DISCHARGE CONSENT REVIEW
FOR
PEN MILL (YEOVIL) STW

Water Quality Planning
(March 1993)

ENVIRONMENT AGENCY
136180

The objective of this work was to review the discharge consent requirement for Yeovil STW to ensure compliance with UK and EC quality objectives in the River Yeo downstream of the discharge.

Further information and details on this work can be obtained from Chris Moore or Antony Lyons. Further copies of this report can be obtained from Lee-Ann Stone.

1. SUMMARY

A review was undertaken of Yeovil STW and its effect on the receiving watercourse (River Yeo). Particular attention was paid to dangerous substances, notably hexachlorocyclohexane and heavy metals, large loads of which may be introduced to the sewerage system under existing trade effluent agreements.

It was found that to maintain existing quality and prevent additional loads to the River Yeo over those discharged in 1989, a standard of 20/30/10 reducing to 20/30/5 as 95%ile for BOD-atu/SS/NH_3-N would be required by the end of the century. The current limit for cadmium of 5 μg/l should remain and a limit of 1 μg/l should be introduced for total hexachlorocyclohexane.

Consideration should also be given to the need for limits on copper, zinc and chromium. This should be investigated in the forthcoming Dangerous Substances Consenting exercise.

2. INTRODUCTION

As part of the 1992/93 programme of consent reviews, Yeovil STW was highlighted as a priority. A particular aim was to focus on dangerous substances, especially lindane as in 1990 the annual mean concentration of this organochlorine insecticide in the River Yeo downstream of the discharge exceeded the EQS limit of 0.1 mg/l. Since then, the EQS has not been exceeded but the load has remained high. The only known discharge of lindane to the river upstream of the monitoring point is from Yeovil STW; limits for lindane do not however appear on the consent to discharge, No 070134, which was last reviewed in February 1987. The existing quality standards are 30 mg/l BOD-atu, 55 mg/l suspended solids, 15 mg/l ammonia-N, all 95%iles, and 5 μg/l Cadmium as maximum. Consented dry weather flow is 14,305 m^3/d from a population of about 45,000. There are a number of important trade inputs to the Yeovil works. Tannery and metal-finishing waters are the largest discharges to the sewerage system of List I and List II substances.

The works design capacity is for a dry weather flow of 14,300 m^3/d. It consists of six primary settlement tanks, eight low and one high rate biological filters, six humus tanks and microstrainers, as shown in Appendix A. About 80% of the organic load is removed by primary settlement, high rate filters and humus tanks. The retention period is about 9 hours at dry weather flow.

In November/December 1991, works were carried out to uprate the high rate filter. Wessex Water plc requested a temporary relaxation for the consent standard during this period, but this was refused as there was a danger of severe deleterious water quality effects on the receiving water, with the possibility of a fall in water quality to NWC Class 3. Modelling work carried out at that time indicated the need for a long term consent of 15/25/10 (BOD-atu/SS/NH_3-N) as 95%iles. This was to maintain existing river quality rather than achieve the LTO. Wessex Water have assigned a further £823,000 in their capital expenditure programme for improvements at Pen Mill, mainly in the 1993/94 period. Flows to the works in excess of 297 l/s (2.4 dwf) receive settlement prior to discharge for which the consented standard is 200/200 (BOD-atu/SS) as maxima.

The works discharge is made to the River Yeo. This is a mature lowland river in the Upper Parrett catchment. It supports a number of uses such as salmon and coarse fishing, industrial cooling, agricultural abstraction, and there is also an emergency public supply source downstream at Langport. Upstream of Pen Mill, the river is achieving the Long Term Objective of 1B. Downstream of the works, the river was reported in 1990 as achieving the Long Term Objective of Class 2. Upstream of the works, the river is a designated salmonid fishery. Downstream, it is designated as cyprinid. In both cases, compliance with the Directive is achieved.

Appendix B shows the location of the works and associated monitoring points. There is also a main gauging station immediately upstream of the works.

3. DATA ANALYSIS AND MODELLING

Monitoring data for the final effluent, upstream and downstream site for the past three years was extracted from the WIMS archive. This was then transferred to the PC for statistical analysis using 'MARY'[1]. For statistical analysis, the data was restricted to that collected for formal audit and routine sampling. Analyzed data was used as input for Monte Carlo simulation modelling. Biological data was requested from the Biology Unit at Blandford.

3.1 Biological Data

Summaries of biological score data are given in Appendix C. These cover the period 1990-1993 for two river sites - Yeovil Bridge (immediately upstream of the STW) and Mudford (about 4 km downstream). The ASPT EQI decreases from 0.92 upstream to 0.78 downstream in 1991, a change of 15%. In 1992, the equivalent change is also one of 15%. This index is a good measure of organic pollution impact. For non-organic pollution, the ASPT is less reliable and the BMWP score is preferred. In 1991, the BMWP EQI was recorded as being 38% lower at Mudford and 11% lower in 1992. The indices are therefore consistently 10-15% lower at the downstream site, which represents a significant change. Although the Mudford site is 4 km downstream of the works, there are no major discharges in the intervening stretch apart from some urban run-off.

3.2 Sanitary Determinands

3.2.1 Biochemical Oxygen Demand

In the last 3 years, 3 exceedances of the 95%ile consent standard were recorded. Overall performance is well within the limit of 30 mg/l (Appendix D). Time series analysis shows the mean BOD to be fairly stable around the 10 mg/l mark. Cusum analysis shows no significant seasonal or long term trends.

Modelling was undertaken using the following input data, derived from the water quality and flow archives:

		Flow (m^3/day)	Quality (mg/l)
Upstream	5%ile	27820	
	mean	212544	2.6
	sd	-	1.6
Discharge	mean	1.25 * dwf#	10.8
	sd	0.33 * mean	5.2

Based on the Class 2(B) objective and on the existing 2A downstream quality, the following consent standard requirements were derived, all figures given being mg/l.

dwf figures for future years supplied by Wessex Water plc

Year	Objective 2B		Objective 2A	
	95%ile	Max	95%ile	Max
1996	30	65	20	35
2001	30	60	20	35
2006	30	60	20	35
2015	25	50	15	30

3.2.2 Ammoniacal Nitrogen

The archived data shows no exceedences of the 95%ile consent limit within the past 3 years. Yearly means shows a slight increase over this time period from less than 1.0 to about 1.5. In the period 2 May 1990 to 15 November 1990 there was significantly good effluent quality. (Appendix E)

Modelling was undertaken using the following input data, derived from the water quality archive (flow data is the same as for BOD modelling):

		Quality (mg/l)
Upstream	mean	0.13
	sd	0.11
Discharge	mean	1.14
	sd	1.10

The following consent standard requirements were derived, all figures given being mg/l:

Year	Objective 2B		Objective 2A	
	95%ile	Max	95%ile	Max
1996	15	50	10	30
2001	15	45	10	30
2006	15	45	10	30
2015	10	40	5	20

However, according to the River Needs Consent document[2], for existing discharges where it seems possible to achieve all other water quality objectives and targets, but still permit a deterioration in river quality, there should be no increase over the load discharged in 1989. For Yeovil, this results in a standard of 30/5 for BOD-atu/Ammonia-N.

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3.3 List I/List II Substances

3.3.1 Statutory Requirements, Policy and Background

The policy followed in setting limits corresponds to that required in the final draft PIN on dangerous substances[3]. The overall approach involved checking the downstream concentrations of the relevant substances against the EQS and identifying the priorities for detailed investigation. Under the terms of the Dangerous Substances Directive, Member States are required to take appropriate steps to eliminate pollution of controlled waters by List I substances. The Guidance Circular from the DoE[4] states that the EQS is a minimum to be achieved and authorities should aim for a quality well within that standard.

There a number of leather-processing and metal-finishing trade premises within the Yeovil sewerage catchment; which are generally authorised for discharges containing the following metals - cadmium, chromium, copper, lead, nickel, silver and zinc. In addition, the leather processors Pittards are authorised to discharge hexachlorocyclohexane (HCH). They have recently been given a trade effluent agreement following an appeal to the DoE, which permits the discharge to the sewer of HCH (either as individual isomers or as a total of all isomers) of 2 μg/l from 26 April 1993 to 26 October 1993, after which the discharge should not exceed 1.5 μg/l. The maximum consented flow is 909 m^3 on any one day.

The analysis of data is separated into organics and metals. Summaries of the available data are shown in Appendix F.

3.3.2 Organic Substances

As stated previously, the annual mean lindane (γ-HCH) concentration exceeded its EQS downstream of Yeovil STW in 1990. Also investigated were a number of other substances where the maximum quoted for concentration was close to or greater than the EQS, ie α-HCH, p,p^1-DDT, Aldrin, Dieldrin and Endrin. Closer examination of this data revealed that for all of these with the exception of α-HCH, the data consists predominantly of 'less than' values.

α- and γ-HCH are undoubtedly derived mainly from the sewage effluent. Comparing the single upstream sample with the mean of the downstream samples (42) for the past three years, shows the following:

	u/s (ng/l)	d/s (ng/l)
γ-HCH	2.8	39.2
α-HCH	<0.5	19.6

Lindane (γ-HCH) is a List I substance with an EQS of 0.1 μg/l. This has been set for all HCH isomers and is expressed as a total annual average HCH concentration. Data provided by WRc gives full details of the aquatic toxicity of both α- and γ-HCH (appendix G).

This suggests that both these isomers are of high acute and chronic toxicity, with the majority of effect concentration being in the ranges 0.0073-0.87 and 0.1-0.8 mg/l respectively.

Hydrophobic materials such as Lindane are commonly regarded as partitioning directly into the organic phase of suspended organic material. Sediment analysis of samples from the Yeo taken on 4 March 1992 showed levels to be less than the limit of detection for all isomers of HCH upstream of the STW at Yeovil Bridge. Downstream at Over Compton, however, γ-HCH had increased to 1.6 μg/kg.

A decrease in lindane concentrations has been observed over the past three years at Over Compton. The EQS was exceeded as an annual mean in 1990, but there was only one sample over the EQS in 1991 and none in 1992. Cusum analysis shows the period August 1990 to January 1991 to be significantly high. This pattern is reflected in the data for the STW effluent, the mean concentrations in the effluent during this period being 602 ng/l. In 1992, the annual mean was 78 ng/l. At 1993 flows taking total (α + γ - isomers) HCH values with a river quality target of 100 ng/l, a maximum limit in the discharge of 1150 ng/l is derived. This falls to just below 1 μg/l at 2011 flows.

It should be noted that β- and Δ- isomers need to be more extensively monitored. If the very limited data for these is included (adding 125 ng/l to the mean discharge quality) then the maximum discharge quality derived by Monte Carlo modelling is 940 ng/l.

3.3.3 Metals

The relationship between concentrations of some metals in the STW effluent, the downstream quality monitoring point and the EQS for the past three years are as follows (all values in μg/l):

METAL	DISCHARGE		RIVER		EQS
	max	mean	max	mean	
Cd	4.3	2.0	0.8	0.29	5
Zn	138	93	51	0.21	500
Cr	250	137	28	10	250
Cu	28	24	9	5	28
Pb	5	3	9	3	250
Ni	23	17	7	3	200
Fe	170	105	330	310	1000
B	1300	1017	420	296	2000

It should be noted that the EQS limits for List II metals are highly dependant on hardness. No data was available from the Yeo and the value had to be derived from Ca and Mg in concentrations from the River Parrett at Westover Bridge. Therefore, until hardness data is collected from Over Compton there cannot be complete confidence in relating river levels to the EQS.

With these assumptions about the EQS, however, none are at or even near the EQS levels in the river. However, three metals (cadmium, chromium and copper) have maxima in the discharge which are at or exceed the EQS. Levels at Over Compton are only about 10-20% of the EQS.

Concentration of metals found in sediment at the upstream and downstream site from samples taken on 4 March 1992 are as follows (all figures in mg/kg):

Metal	Upstream	Downstream	% change
Copper	16.2	31.6	+ 95
Zinc	79.6	148.0	+ 92
Cadmium	0.46	0.81	+ 76
Mercury	0.037	0.12	+ 224
Lead	66.3	126.0	+ 89
Chromium	18.7	55.7	+ 197
Iron	548.2	7945	+ 44
Nickel	12.0	15.7	+ 31

Mercury and chromium show the greatest increase, with chromium being the greater cause for concern as it is present at a much higher level. Turbulence such as that observed during storm floods can result in resuspension and absorption of metals from sediments, raising levels in the water column.

Trade effluent discharge consents were examined to determine the origin of these metal loads. Theoretically, if consents were used up to the allowed limits, then the loads given below can be discharged to the sewer. The greater part of the metal load is removed with the sludge. The metals with the highest consented loads to sewer are as follows, together with loads to rivers and the ratios of these:

Metal	To sewer Maximum Discharge	To river		Ratio of Sewer Discharge:Actual Load
		Consented level	Actual level	
Cd	1204 kg/yr	26 kg/yr	10 kg/yr	120.1 : 1
Cr	18980 kg/yr		730 kg/yr	26 : 1
Zn	1658 kg/yr		417 kg/yr	3.97 : 1
Cu	5840 kg/yr		104 kg/yr	56.1 : 1

The ratio of consented load in the sewer to actual load to the river is quite high for cadmium, chromium and copper. Levels of copper in the river could give cause for concern if raised.

A gradual reduction of the cadmium level in the effluent was observed in the course of 1992, reaching a minimum of 1 µg/l at the end of the year. Modelling carried out on the basis of EQS targets indicates a maximum consent standard of 40 µg/l. If the PIN guidelines (ie 2 x 95%ile) are followed then a maximum standard of 8.6 µg/l results.
In the cases of chromium, copper and zinc, no particular trends are observed from the limited available data. Using PIN guidelines, limits of 0.5, 0.04 and 0.3 mg/l are derived for chromium, copper and zinc respectively.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Sanitary Determinands

Setting consent standards to maintain existing downstream quality suggests a revision of consent limits to 20/30/10 as 95%iles with an upper tier of 35/50/30 (BOD-atu/SS/NH_3-N) before 2000. Further tightening to 15/25/5 as 95ile is indicated by 2015. If the Rivers Needs Consents guidelines are followed, then the ammonia-N standard needs immediate tightening to 5 mg/l (95%ile) based on 1989 loads.

4.2 Organic Substances

The need for a standard for HCH (all isomers) has been demonstrated. However, as well as the γ-isomer, monitoring is required for the other HCH isomers. Concentrations of lindane have declined in the past couple of years to levels at which the EQS is not threatened. However, the potential exists via the Pittards trade effluent agreement, for substantially higher levels to be released. Hexachlorocyclohexane should therefore be consented in any review at a concentration of 1 µg/l (all isomers).

4.3 Metals

The current consented level for cadmium appears to be adequate. From consented loads, the List II metals copper, zinc and chromium could be candidates for consenting. The guidelines in the draft PIN are however not entirely clear. There is also a lack of hardness and other monitoring data. Those shortcomings should be rectified in the Dangerous Substances Consenting Programme. A programme for reduction of metals needs to be formulated.

4.4 Recommendations

The consent for Yeovil should be amended as follows for sanitary determinands by the date shown:

95%ile	Upper tier	Date
20/30/10	40/60/20	1996
20/30/5	40/60/10	1998

Hexachlorocyclohexane should be consented initially at 1 µg/l and a programme for reduction of this limit drawn up with Wessex Water plc.

Cadmium to be maintained at the present level of 5 µg/l.

Consideration of consenting other metals, notably zinc, chromium and copper, in the 1993/94 Dangerous Substances Consenting exercise. As part of this, further sediment-level monitoring should be carried out. Also, biological monitoring to be undertaken immediately downstream of the discharge.

5. REFERENCES

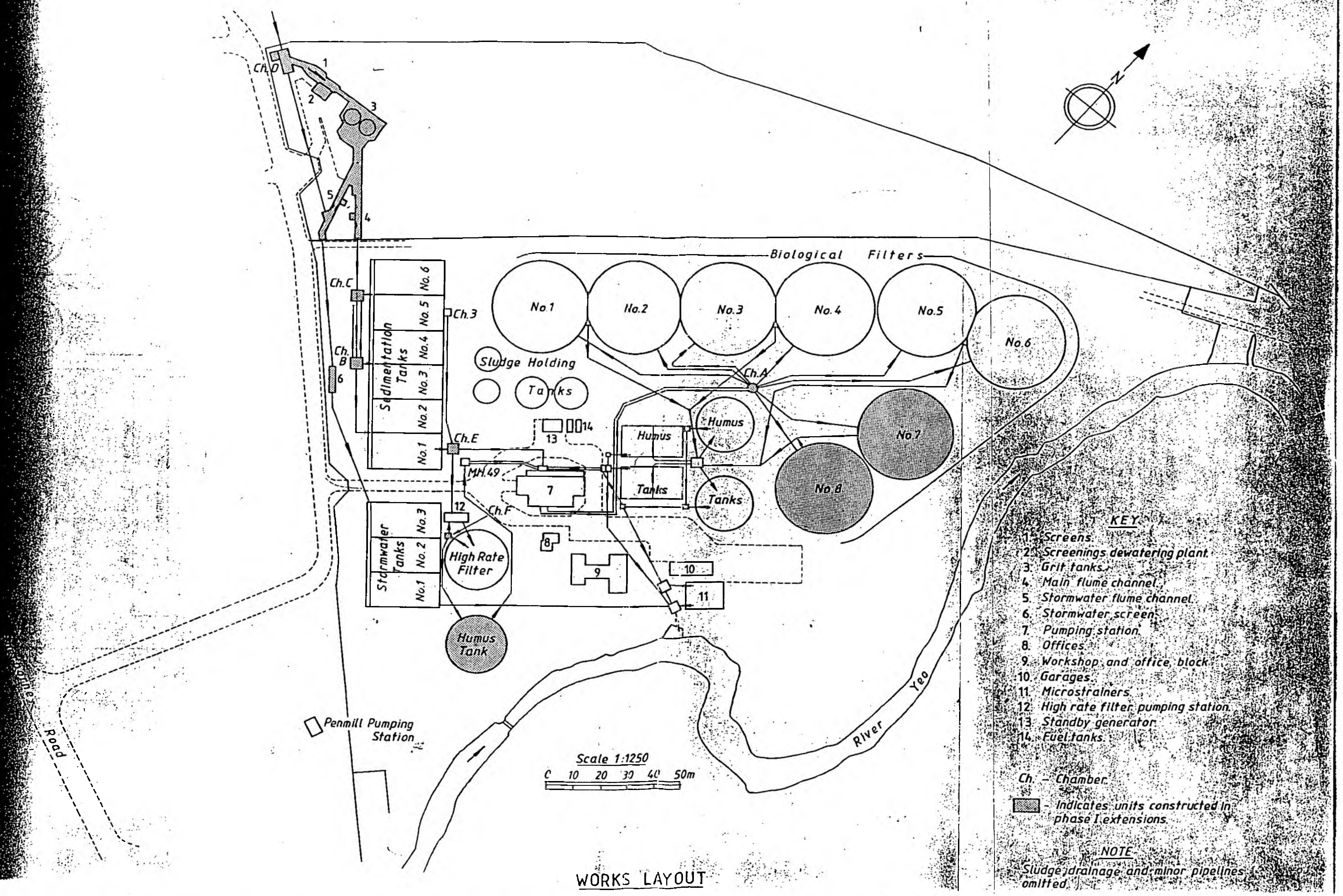
1. MARY- Make Aardvark Read Your data:
Fortran Programme. Chris Moore & Helen Kelly, September 1992

2. RIVER NEEDS CONSENTS - National Rivers Authority, March 1991

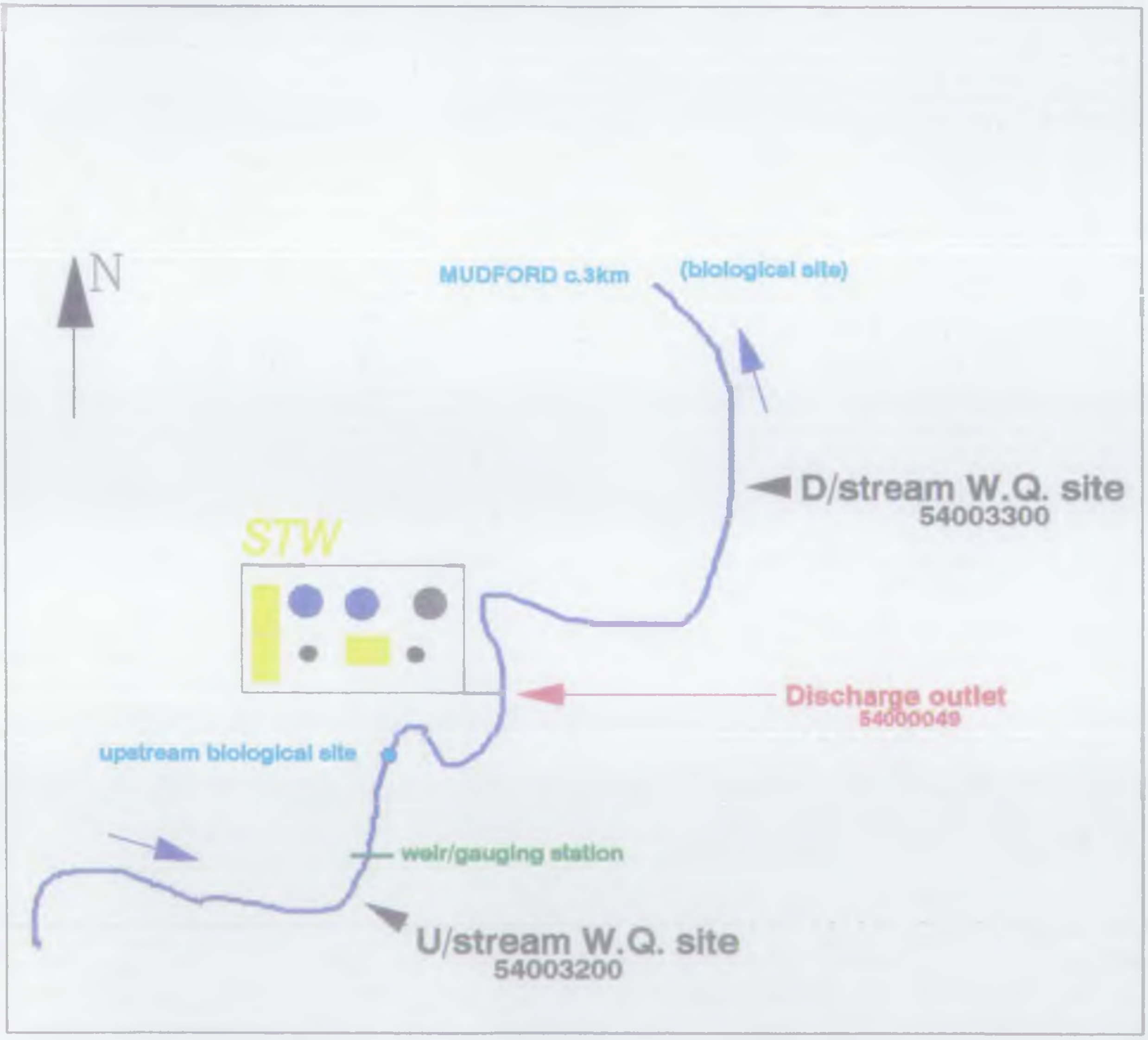
3. FINAL DRAFT: POLICY IMPLEMENTATION GUIDELINES NOTE - THE CONSENTING OF DANGEROUS SUBSTANCES IN DISCHARGES TO SURFACE WATERS (EQC/0492/5.5): National Rivers Authority, March 1992

4. WATER AND THE ENVIRONMENT: THE IMPLEMENTATION OF EUROPEAN COMMUNITY DIRECTIVES ON POLLUTION CAUSED BY CERTAIN DANGEROUS SUBSTANCES DISCHARGED INTO THE AQUATIC ENVIRONMENT: Department of The Environment (Circular 7/89), 1989

APPENDIX A: Works Lay-out



YEOVIL Pen Mill STW



APPENDIX C: Biological Score Data

Master Sheet

Watercourse: River Yeo
Site: Yeovil
Grid Reference: ST57301595

Status: A
Sampled in 1991: Y
T Code 1990: T198
Aut92 P Date: [illegible]/10/92
Sampled in 1992: Y
Sample Reason: R
Sampled in 1990: Y
Full Reference: 5202 YEO 265
Altitude: 30.00
Discharge: 04
Risk: M
Source Distance: 20.00
Slope: 1.30
Biologist: PDS
Comments

	Spr 90	Sum 90	Aut 90	Tot 90	Spr 91	Sum 91	Aut 91	Tot 91	Spr 92	Sum 92	Aut 92	Tot92
Date					2/4/91	15/7/91	23/9/91			10/6/92	7/11/92	
Alkalinity				200	216	222	228	222		230	241	236
Families	18	26	19	29	25	29	27	36		32	22	34
Pred Families	25	25	26	34	25	25	25	33		24	24	30
Families EQI	0.72	1.04	0.73	0.86	1.01	1.18	1.09	1.08		1.33	0.90	1.14
BMWP	88	123	87	140	121	136	128	183		168	103	184
Pred BMWP	135	131	136	190	133	127	126	183		124	123	159
BMWP EQI	0.65	0.94	0.64	0.74	0.91	1.07	1.01	1.00		1.35	0.84	1.16
ASPT	4.89	4.73	4.58	4.80	4.84	4.69	4.74	5.08		5.25	4.68	5.41
Pred ASPT	5.40	5.30	5.20	5.60	5.30	5.10	5.10	5.50		5.10	5.00	5.30
ASPT EQI	0.91	0.89	0.88	0.86	0.91	0.92	0.93	0.92		1.03	0.94	1.02
Suitability	1	1	1		1	1	1	1		1	1	1
Class				B				A				

Master Sheet

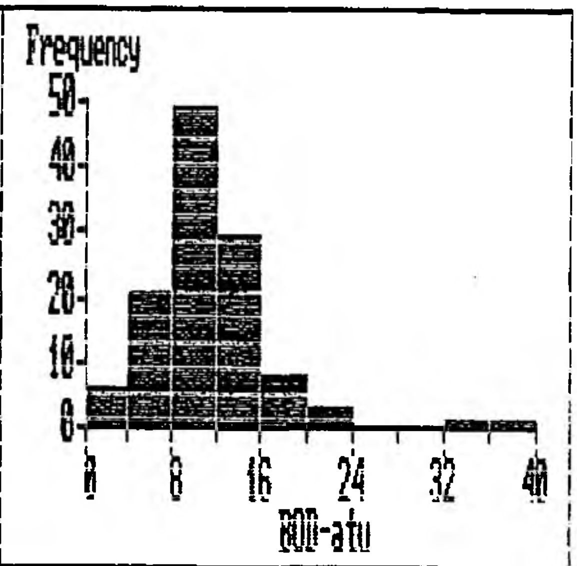
Watercourse: River Yeo
Site: Mudford
Grid Reference: ST57551995

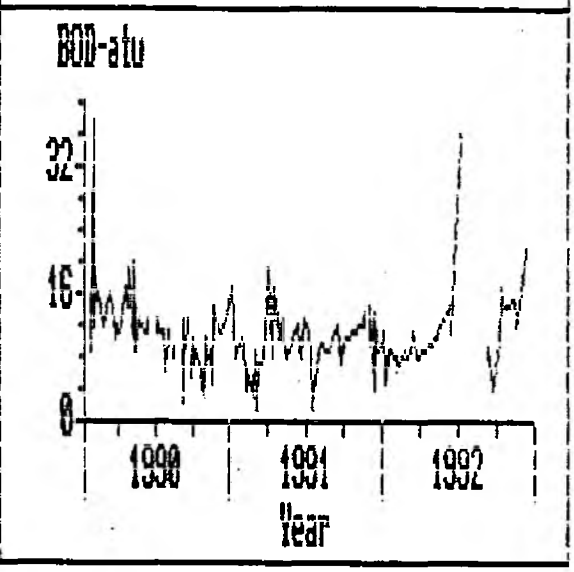
Status: A
Sampled in 1991: Y
T Code 1990: T356
Aut92 P Date: 18/10/92
Sampled in 1992: Y
Sample Reason: R
Sampled in 1990: Y
Full Reference: 5202 YEO 215
Altitude: 20.00
Discharge: 04
Risk: M
Source Distance: 25.00
Slope: 1.30
Biologist: PDS
Comments

	Spr 90	Sum 90	Aut 90	Tot 90	Spr 91	Sum 91	Aut 91	Tot 91	Spr 92	Sum 92	Aut 92	Tot92
Date					2/4/91	17/7/91	23/9/91			18/6/92		
Alkalinity				207	198	179	160	179		222		222
Families	11	23	22	24	16	23	24	28		30		30
Pred Families	25	25	26	34	26	26	27	35		25		25
Families EQI	0.45	0.91	0.86	0.70	0.63	0.88	0.90	0.80		1.19		1.19
BMWP	40	97	91	102	62	95	103	122		133		133
Pred BMWP	132	132	133	186	139	138	143	196		129		129
BMWP EQI	0.30	0.74	0.69	0.55	0.45	0.69	0.72	0.62		1.03		1.03
ASPT	3.64	4.22	4.14	4.30	3.88	4.13	4.29	4.36		4.43		4.43
Pred ASPT	5.40	5.20	5.10	5.50	5.40	5.30	5.30	5.60		5.10		5.10
ASPT EQI	0.67	0.81	0.81	0.78	0.72	0.78	0.81	0.78		0.87		0.87
Suitability	1	1	1		1	1	1	1		1		
Class				B				B				

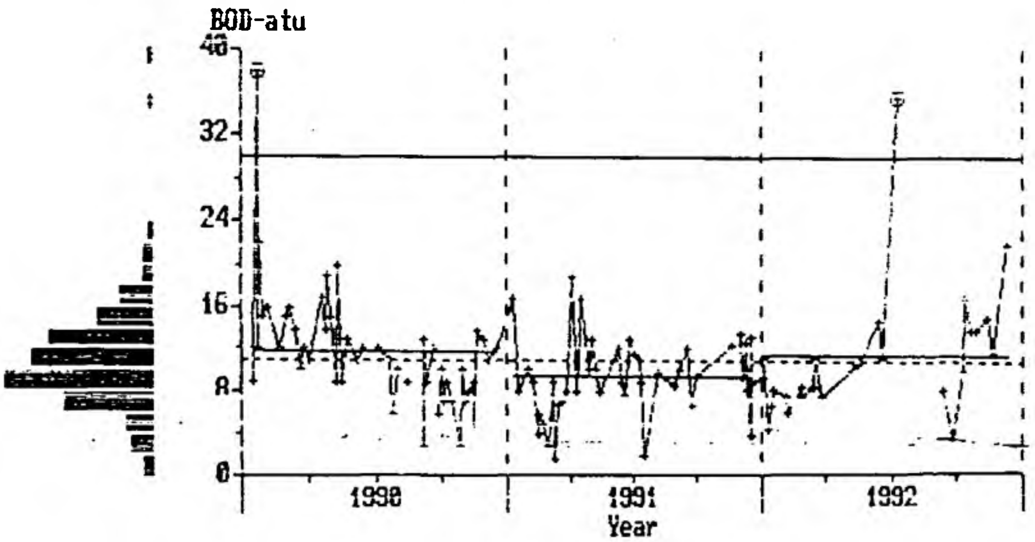
YEOVIL FINAL BOD-atu 16/ 1/90 to 11/12/92

Number of observations	118
Minimum	1.5
Mean	10.8
Maximum	38.0
Standard deviation	5.23
SDD	4.42
Non-parametric estimate of:	
5 percentile	3.7
10 percentile	5.9
20 percentile	7.5
Median	10.0
80 percentile	13.6
90 percentile	16.1
95 percentile	19.0



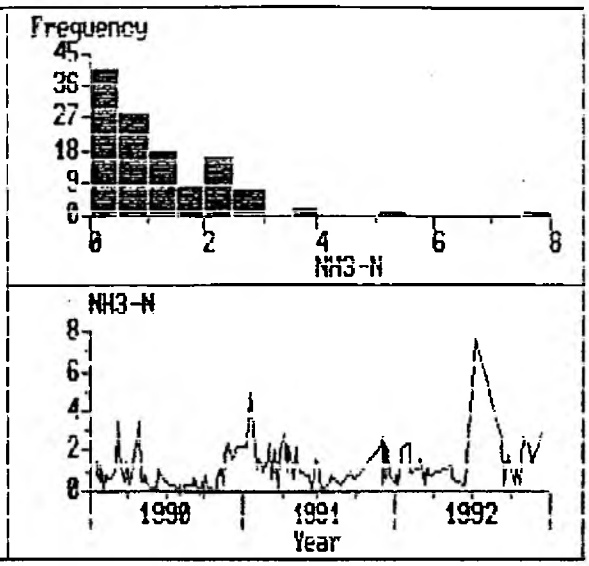


YEOVIL FINAL 16/ 1/90 to 11/12/92

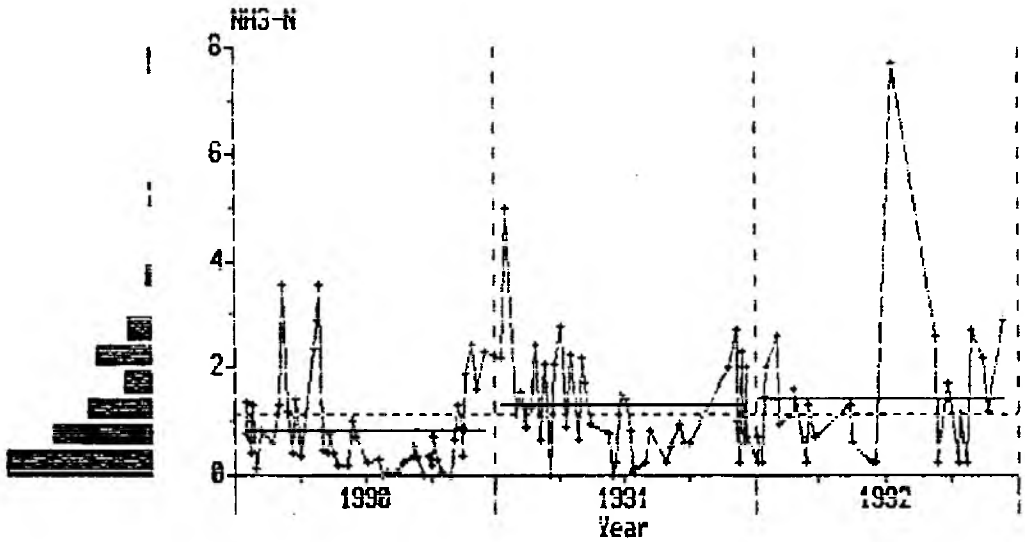


YEOVIL FINAL NH3-N 16/ 1/90 to 11/12/92

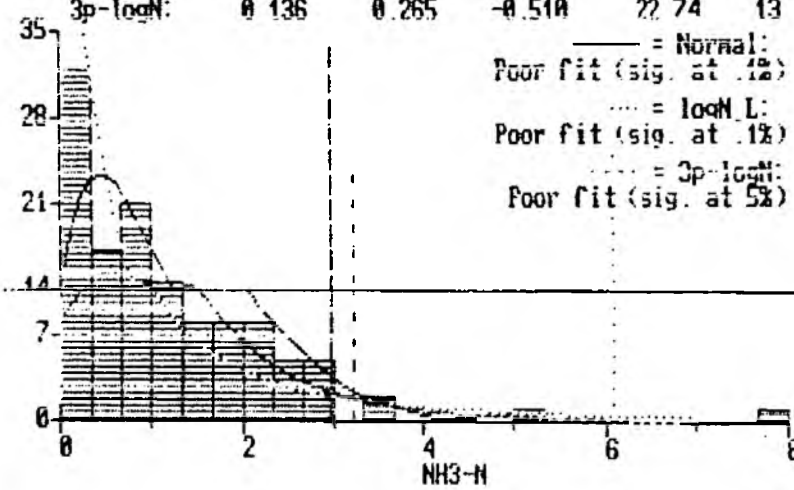
Number of observations	122
Minimum	0.01
Mean	1.14
Maximum	7.79
Standard deviation	1.108
SDD	0.969
Non-parametric estimate of:	
5 percentile	0.02
10 percentile	0.13
20 percentile	0.25
Median	0.82
80 percentile	2.00
90 percentile	2.42
95 percentile	2.88



YEOVIL FINAL 16/ 1/90 to 11/12/92

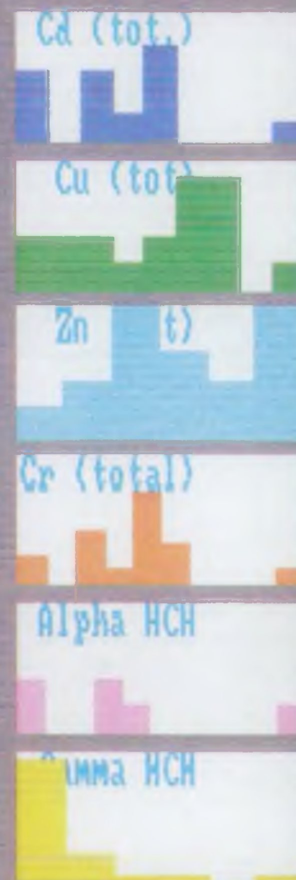


NH3-N	$\hat{\mu}$	$\hat{\sigma}$	"zero"	chi-sq	df
Normal:	1.137	1.108	-	79.34	19
logN_L:	-0.203	0.599	-	45.29	12
3p-logN:	0.136	0.265	-0.510	22.74	13



YEOVIL FINAL 7/ 8/90 to 10/ 2/93

Determinand	N	minimum	mean	maximum	st.dev.	SDD
Cd (tot.)	20	1.00	2.04	4.30	0.882	0.629
Cu (tot)	18	0.03	0.03	0.03	0.002	0.003
Zn (tot)	18	0.03	0.09	0.14	0.031	0.023
Cr (total)	18	0.07	0.14	0.25	0.041	0.048
Alpha HCH	6	19.10	144.42	400.60	138.966	124.158
Gamma HCH	30	2.50	180.48	1044.00	222.290	99.296



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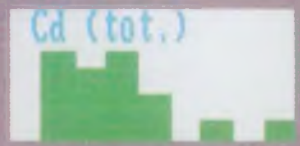
R YEO OVER COMPTON 26/ 4/90 to 20/ 1/93

Determinand	N	minimum	mean	maximum	st.dev.	SDD
Gamma HCH	34	0.25	45.52	251.00	63.031	37.463
Cd (tot.)	22	0.10	0.20	0.60	0.180	0.144
Cr (total)	1	0.00	0.00	0.00	0.000	0.000
Cu (diss)	27	0.00	0.01	0.03	0.007	0.005
Zn (tot)	22	0.00	0.02	0.05	0.010	0.007

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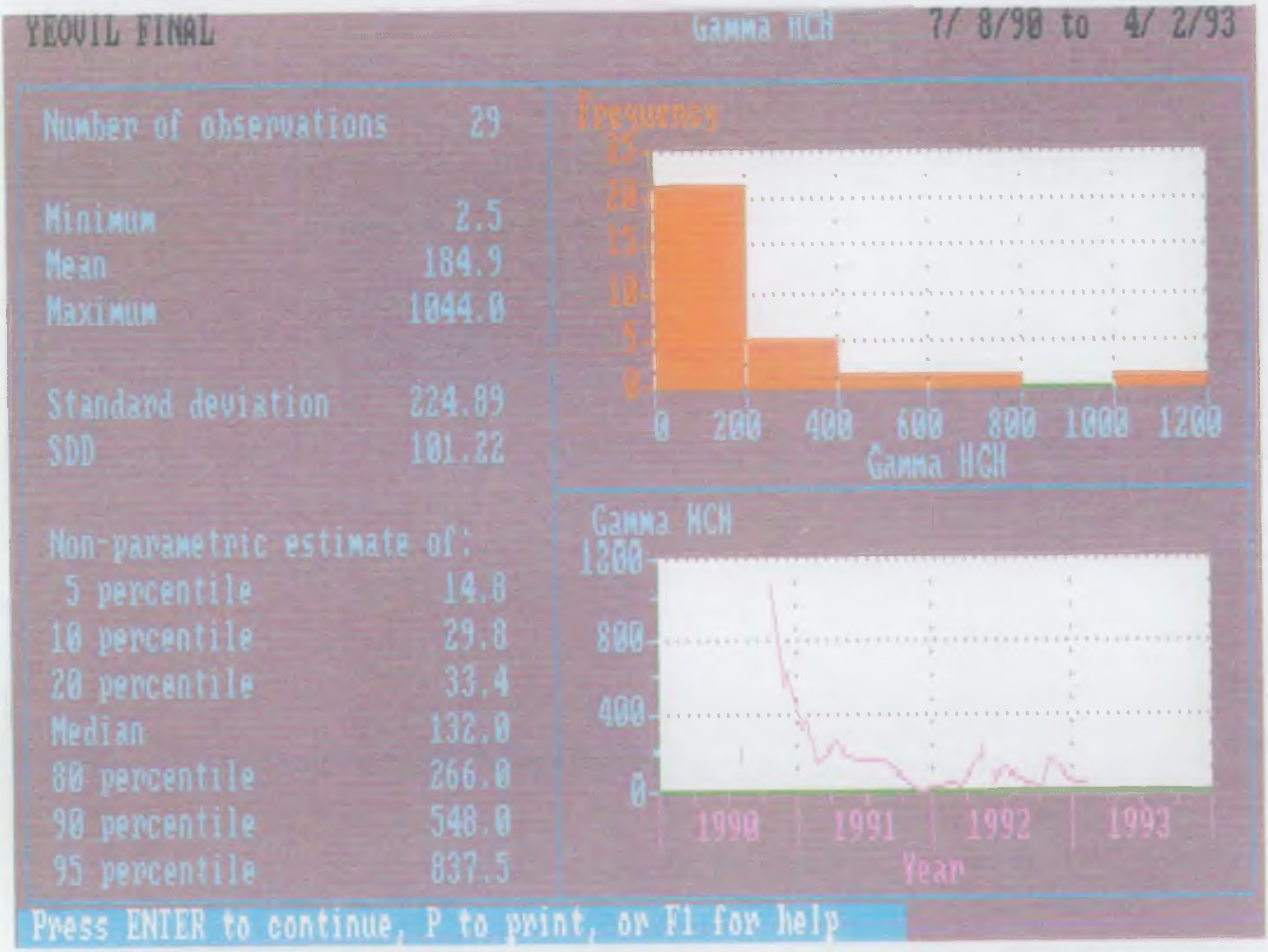
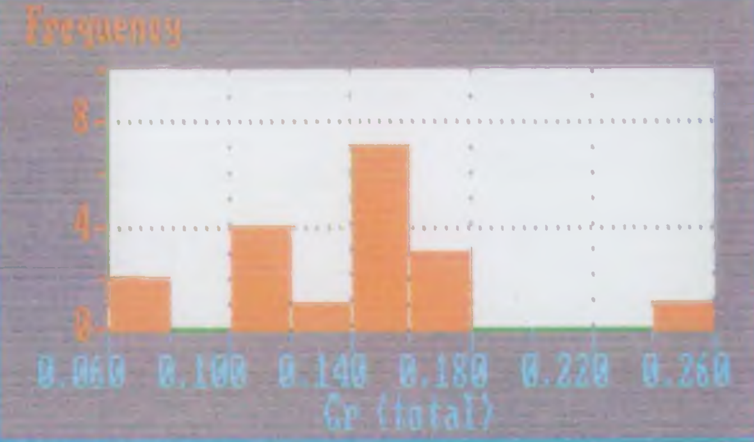
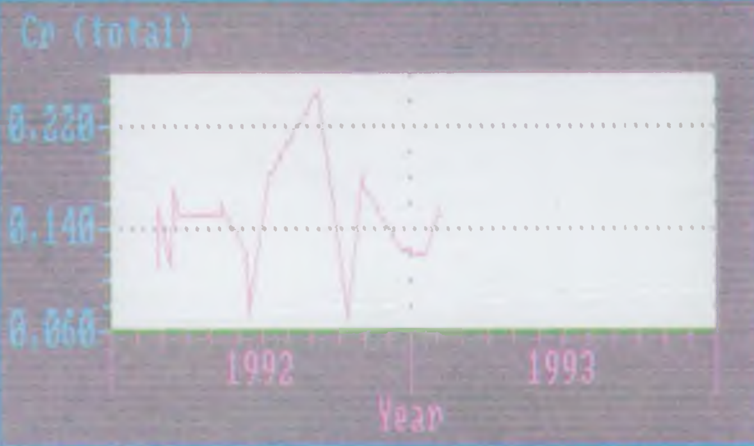

YEOVIL FINAL
Gamma HCH
7/ 8/90 to 4/ 2/93
Number of observations 29
Minimum 2.5
Mean 184.9
Maximum 1044.0
Standard deviation 224.89
SDD 101.22
Non-parametric estimate of:
5 percentile 14.8
10 percentile 29.8
20 percentile 33.4
Median 132.0
80 percentile 266.0
90 percentile 548.0
95 percentile 837.5
Frequency
25
20
15
10
5
0
0 200 400 600 800 1000 1200
Gamma HCH
Gamma HCH
1200
800
400
0
1990 1991 1992 1993
Year
Press ENTER to continue, P to print, or F1 for help

YEOVIL FINAL   Cr (total)   7/ 8/90 to 10/ 2/93

Number of observations	18
Minimum	0.0700
Mean	0.1441
Maximum	0.2500
Standard deviation	0.04142
SDD	0.04829
Non-parametric estimate of:	
10 percentile	0.0754
20 percentile	0.1116
Median	0.1500
80 percentile	0.1720
90 percentile	0.1870

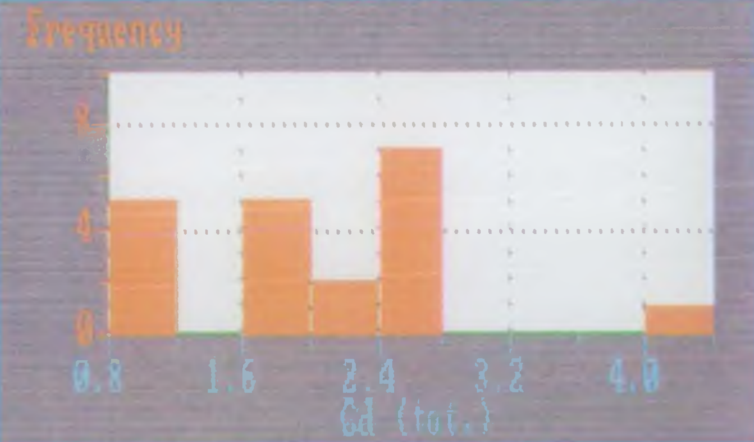


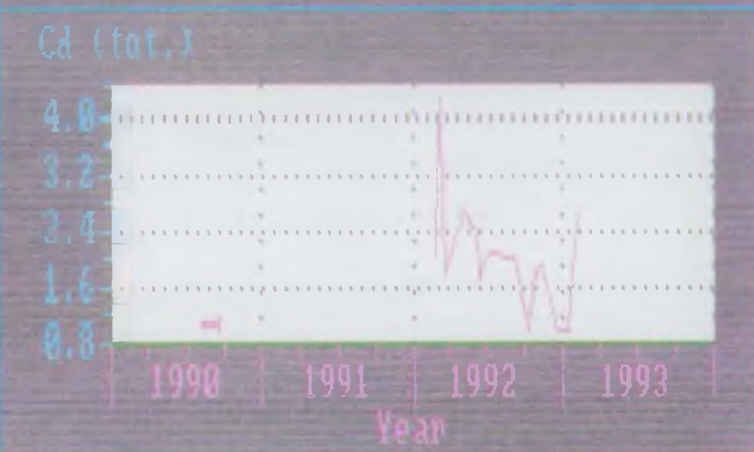


Press ENTER to continue, P to print, or F1 for help

YEOVIL FINAL   Cd (tot.)   7/ 8/90 to 10/ 2/93

Number of observations	20
Minimum	1.00
Mean	2.04
Maximum	4.30
Standard deviation	0.802
SDD	0.629
Non-parametric estimate of:	
5 percentile	1.00
10 percentile	1.00
20 percentile	1.10
Median	2.05
80 percentile	2.60
90 percentile	2.69
95 percentile	4.22

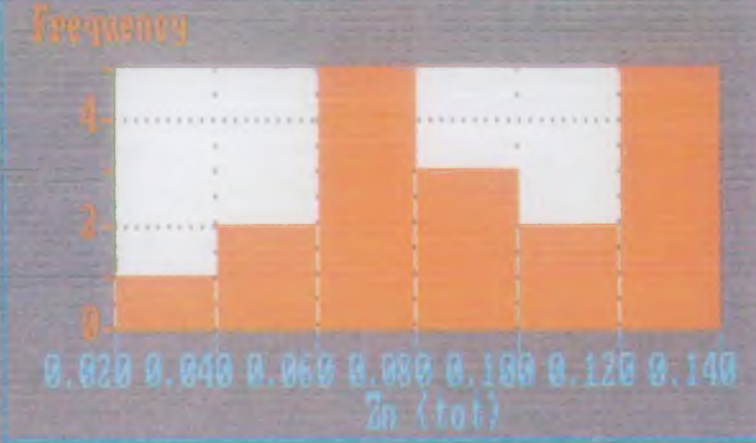




Press ENTER to continue, P to print, or F1 for help

YEOVIL FINAL   Zn (tot)   7/ 8/90 to 10/ 2/93

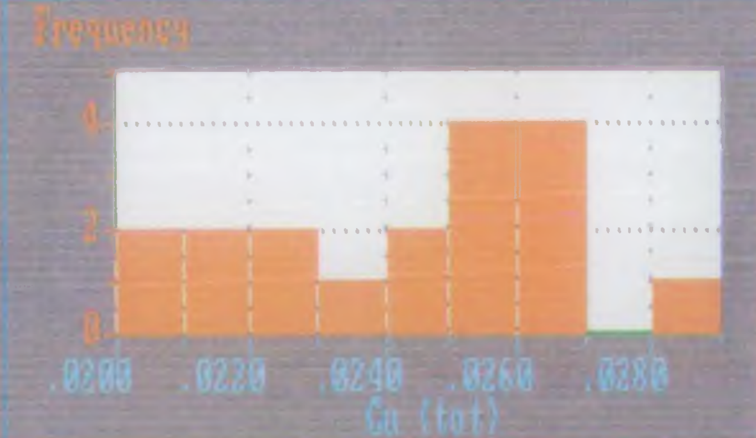
Number of observations	18
Minimum	0.0320
Mean	0.0873
Maximum	0.1380
Standard deviation	0.03145
SDD	0.02327
Non-parametric estimate of:	
10 percentile	0.0419
20 percentile	0.0594
Median	0.0850
80 percentile	0.1220
90 percentile	0.1245

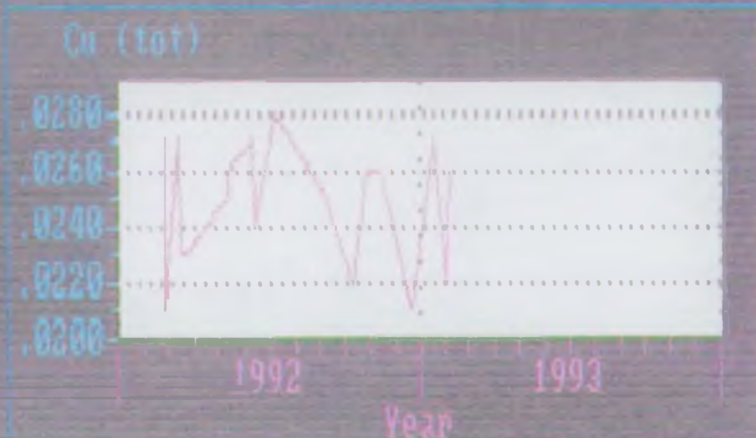


Press ENTER to continue, P to print, or F1 for help

YEOVIL FINAL   Cu (tot)   7/ 8/90 to 10/ 2/93

Number of observations	18
Minimum	0.02100
Mean	0.02478
Maximum	0.02800
Standard deviation	0.002264
SDD	0.002823
Non-parametric estimate of:	
10 percentile	0.02100
20 percentile	0.02200
Median	0.02550
80 percentile	0.02700
90 percentile	0.02710





Press ENTER to continue, P to print, or F1 for help

R YEO OVER COMPTON

Gamma HCH 26/ 4/90 to 20/ 1/93

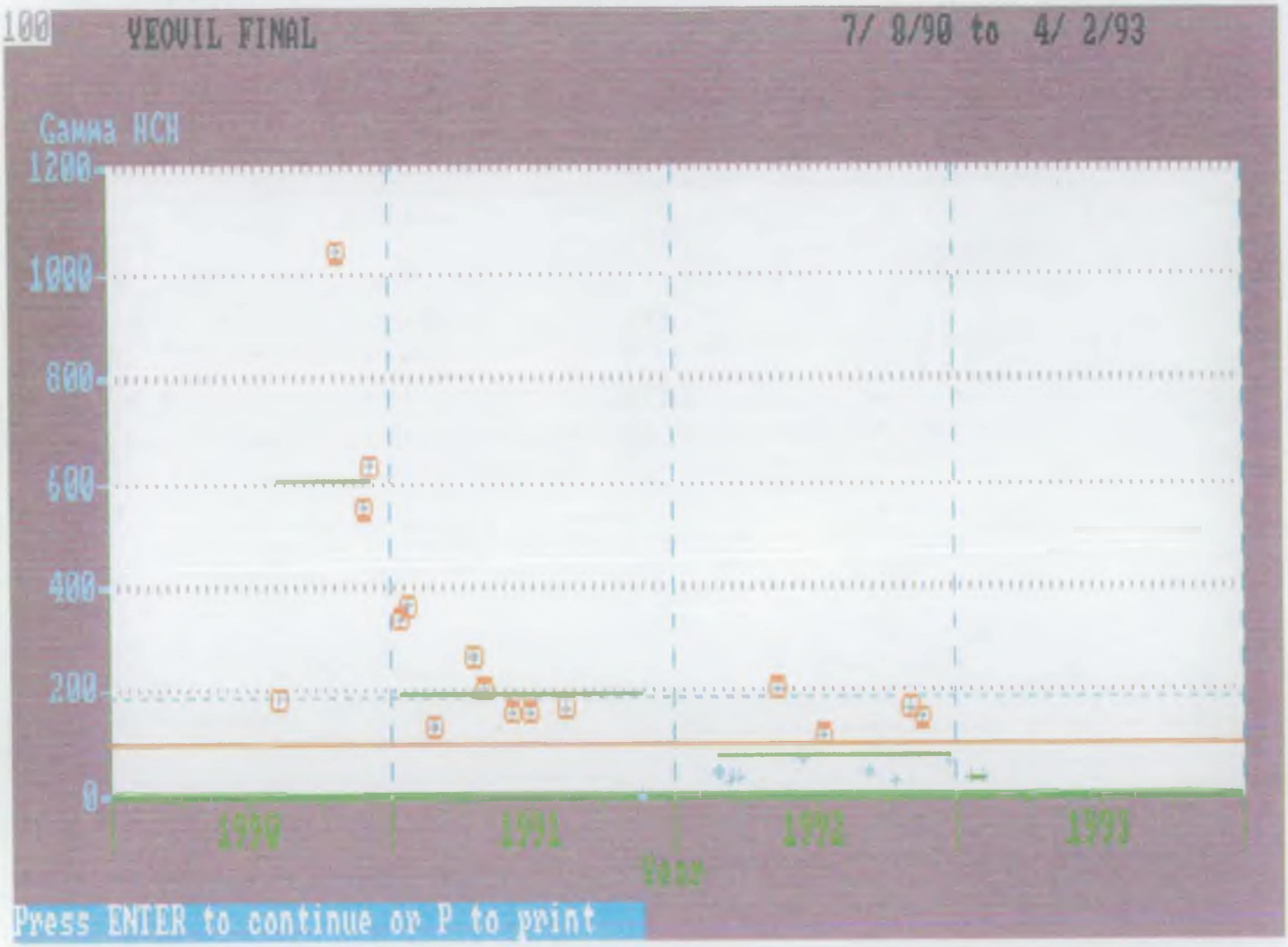
Number of observations	34
Minimum	0.2
Mean	45.5
Maximum	251.0
Standard deviation	63.03
SDD	37.46

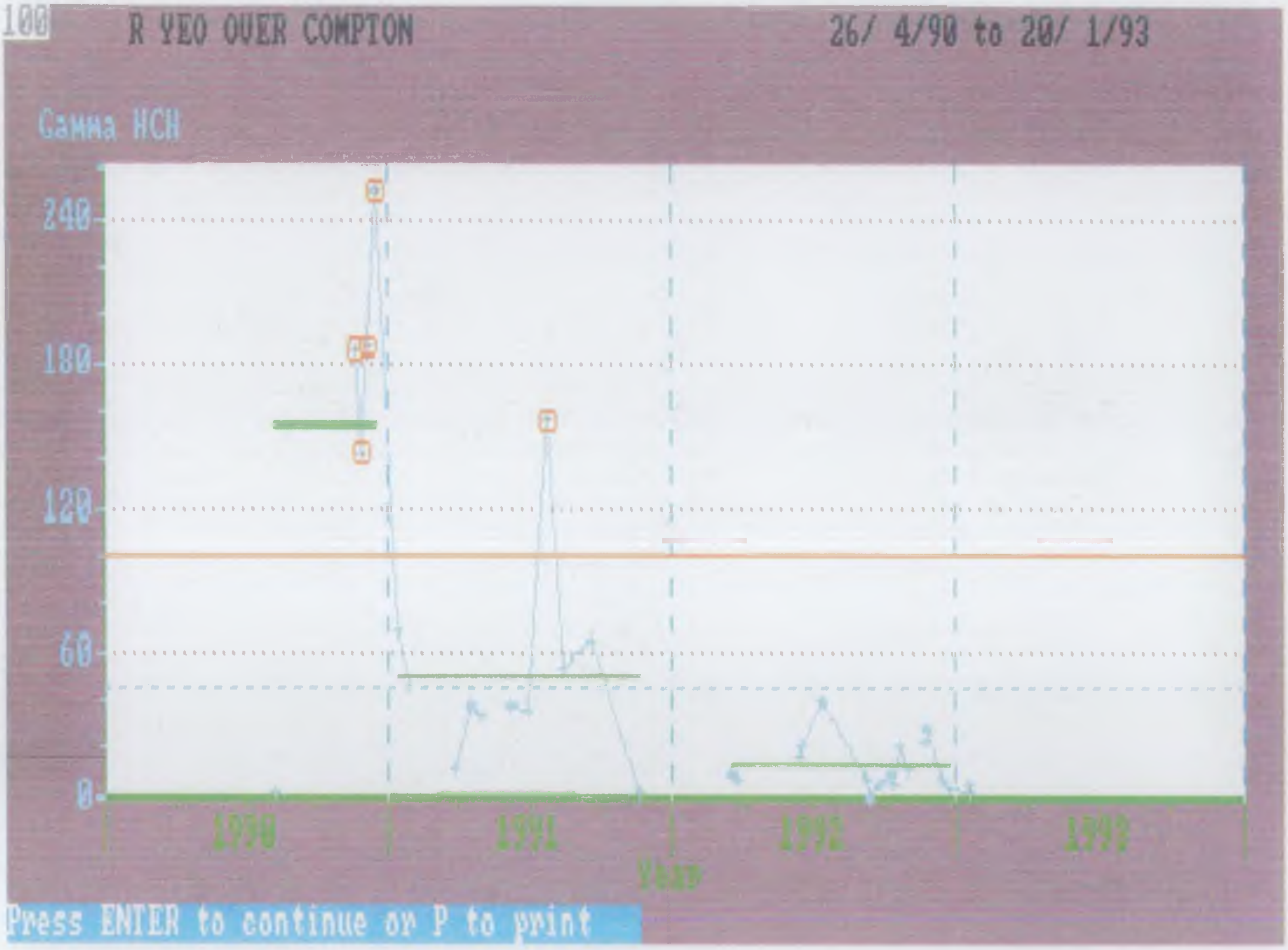
Non-parametric estimate of:

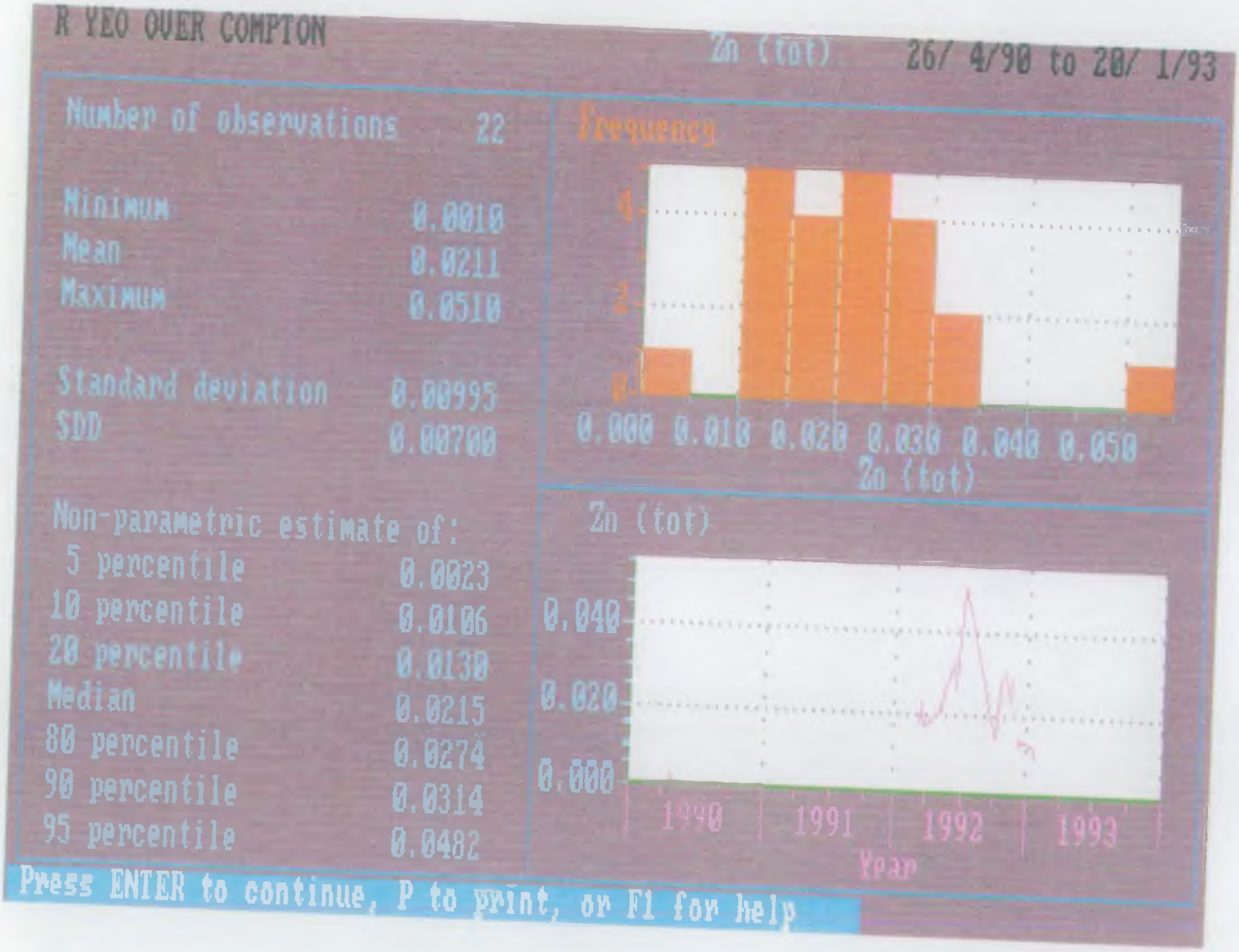
5 percentile	1.9
10 percentile	2.5
20 percentile	5.2
Median	21.0
80 percentile	65.0
90 percentile	171.0
95 percentile	203.0

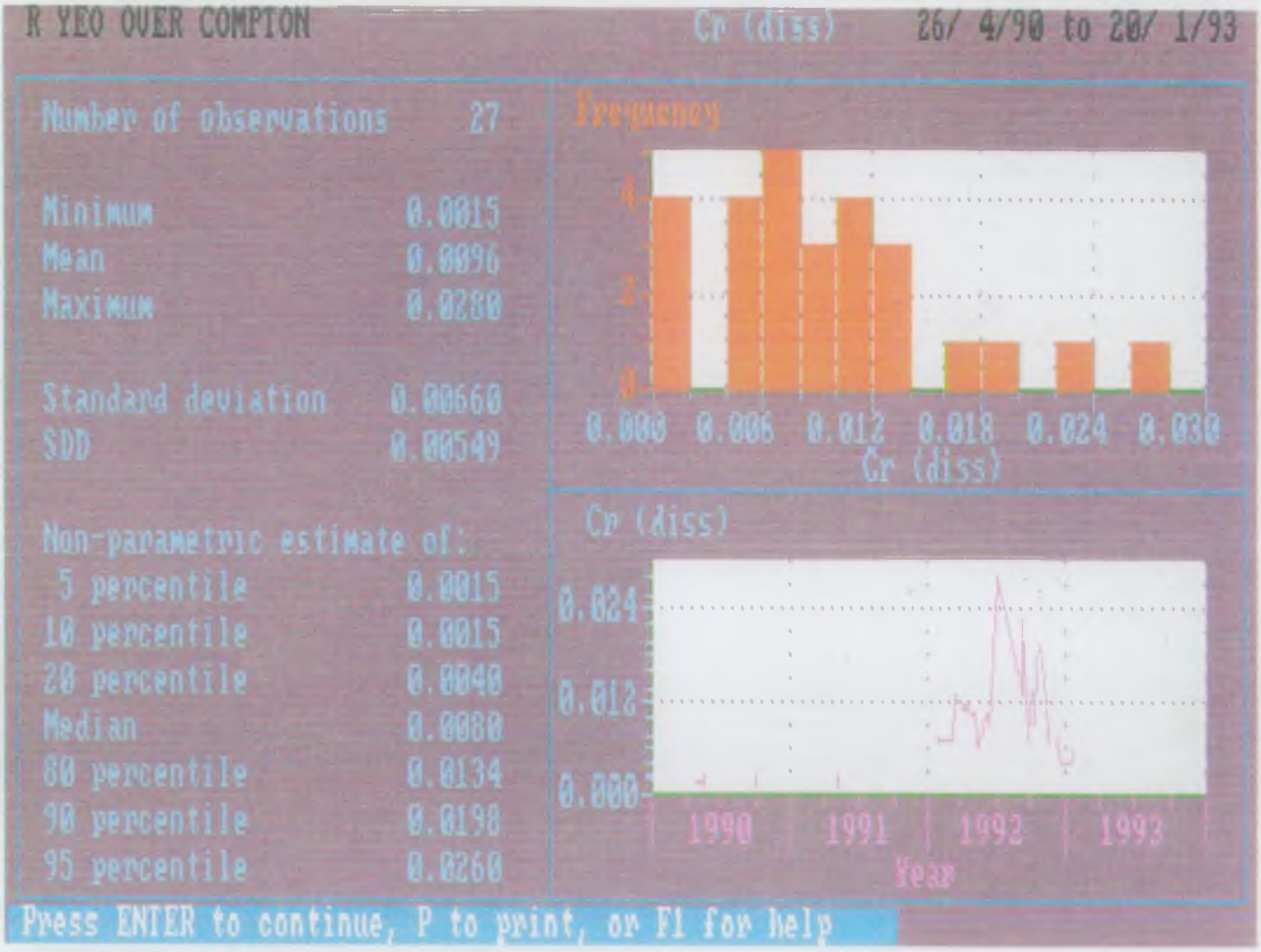
Gamma HCH

Press ENTER to continue, P to print, or F1 for help


100
YEOVIL FINAL
7/ 8/90 to 4/ 2/93
Gamma HCH
1200
1000
800
600
400
200
0
1990
1991
1992
1993
Year
Press ENTER to continue or P to print

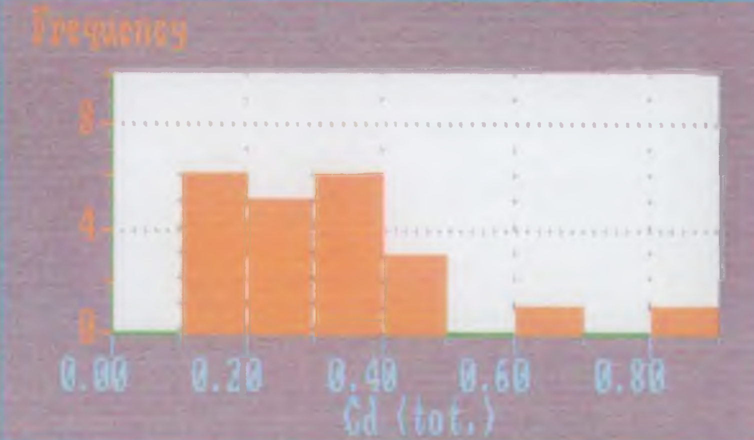

100
R YEO OVER COMPTON
26/ 4/90 to 20/ 1/93
Gamma HCH
240
180
120
60
0
1990
1991
1992
1993
Year
Press ENTER to continue or P to print

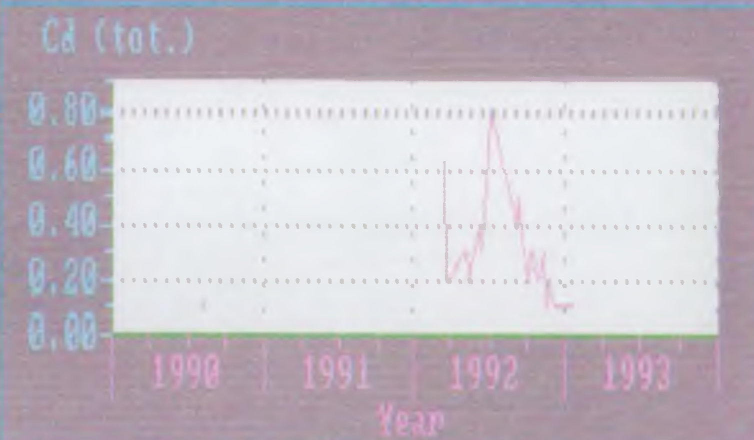

R YEO OVER COMPTON
Zn (tot)
26/ 4/90 to 20/ 1/93
Number of observations 22
Minimum 0.0010
Mean 0.0211
Maximum 0.0510
Standard deviation 0.00995
SDD 0.00700
Non-parametric estimate of:
5 percentile 0.0023
10 percentile 0.0106
20 percentile 0.0130
Median 0.0215
80 percentile 0.0274
90 percentile 0.0314
95 percentile 0.0482
Frequency
0.000 0.010 0.020 0.030 0.040 0.050
Zn (tot)
Zn (tot)
0.040
0.020
0.000
1990 1991 1992 1993
Year
Press ENTER to continue, P to print, or F1 for help


R YEO OVER COMPTON
Cr (diss)
26/ 4/90 to 20/ 1/93
Number of observations 27
Minimum 0.0015
Mean 0.0096
Maximum 0.0280
Standard deviation 0.00660
SDD 0.00549
Non-parametric estimate of:
5 percentile 0.0015
10 percentile 0.0015
20 percentile 0.0040
Median 0.0080
80 percentile 0.0134
90 percentile 0.0198
95 percentile 0.0260
Frequency
4
2
0
0.000 0.006 0.012 0.018 0.024 0.030
Cr (diss)
Cr (diss)
0.024
0.012
0.000
1990 1991 1992 1993
Year
Press ENTER to continue, P to print, or F1 for help

R YEO OVER COMPTON   Cd (tot.)   26/ 4/90 to 20/ 1/93

Number of observations	22
Minimum	0.100
Mean	0.277
Maximum	0.800
Standard deviation	0.1798
SDD	0.1442
Non-parametric estimate of:	
5 percentile	0.100
10 percentile	0.100
20 percentile	0.100
Median	0.250
80 percentile	0.400
90 percentile	0.570
95 percentile	0.770





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WRc

WORLD HEALTH ORGANIZATION
COLLABORATING CENTRE FOR
DRINKING WATER AND
WATER POLLUTION CONTROL

Mr A Lions
NRA Wessex Region
Rivers House
East Quay
Bridgewater
Somerset TA6 4YS

Our Ref: E1951

26 February 1993

Dear Mr Lions

AQUATIC TOXICITY OF GAMMA- (LINDANE) AND ALPHA-HCH AND STATUS OF LINDANE EQS

Thank you for your enquiry of 24 February 1993 concerning the above. I have searched the databases held at WRc as well as a number of commercial databases and have managed to locate the information that you require (see Appendix A).

The available data suggest that gamma- (lindane) and alpha-HCH are of high acute and chronic toxicity, with the majority of effect concentrations ranging from 0.0073-0.87 and 0.1-0.8 mg l^{-1}, respectively.

Both isomers appear to bioaccumulate, with reported BCFs ranging from 50-220 for crustaceans and fish. However, it is likely that these values are whole body BCFs since Marcelle and Thome (1983) have reported a BCF of approximately 6,000 for the brain and liver of the guppy (Poecilia reticulata) after 96 hours exposure to a concentration of 0.14 mg l^{-1}. This BCF indicates that organ specific or lipid normalised BCFs are higher and probably more meaningful for organic compounds, than whole body BCFs.

Lindane is a List I substance, and as such a Water Quality Standard of 0.1 $\mu g\ l^{-1}$, arising from the EC dangerous substances directive, has been set for all HCH isomers (The Surface Waters (Dangerous Substances) (Classification) Regulations. Statutory Instrument No. 2286). This standard is expressed as total HCH concentration (ie without filtration) and as an annual average.

I hope that you will find this information useful. Please do not hesitate to contact me should you require anything further.

Yours sincerely

Mark Grimwood
Environmental Biologist
INSTAB

Enc

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APPENDIX A: AQUATIC TOXICITY OF GAMMA- (LINDANE) AND ALPHA-HCH

1. G-HEXACHLOROCYCLOHEXANE (HCH) (LINDANE)

1.1. Fate and behaviour

Lindane has a relatively low solubility in water (7 mg l^{-1} at 20°C) and a high octanol-water coefficient (log K_{ow} = 3.72), indicating that this compound will have a strong tendency to adsorb onto sediments and particulate matter. In the aquatic environment it has been reported that 30 - 40% of lindane will be adsorbed over a equilibrium period of 3-100 hours (Verschueren 1983).

Hydrolysis half-lifes of 191 and 11 days have been reported at pH's of 7 and 11 respectively (Worthing and Hance 1991).

1.2. Aquatic toxicity

The available data suggest that lindane is of high acute and chronic toxicity to aquatic invertebrates (majority of effect concentrations range from 0.0073 to 0.33 mg l^{-1}) with crustaceans appearing to be less sensitive than insects (see Table 1) although more data are required to confirm this.

The available data suggest that lindane is also of high acute toxicity to fish, with the majority of reported effect concentrations ranging from 0.002 - 0.087 mg l^{-1}. However, the eel, *Aguilla anguilla* appears to be less sensitive, with a reported 96 hour LC50 of 0.67 mg l^{-1}, although this figure still indicates high acute toxicity (see Table 1).

Table 1. Aquatic toxicity of lindane (gamma-HCH).

SPECIES	DURATION	EFFECT	CONC ($mg\ l^{-1}$)	REF
Insects				
Midge 2 generations (*Chironomus tentans*)	Larval	0.0073 mortality retarded development and reduced emergence	1	
Crustaceans				
Water flea (*Daphnia sp.*)	16 days	EC50 (reproduction)	0.05	2
Water flea (*Daphnia sp.*)	16 days	10% reduction in growth	0.33	2
Water flea (*Daphnia sp.*)	16 days	NOEC (Growth)	0.33	2
Water flea (*Daphnia pulex*)	24 hours	LC50	1.25	3
Freshwater shrimp (*Gammarus pulex*)	48 hours	LC50	0.03	3
Fish				
Brown trout (*Salmo trutta*)	96 hours	LC50	0.002	4
Guppy (*Poecilia reticulata*)	48 hours	LC50	0.16	5
Rainbow trout (*Oncorhynchus mykiss*)	96 hours	LC50	0.022-0.027	6
Fathead minnow (*Pimephales promelas*)	96 hours	LC50	0.059-0.087	6
Bluegill sunfish (*Lepomis macrochirus*)	96 hours	LC50	0.068-0.077	6
Gudgeon (*Gobio* sp)	96 hours	LC50	0.074	7
Eel (*Anguilla anguilla*)	96 hours	LC50	0.67	8

1. Manek *et al* (1976)
2. Deneer *et al* (1988)

3. Gliwicz and Sieniawaska (1986)
4. Verschueren (1983)
5. Worthing and Hance (1991)
6. Mayer and Ellersieck (1986)
7. Randall et al (1979)
8. Ferrando et al (1991)

1.3. Bioaccumulation

Lindane is likely to bioaccumulate due to its high octanol-water partition coefficient. A bioconcentration factor (BCF) of 220 has been reported for Daphnia magna (concentration and exposure time not stated) (Geyer et al 1991). Thybaud and LeBras (1988) have reported a BCF of 50 for the hog louse, Asellus aquaticus, on exposure to 2.0 $\mu g\ l^{-1}$ over a 48 hour period. On removal to clean water lindane elimination was seen to be rapid, 40% was eliminated after 24 hours.

Marcelle and Thome (1983) have reported that above a water concentration of 0.029 mg l^{-1}, the accumulation of lindane causes mortality. The authors found that after 96 hours exposure to a concentration of 0.14 mg l^{-1}, the residue levels in the brain and liver of the gudgeon (Gobio sp) were 8 - 9 mg kg^{-1}, with concentrations in the muscle being slightly lower. These values represent a BCF of approximately 6,000, and indicate that organ specific or lipid normalised BCFs are higher and probably more meaningful for organic compounds, than whole body BCFs.

2. A-HEXACHLOROCYCLOHEXANE (HCH)

2.1. Aquatic toxicity

The limited data available suggest that this isomer is of high acute and chronic toxicity to freshwater crustaceans, molluscs and fish, with reported effect concentrations ranging from 0.1 - 0.8 mg l^{-1}. Algae appear to be less sensitive to a-HCH, with a 48 hour LC50 of >10.0 mg l^{-1} having been reported for Chlorella pyrenoidosa (see Table 2).

Table 2. **Aquatic toxicity of alpha HCH.**

SPECIES	DURATION	EFFECT	CONC (mg l^{-1})	REF
Algae				
Green alga (Chlorella pyrenoidosa)	48 hours	EC50 (growth)	>10	1
Molluscs				
Great pond snail (Limnaea stagnalis)	40 days	LC50	0.23	2
Great pond snail (Limnaea stagnalis)	40 days	EC50 (egg production)	0.25	2
Crustaceans				
Water flea (Daphnia magna)	1-21 days	EC50 (reproduction)	0.1	1
Fish				
Guppy (Poecilia reticulata)	48 hours	EC50 (mortality/paralysis)	0.8	1

1. Canton et al (1975)
2. Canton and Sloof (1977)

2.2. Bioaccumulation

As with gamma-HCH, alpha-HCH appears to be bioaccumulated. BCFs of 60 and 140 have been reported for the water flea (Daphnia magna) and guppy (Poecilia reticulata), respectively, on exposure to 10.0 $\mu g\ l^{-1}$, over an exposure period of 3 hours (Canton and Greve 1975). It is not stated whether these BCFs are whole body or lipid normalised. However, based on the BCF of 6,000 reported for the brain and liver of guppy (Poecilia reticulata) exposed to gamma HCH, it seems likely that these values are whole body BCFs, rather than lipid normalised BCFs.

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