01	0.01	0.01	0.17	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
18-DEC-1990	0.39	0.22	0.30	0.14	0.16	0.12	0.08	0.01	0.01	0.03	0.12	0.05	0.28
8-JAN-1991	0.80	0.26	0.15	0.16	0.11	0.06	0.01	0.04	0.01	0.01	0.02	0.14	0.21
15-JAN-1991	0.85	0.17	0.27	0.14	0.09	0.01	0.07	0.01	0.01	0.12	0.22	0.22	0.21
22-JAN-1991	0.42	0.30	0.51	0.09	0.20	0.06	0.09	0.01	0.10	0.26	0.13	0.01	0.06
29-JAN-1991	0.51	0.47	0.41	0.48	0.44	0.21	0.53	0.45	0.51	0.47	0.55	0.45	0.47
5-FEB-1991	0.42	0.18	0.20	0.13	0.23	0.13	0.14	0.01	0.07	0.12	0.13	0.01	0.10
12-FEB-1991	0.55	0.48	0.41	0.42	0.44	0.37	0.37		0.26	0.35	0.39		
19-FEB-1991	0.50	0.55	0.21	0.30	0.26	0.24	0.23	0.03	0.17	0.21	0.27	0.15	0.29
26-FEB-1991	0.04	0.21	0.15	0.15	0.19	0.16	0.08	0.01	0.14	0.10	0.13	0.08	0.21
5-MAR-1991	0.50	0.25	0.14	0.24	0.34	0.49	0.60	0.23	0.21	0.27	0.50	0.22	0.47
12-MAR-1991	0.24	0.36	0.33	0.49	0.51	0.74	1.95	1.19	0.39	0.68	1.00	0.49	0.75
19-MAR-1991	0.11	0.01	0.01	0.01	0.08	1.39	4.02	2.23	0.01	0.92	1.75	1.21	1.21

Table A31. Dibromo, Chloromethane (ug/l)

DATE	SAMPLE NUMBER 1	3	4	5	6	7	8	9	10	11	12	13	14
7-AUG-1990	0.05	0.05	0.05	0.22	0.05	0.23	0.18	0.29	0.05	0.05	0.29	0.05	0.56
14-AUG-1990	0.05	0.05		0.05	0.05	0.05	0.05	0.11	0.05	0.05	0.05	0.05	0.05
21-AUG-1990	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
29-AUG-1990	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
4-SEP-1990	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.12	0.05	0.05	0.05
11-SEP-1990	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
18-SEP-1990	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
25-SEP-1990	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.23	0.05
2-OCT-1990	0.05	0.21	0.11	0.13	0.24	0.05	0.05	0.05	0.05	0.27	0.19	0.46	0.25
9-OCT-1990	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
16-OCT-1990	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.07	0.05	0.12	0.05	0.05
23-OCT-1990	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.08	0.05	0.13	0.14
30-OCT-1990	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
6-NOV-1990	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
13-NOV-1990	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
20-NOV-1990	0.05	0.05	0.05	0.24	0.16	0.05	0.05	0.14	0.05	0.05	0.05	0.12	0.13
27-NOV-1990	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.07
4-DEC-1990	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
11-DEC-1990	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
18-DEC-1990	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.07	0.06
8-JAN-1991	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.08	0.08
15-JAN-1991	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.09	0.07
22-JAN-1991	0.05	0.07	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
29-JAN-1991	0.05	0.05	0.05	0.05	0.74	0.14	0.20	0.05	0.05	0.05	0.05	0.05	0.05
5-FEB-1991	0.17	0.05	0.05	1.03	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
12-FEB-1991	0.05	0.05	0.15	0.05	0.05	0.05	0.05		0.05	0.05	0.05		
19-FEB-1991	0.05	0.11	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
26-FEB-1991	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
5-MAR-1991	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.10
12-MAR-1991	0.05	0.05	0.05	0.05	0.05	0.05	0.33	0.22	0.05	0.05	0.15	0.05	0.05
19-MAR-1991	0.05	0.05	0.05	0.05	0.05	0.05	0.07	0.05	0.05	0.05	0.05	0.05	0.05

Table A32. Bromoform (ug/l)

DATE	SAMPLE NUMBER 1	3	4	5	6	7	8	9	10	11	12	13	14
7-AUG-1990	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
14-AUG-1990	0.03	0.03		0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
21-AUG-1990	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
29-AUG-1990	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
4-SEP-1990	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
11-SEP-1990	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
18-SEP-1990	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
25-SEP-1990	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
2-OCT-1990	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
9-OCT-1990	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
16-OCT-1990	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
23-OCT-1990	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
30-OCT-1990	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
6-NOV-1990	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
13-NOV-1990	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
20-NOV-1990	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
27-NOV-1990	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
4-DEC-1990	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
11-DEC-1990	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
18-DEC-1990	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
8-JAN-1991	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
15-JAN-1991	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
22-JAN-1991	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
29-JAN-1991	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
5-FEB-1991	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
12-FEB-1991	0.03	0.03	0.03	0.03	0.03	0.03	0.03		0.03	0.03	0.03		
19-FEB-1991	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
26-FEB-1991	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
5-MAR-1991	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
12-MAR-1991	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
19-MAR-1991	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03

Table A33. Total Trihalomethanes (ug/1)

DATE	SAMPLE NUMBER 1	3	4	5	6	7	8	9	10	11	12	13	14
7-AUG-1990	20.70	2.20	12.73	3.04	23.59	4.04	14.74	10.65	0.22	0.22	3.36	0.22	5.73
14-AUG-1990	19.77	0.22		0.22	0.22	0.76	9.81	10.97	0.22	0.22	0.22	0.22	0.36
21-AUG-1990	20.38	0.22	7.65	0.84	0.22	2.83	10.13	7.02	0.22	0.22	2.08	0.22	4.27
29-AUG-1990	23.46	0.91	8.04	1.40	0.29	5.54	12.16	9.28	0.22	0.22	4.09	0.22	6.85
4-SEP-1990	18.57	0.22	6.93	0.22	0.22	5.47	7.29	6.53	0.22	0.29	1.19	0.22	4.08
11-SEP-1990	17.98	0.22	5.79	2.69	0.22	5.09	8.08	5.03	0.22	0.22	3.09	0.22	5.09
18-SEP-1990	18.29	2.05	8.48	3.77	1.29	5.99	9.80	5.55	0.22	0.48	2.81	0.26	5.38
25-SEP-1990	17.96	1.09	4.77	2.03	0.22	4.44	8.10	4.18	0.22	0.22	2.06	0.60	4.19
2-OCT-1990	13.78	2.01	6.44	0.52	0.68	3.81	8.64	4.90	0.22	0.70	4.16	0.84	4.42
9-OCT-1990	18.71	1.93	5.44	3.78	1.08	5.11	7.17	5.04	0.22	0.22	3.30	0.22	3.80
16-OCT-1990	28.89	1.96	4.98	3.81	0.99	5.49	7.57	6.58	0.24	0.22	2.05	0.22	3.87
23-OCT-1990	21.05	3.34	5.05	3.52	1.12	5.47	7.40	5.46	0.22	0.53	4.99	0.30	3.90
30-OCT-1990	26.71	4.78	5.47	5.92	0.68	6.36	8.35	7.87	0.22	2.09	4.39	0.22	7.17
6-NOV-1990	27.79	4.12	3.66	5.82	3.92	6.83	8.08	6.10	0.95	1.80	5.98	0.89	5.47
13-NOV-1990	21.80	7.51	7.40	9.50	6.64	10.02	9.29	8.94	3.22	6.20	8.01	3.97	10.01
20-NOV-1990	25.61	7.33	8.17	10.06	8.63	10.25	12.01	9.27	3.49	5.42	9.55	3.95	9.40
27-NOV-1990	22.99	5.42	6.15	5.72	5.04	7.81	7.83	5.53	1.42	3.64	5.80	2.07	5.99
4-DEC-1990	30.56	9.29	10.35	10.61	9.76	10.53	12.25	9.38	5.10	9.43	10.62	7.35	9.75
11-DEC-1990	19.13	3.21	5.66	5.93	5.37	4.37	6.87	4.42	2.00	3.64	6.38	2.13	3.81
18-DEC-1990	18.48	2.54	3.98	3.27	2.54	3.89	3.61	0.59	0.18	2.39	3.76	0.53	2.36
8-JAN-1991	32.99	4.27	4.04	4.04	2.83	5.37	5.44	2.85	0.45	1.41	3.41	1.51	2.01
15-JAN-1991	28.63	2.08	2.62	4.06	2.60	3.48	4.23	1.59	1.57	3.90	4.71	1.65	2.28
22-JAN-1991	23.84	2.76	3.55	2.94	3.97	2.87	4.20	3.10	3.07	4.65	5.15	1.26	1.70
29-JAN-1991	13.56	4.21	4.15	5.28	4.95	0.51	6.60	6.80	6.68	5.90	6.68	4.03	4.38
5-FEB-1991	22.32	2.49	3.74	3.36	2.16	3.45	4.00	0.96	1.38	1.71	3.41	0.24	1.28
12-FEB-1991	20.81	2.63	2.41	3.44	2.98	3.41	3.75		1.52	3.88	4.47		
19-FEB-1991	18.18	3.14	6.33	5.93	6.66	5.99	3.76	1.45	1.37	3.79	4.00	5.11	3.95
26-FEB-1991	20.63	1.25	5.49	5.11	5.43	6.36	5.46	0.37	5.44	6.21	6.55	3.80	4.68
5-MAR-1991	28.36	6.75	6.86	6.82	7.04	9.02	11.01	4.89	5.36	7.68	9.93	4.79	6.75
12-MAR-1991	10.33	5.11	5.60	5.36	5.15	7.39	11.71	6.96	4.63	7.06	6.35	5.12	6.64
19-MAR-1991	24.44	6.64	7.01	6.79	6.37	10.57	16.65	9.27	5.96	10.20	12.77	8.71	9.79

Table A34. Adsorbable Organic Halide (ug/l)

DATE	1	3	4	5	6	7	8	9	10	11	12	13	14
	SAMPLE NUMBER												
7-AUG-1990	55.5	8.0	26.6	26.0	8.0	8.0	34.0	15.1	8.0	8.0	8.0	8.0	8.5
21-AUG-1990	55.5	8.0	28.5	8.0	8.0	14.5	29.4	10.4	8.0	8.0	20.3	8.0	11.4
4-SEP-1990	50.5	8.3	26.7	8.5	8.0	20.6	30.8	13.4	8.0	8.0	20.7	8.0	10.2
18-SEP-1990	68.0	9.6	26.9	11.4	8.0	25.5	37.9	16.5	8.0	8.0	31.4	8.0	9.3
2-OCT-1990	56.7	20.2	31.1	14.6	11.2	25.3	29.3	15.7	8.0	18.0	27.7	8.0	15.9
16-OCT-1990	67.2	14.8	32.6	15.6	15.5	26.1	74.9	13.3	8.0	9.7	27.8	8.0	11.5
30-OCT-1990	89.6	15.7	29.1	28.0	18.2	31.5	35.1	15.2	8.0	15.4	25.8	8.0	14.6
13-NOV-1990	88.1	44.5	32.7	11.3	15.8	8.0	37.5	14.6	8.1	20.8	33.1	8.8	15.6
27-NOV-1990	82.4	27.1	50.7	30.7	24.7	34.8	37.8	15.5	14.0	20.2	32.2	8.0	13.5
11-DEC-1990	75.8		32.4	24.7	24.1	26.6	30.4	35.3	8.4	59.1	32.8	8.0	12.8
8-JAN-1991	76.0	17.9	22.7	23.2	17.2	15.5	22.7	8.7	9.8	15.1	19.8	8.0	16.0
22-JAN-1991	89.7	20.2	30.7	19.8	28.6	19.5	8.0	12.4	18.3	25.1	34.2	17.2	13.4
5-FEB-1991	74.0	22.1	25.4	20.1	18.4	25.8	28.0	10.9	15.1	21.9	26.4	8.0	8.0
19-FEB-1991	78.7	30.4	33.3	29.1	26.9	31.8	32.9	13.4	20.1	27.5	31.2	9.4	10.0
5-MAR-1991	107.9	27.4	32.8	27.3	25.0	36.2	34.3	12.2	24.8	30.1	40.4	11.7	17.5
19-MAR-1991	74.8	24.2	18.3	27.3	22.5	32.6	27.0	8.0	13.4	23.4	32.1	8.0	16.6

Table A35 - TA 98 Mutagenic Activity At pH 2 (Slope Value)

DATE	SAMPLE NUMBER 5	6	7	8	9	10	11	12	13	14
7-AUG-1990	0.50	0.96				-0.03	0.61	0.91		
21-AUG-1990			1.07	2.33	0.13				0.40	0.23
4-SEP-1990	0.62	0.57				0.25	0.21	1.13		
18-SEP-1990			1.39	3.51	0.66				0.18	0.31
2-OCT-1990	1.10	0.47				0.77	0.17	1.92		
16-OCT-1990			1.76	2.09	0.85				0.41	0.42
30-OCT-1990	1.04	0.55				0.43	0.50	1.10		
13-NOV-1990			2.16	3.95	0.57				0.05	0.12
27-NOV-1990	1.63	2.09				0.68	1.61	1.76		
11-DEC-1990			1.95	2.46	1.03				0.40	-0.08
8-JAN-1991	2.07	1.95				1.06	1.48	1.61		
22-JAN-1991			2.76	2.75	0.87				0.50	0.93
5-FEB-1991	2.47	1.71				1.04	1.25	1.86		
19-FEB-1991			2.06	2.78	1.15				0.42	0.62

Table A36 - TA 98 Mutagenic Activity At pH 7 (Slope Value)

DATE	SAMPLE NUMBER 5	6	7	8	9	10	11	12	13	14
7-AUG-1990	0.53	0.47				0.79	0.52	1.71		
21-AUG-1990			0.43	2.73	0.41				-0.05	0.43
4-SEP-1990	0.75	0.00				0.38	0.41	0.94		
18-SEP-1990			1.36	5.33	0.75				0.30	0.98
2-OCT-1990	1.37	0.51				0.20	0.52	1.95		
16-OCT-1990			2.15	4.14	0.41				0.17	0.17
30-OCT-1990	2.14	0.63				-0.16	0.08	1.20		
13-NOV-1990			1.60	2.87	0.27				-0.23	0.36
27-NOV-1990	0.94	1.22				0.29	0.62	1.61		
11-DEC-1990			2.91	4.30	0.87				0.26	0.38
8-JAN-1991	2.04	1.66				0.74	1.16	1.79		
22-JAN-1991			2.90	4.00	0.58				0.84	0.69
5-FEB-1991	1.75	1.76				0.69	1.08	1.94		
19-FEB-1991			2.24	3.88	1.00				0.63	0.60

Table A37 - TA 100 Mutagenic Activity At pH 2 (Slope Value)

DATE	SAMPLE NUMBER 5	6	7	8	9	10	11	12	13	14
7-AUG-1990	2.69	1.50				0.75	1.01	4.23	0.38	4.81
21-AUG-1990			8.34	6.82	2.57					
4-SEP-1990	6.03	3.99				1.25	3.46	7.73	2.83	3.52
18-SEP-1990			7.09	14.91	5.63					
2-OCT-1990	4.23	3.07				0.27	3.15	2.92	2.58	6.20
16-OCT-1990			9.67	9.64	7.53					
30-OCT-1990	10.29	7.04				2.81	5.13	10.04	3.99	7.81
13-NOV-1990			11.54	15.99	7.58					
27-NOV-1990	9.54	10.41				5.25	7.52	10.28	3.88	3.33
11-DEC-1990			5.66	11.77	3.15					
8-JAN-1991	10.41	10.23				6.07	11.76	12.98	4.29	5.20
22-JAN-1991			8.97	4.96	3.35					
5-FEB-1991	9.95	9.59				5.95	9.47	10.01	4.28	4.47
19-FEB-1991			12.51	14.69	6.73					

Table A38 - TA 100 Mutagenic Activity At pH 7 (Slope Value)

DATE	SAMPLE NUMBER 5	6	7	8	9	10	11	12	13	14
7-AUG-1990	2.02	2.03				1.28	1.82	3.65	0.29	1.74
21-AUG-1990			0.69	4.96	1.73					
4-SEP-1990	2.69	2.85				2.63	2.17	6.47	1.11	6.27
18-SEP-1990			6.68	17.97	6.30					
2-OCT-1990	4.22	2.73				0.96	1.98	2.69	0.40	2.18
16-OCT-1990			7.51	8.11	2.00					
30-OCT-1990	4.88	5.56				1.08	2.14	8.12	0.08	1.03
13-NOV-1990			4.76	5.90	1.75					
27-NOV-1990	1.94	4.49				0.97	1.83	6.51	1.07	1.78
11-DEC-1990			9.46	10.32	3.37					
8-JAN-1991	7.15	4.96				5.50	5.38	9.40	2.04	0.28
22-JAN-1991			7.05	10.08	2.95					
5-FEB-1991	6.16	5.04				3.80	3.84	2.72	1.88	2.35
19-FEB-1991			9.93	9.90	2.85					