NRA Thames 106

SWORDS WATER QUALITY STUDY - PHASE I

Modelling the Water Quality of the River Thames

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Contents.

Validity of the Water Quality Model, TOMCAT, as set up by TWU

Summary

An assessment of the Tomcat water quality model set up for the River Thames between Farmoor and Days shows the model to be over predicting ammonia 95%iles and dissolved oxygen 5%iles as well as underpredicting BOD 95%iles. These problems become worse during the low flow validation period. It appears possible though to calculate the likely error on the model output and thus use it in calculation of abstraction scenarios.

Introduction

To investigate the effects of the proposed new surface water abstraction from the river Thames near Abingdon, Thames Water set up the water quality model Tomcat for the period October 1984 - Sept 1989.

The model was set up for the stretch of the Thames between Farmoor water intake and Days weir and upon achieving a satisfactory calibration of the model at three sites, Thames Water supplied a copy of the calibrated data files to the Thames NRA.

This report is an assessment of the accuracy of the initial calibration and also outlines an attempt to validate the model using data from the period January 1990 - December 1991.

The only changes during the validation of the model were to the data sets of water quality and flow. These became either changed or scaled to the 1990/91 data. All other details of the model remain the same and may be found in Progress Reports 1 & 2 written by Thames Water Utilities.

Calibration Results

The calibrated model provided by Thames Water has been rerun using 864 shots rather than 288 shots which they used in producing Progress report No. 2. This should increase the accuracy of the predicted statistics and also enable confidence intervals to be calculated on 5th and 95th percentiles of water quality determinands.

Table 1 shows the calculated test statistics. The values in table 1 are expected to be difference from those produced by a 288 shot run. There is a significant change though in terms of the KS test failing for BOD and ammonia at Days Weir. The KS test and MW test fail for ammonia at Osney Weir and DO at Day's Weir in a 288 shot run as well.

Figs. 1-13 show the normal probability calibration plots for BOD, Un-I-Amm, T Ammonia, DO and chloride at all three calibration sites. These enable a qualitative comparison of the goodness of fit between observed and simulated data.

The model produces good agreement between observed and simulated data for both chloride and unionized ammonia, apart from at Days Weir where for chloride it is underestimating the higher observed values.

For BOD there is a good fit at Osney weir whilst at Abingdon and Days the higher values are being slightly underestimated. At Days the upper simulated values are approximately 20% too small which is in fact reflected by the failure of the KS test at this site.

The failure of the KS test at Osney Weir for ammonia can be seen to be due to the high number of 0.05mg/l in the observed data set. This is in fact a detection limit for ammonia testing. At Abingdon and Days the model is overpredicting the upper values and this causes the KS test to fail at Days.

The model is slightly overpredicting the DO concentration at all three sites particularly at lower concentrations of DO. The overpredicting of these low DO's causes the KS test to fail at Days.

Validation

The period January 1990 - December 1991 was chosen as the time period in which to set up the model for validation purposes. Flows during this time varied from the high flood flows of February 1990 to the low flows of the summers of both these years. In generally flows were lower than average and if the model is capable of simulating the water quality conditions during this period, confidence will be high that it is capable of estimating the effects of the new abstractiion upon the water quality.

Flows

A first attempt at modelling the 1990/91 flows was made by scaling the 1984/1989 flow data set (ie. assumes the same distribution) but this was found to give a very poor fit though, so actual 1990/91 flow data was used where it was available. Table 2 shows the mean flow from each discharge whilst Table A in Appendix A shows the source of the data used in the model input file. For the major rivers represented in the model, 1990/91 gauging station data was used whilst for the STW the 1984/1989 flow data was simply scaled where data was available. Table 2 also shows the total accretion flow which must be added to the river to make the sum of the means of the discharges equal to the mean flow at Days. Table 3 shows the accretion flow added to each reach. The same fraction of the total accretion flow is added to each reach as was used by Thames Water in the setting up of the model.

Calibration plots of the simulated and observed data at Days and Eynsham are shown in Figs. 16 and 17. The flows are logged values so as to show in more detail the low flow part of the curve which is the region of particular interest. It is clear that both at Eynsham and Days the flows are being well represented. The models low flow values are in fact lower than the observed values and similarly the upper model values are higher than observed values. This is unusual for the Tomcat model where due to the random selection of residuals for combining with monthly and grand means the breadth of the distribution is normally reduced.

Table 4 shows the corresponding statistics for flows produced from Tomcat compared with the observed statistics. The differences between the observed and predicted are within the 90% confidence interval of the predicted on all but two occasions.

Quality

As an initial stage in the validation process the 1984/89 WQ data was scaled by comparing the means of the 1984/89 data with those of the 1990/91 data set. Calibration plots and the test statistics were then examined to estimate the goodness of fit between observed and simulated data. The plots showed a poor fit between observed and simulated so in an attempt then to improved the goodness of the fit, actual 1990/91 data was introduced into the model at the sites which were considered to have the most significant effects on the simulated quality data. Table B in Appendix A shows the source of the WQ data used.

Best fit calibration curves at Trout Inn Farm, Radley College Boat House and Days Weir are given in Fig. 18-33 and table 5 shows the calibration test statistics produced by the model. The first two calibration sites are different than those used in the original calibration because monitoring at Osney Weir and Abingdon Weir was stopped in 1989.

Though the simulated chloride data passes both tests at all three calibration sites the quality of the fits shows in the calibration plots is quite poor, apart from at Trout Inn Farm. At Radley College the model is failing to simulate the highest and lowest chloride values accurately, the deviation of the simulated data being too small. The major input of chloride at this point has been the Oxford STW (via Northfield Brook) and it is possible that this data set is poorly represented. At Days the error in the chloride data is more systematic with the chloride being constantly underestimated.

The unionized ammonia passes both statistics tests at all three sites. This can be seen clearly in the calibration plots and indicates that the model is representing the data well.

At Trout Inn the calibration plot shows an adequate fit for ammonia though the KS test fails for ammonia at this site. This failure is again due to the number of observed samples which are at the detection limit for ammonia. At Radley college the ammonia is a good fit apart from the higher values where the model is overestimating the observed data. This cause the KS test to fail at this point. At Days the ammonia appears to be a good fit despite the fact the KS test fails at this point.

The BOD calibration curves show very poor fits and this is reflected in the test statistics. At Radley College and Days the model is underestimating the higher values of BOD whilst at Trout Inn the model is over estimating the higher values. The poor fit at Days and Radley College may possible be due to poor representation of the Oxford STW data which has been the major input at Radley College. There are also a number of less than 2mg/l readings in the observed data at all three sites which will reduce the effectiveness of the statistical tests. The failure at Trout Inn Farm must either be associated with a poor starting data at Farmoor or poor calibration data at Trout Inn Farm. Both of these must be considered likely since the size of our observed data sets are only approximately 30 readings.

The DO calibration curves show that DO concentrations are being constantly overestimated. This overestimation seems worse at Trout Inn Farm where both stats tests are failed and then improves at the other two sites. The overestimation is worst at lower values of DO.

Quantitive Analysis

In order to use the model for assessment of the effects of a SW abstraction a quantitive estimate of the accuracy of the model is needed.

Tables 6 and 7 show calculated 95%ile figures for the various WQ details compared with the observed figures for both the 1984/89 time period and the period of validation.

It can be clearly seen that for ammonia the model at present is over predicting the 95%ile value for both time periods apart from at Days for the 1990/91 period where the observed value falls within the simulated confidence intervals. For work on the abstraction scenarios it may be reasonable to use the lower confidence band of the calculated ammonia figures. The fact that this may slightly under predict the ammonia at Days need not concern us since the model will predict a failure of an RQO upstream of Days before ammonia concentrations at Days become a problem.

For un-I-amm using the upper confidence interval of the simulated data in abstraction simulation modelling appears to give a reasonable estimate of the actual un-I-amm. This only underpredicts the concentration at Days during the 1990/91 time period, but again concentrations upstream of Days are of more concern than actually at Days.

The BOD model shows a poor fit for the 1990/91 time period. For the earlier time period the upper confidence interval is suitable for abstraction modelling, the observed value always falling below the upper confidence interval. If abstraction modelling is conducted using the 1990/91 data set the error in the predicted value may be up to 57%.

For DO% sat the model is constantly underpredicting by up to 30%. This introduces quite a large error margin into predicted DO concentrations.

Conclusions

Assessment of the calibration model set up by Thames Water has shown up a number of areas of concern. These include the over prediction of ammonia 95%iles concentrations and DO 5%ile concentrations as well as underprediction of BOD 95%ile concentration.

Attempting to validate the model with a more extreme data set has exaggerated these problems. It is possible though to make a reasonable estimate of the ammonia 95%ile though an error of up to 57% may be incurred by attempting to estimate BOD 95%ile concentrations. The overprediction of ammonia and underprediction of BOD concentrations may possibly be due to poor representation of Oxford STW quality data within the model At present data from Northfield Brook is used but it may be possible to use actual Oxford STW data suitably scale to produce a larger and more accurate data set and thus a better representation within the model.

The BOD underestimation may also be a result of algal effects on the BOD test, not included in TOMCAT, and perhaps enhanced during the validation years. At present it does not seem reasonably to use the 1990/91 set to predict BOD 95%iles since an error of 57% makes "accurate" prediction unreliable. Reasonably estimates of BOD 95%iles may be made though using the 1984/89 data set, but these may not be applicable to low flow situations.

The predicted values of DO are generally too high, and are up to 30% too high at the 5%ile level. This again makes prediction unreliable and it is possible that either the rearation coefficients or background summer temperatures may need adjusting to improve the accuracy of the model.

Further Work

1. Abstraction simulations may be undertaken using the model as it stands provided that the limitations of the model discussed within this report are taken into account.

2. It may be possible to improve the accuracy of the model by making a closer examination of the effects of Oxford STW.

M Tinsley
18/8/92
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List of Tables and Figures.

Table 1. Tomcat test statistics at calibration points.(1984/89 time period)

Osney Weir

	mean		Mann Witney	K.S Test	
	Observed	predicted	Test	Critical	Calculated
BOD	1.872	1.851	22.36	0.19435	0.1546
ammonia	0.0846	0.0834	5.85 *	0.19435	0.425 *
un-i-amm	0.0013	0.0013	29.44	0.19435	0.0518
DO	10.68	10.93	32.08	0.19435	0.6882
temp	10.32	11.19	18.56	0.19435	0.1344
chloride	31.44	31.48	92.3	0.19435	0.1159

Abingdon Weir

	mean		Mann Witney	K.S Test	
	Observed	predicted	Test	Critical	Calculated
BOD	2.023	1.991	65.12	0.1619	0.1026
ammonia	0.234	0.2492	63.29	0.1619	0.1034
un-i-amm	0.0039	0.0039	44.25	0.1619	0.0857
DO	10.36	10.6	31.03	0.1619	0.1321
temp	10.91	11.22	35.37	0.1619	0.112
chloride	35.66	35.25	49.69	0.1619	0.1455

Days Weir

	mean		Mann Witney	K.S Test	
	Observed	predicted	Test	Critical	Calculated
BOD	2.023	1.881	60.93	0.1562	0.1741 *
ammonia	0.1764	0.1923	58.11	0.1562	0.1639 *
un-i-amm	0.0031	0.0031	60.5	0.1562	0.0801
DO	10.16	10.03	1.75	0.157	0.1575 *
temp	11.88	11.67	82.14	0.157	0.0648
chloride	38.76	37.07	13.84	0.157	0.1186

* = failure of stats test

Table 2. Mean flows and accretion flows.

Trib/Discharge/abst	Mean flow(m3/day)
Eynsham	802138
South Leigh	114.4
Stanton Harcourt	226
Evenlode	218074
Cassington	6187
Oxford Canal	8356
Cherwell	222826
Northfield Brook	39353
Culham Abst	-3335
Ock	83013
Abingdon	3417
Ginge Brook	47000
Harewell	-7957
Didcot Abst	111370
Didcot Discharge	72749
Moor Ditch	4225
Long Witt	259
Clifton Hampden	901
Burcot Brook	2574
Total at Days	1388751
Actual at Days	1556150
Inferred Accretion	167400
Accretion(m3/km/day)	3720

Table 3. Accretion Flow in Reaches.

	Length(km	Accretion Fraction of Total	Acc(m3/km/day)
Farmoor - Pinkhill	1.19	0.419	1559
Pinkhill - Eynsham	2.22	0.419	1559
Eynsham - Kings	4.47	0.419	1559
Kings - Godstow	1.9	0.419	1559
Godstow - Osney	3.96	0.419	1559
Osney - Iffley	3.91	0.6285	2338
Iffley - Sandford	2.72	0.6285	2338
Sandford - Abingdon	7.63	0.6285	2338
Abingdon - Culham	4.17	2.6186	9741
Culham - Clifton	2.79	2.6186	9741
Clifton - Days	7.55	2.6186	9741

Table 4. Predicted and observed flows.

Flow at Eynsham.(m3*E+5/day)

	Predicted			Observed
	lower	central	upper	
5%ile	0.437	0.484	0.521	0.504
10%ile	0.568	0.631	0.690	0.718
50%ile	2.56	2.91	3.22	3.27
90%ile	20.3	22.6	25.5	21.0
95%ile	29.1	34.2	38.1	29.7
mean		8.64		8.02

Flow at Days(m3*E+5/day)

	Predicted			Observed
	lower	central	upper	
5%ile	1.74	1.97	2.12	2.01
10%ile	2.14	2.30	2.48	2.33
50%ile	5.99	6.85	7.62	7.13
90%ile	34.5	39.6	47.2	36.6
95%ile	47.3	55.6	70.1	56.7
mean		15.2		15.5

Table 5. Tomcat test statistics at calibration points.(1990/91 time period)

Trout Inn Farm

	mean		Mann Witney	K.S Test	
	Observed	predicted	Test	Critical	Calculated
BOD	2.03	1.764	10.96	0.2501	0.3857 *
ammonia	0.0615	0.064	0 *	0.2501	0.745 *
un-i-amm	0.0013	0.0012	25.53	0.2501	0.087
DO	9.888	10.44	5.23 *	0.2501	0.2709 *
temp	12.59	11.78	46.58	0.2501	0.1789
chloride	39.04	39.21	91.79	0.2501	0.1328

Radley College Boat House

	mean		Mann Witney	K.S Test	
	Observed	predicted	Test	Critical	Calculated
BOD	2.36	1.78	5.57 *	0.265	0.347 *
ammonia	0.2039	0.2969	62.73	0.265	0.2863 *
un-i-amm	0.0034	0.0034	70.98	0.265	0.0899
DO	9.718	10.15	23.1	0.265	0.175
temp	13.04	12.75	90.98	0.265	0.1511
chloride	50.39	48.43	49.54	0.265	0.2117

Days Weir

	mean		Mann Witney	K.S Test	
	Observed	predicted	Test	Critical	Calculated
BOD	2.313	1.662	1.15 *	0.2588	0.36 *
ammonia	0.1412	0.1414	28.81	0.2494	0.28 *
un-i-amm	0.0028	0.0022	18.87	0.2494	0.1339
DO	9.69	10.22	21.19	0.2494	0.2308
temp	12.72	12.93	93.77	0.2494	0.13
chloride	56.12	51.79	17.98	0.254	0.2

* = failure of stats test

Table 6. Comparison of observed and predicted 95%iles

Osney Weir

	No. of samples	Observed
BOD(mg/l)	50	3.6
Ammonia(mg/l)	50	0.32
Un-I-Amm(mg/l)	50	0.002
DO(mg/l)	50	8.165
DO%sat	50	80.7

Abingdon Weir

	No. of samples	Observed
BOD(mg/l)	67	4.5
Ammonia(mg/l)	67	0.59
Un-I-Amm(mg/l)	67	0.013
DO(mg/l)	67	7.726
DO%sat	67	76.45

Sutton Bridge

	No. of samples	Observed
BOD(mg/l)	26	3.1
Ammonia(mg/l)	26	0.58
Un-I-Amm(mg/l)	26	0.007
DO(mg/l)	26	6.87
DO%sat	27	74.4

Days Weir

	No. of samples	Observed
BOD(mg/l)	77	4.4
Ammonia(mg/l)	77	0.41
Un-I-Amm(mg/l)	77	0.007
DO(mg/l)	77	7.969
DO%sat	77	81.51

(1984/89 data)

lower	Simulated actual	upper	observed (np)	(n)	(Jn)	(mm)
3.21	3.97	5.38	3.7	3.2	3.4	3.4
0.24	0.315	0.394				
0.002	0.0029	0.0038				
9.02	9.23	9.28				
96.87	97.28	97.54	50.7	77.4		[illegible]

lower	Simulated actual	upper				
3.45	3.71	4.68	4.7		3.9	4.5
0.645	0.684	0.77				
0.0094	0.014	0.012				
8.04	8.21	8.35				
84.7	85.99	87.81	76.5	76.1		[illegible]

lower	Simulated actual	upper
3.18	3.49	4.12
0.617	0.685	0.737
0.0079	0.0093	0.01
9.07	9.146	9.18
96.1	96.24	96.79

lower	Simulated actual	upper				
3.03	3.313	4.56	4.8		4.1	4.2
0.431	0.486	0.561				
0.0065	0.0072	0.0087				
8.68	8.81	8.84				
92.73	93.78	94.12	81.3	79.3		

Table 7. Comparison of observed and predicted

Trout Inn Farm

	No. of samples	Observed
BOD(mg/l)	27	5.24
Ammonia(mg/l)	27	0.146
Un-I-Amm(mg/l)	27	0.003
DO(mg/l)	27	7.58
DO%sat	27	80

Radley College Boat House

	No. of samples	Observed
BOD(mg/l)	23	7.54
Ammonia(mg/l)	23	0.914
Un-I-Amm(mg/l)	23	0.015
DO(mg/l)	23	6.8
DO%sat	23	72.6

Sutton Bridge

	No. of samples	Observed
BOD(mg/l)	21	6.59
Ammonia(mg/l)	23	0.388
Un-I-Amm(mg/l)	29	0.009
DO(mg/l)	24	7.101
DO%sat	24	76

Days Weir

	No. of samples	Observed
BOD(mg/l)	24	7.15
Ammonia(mg/l)	26	0.454
Un-I-Amm(mg/l)	26	0.01
DO(mg/l)	26	6.05
DO%sat	26	64.5

95%iles (1990/91 data)

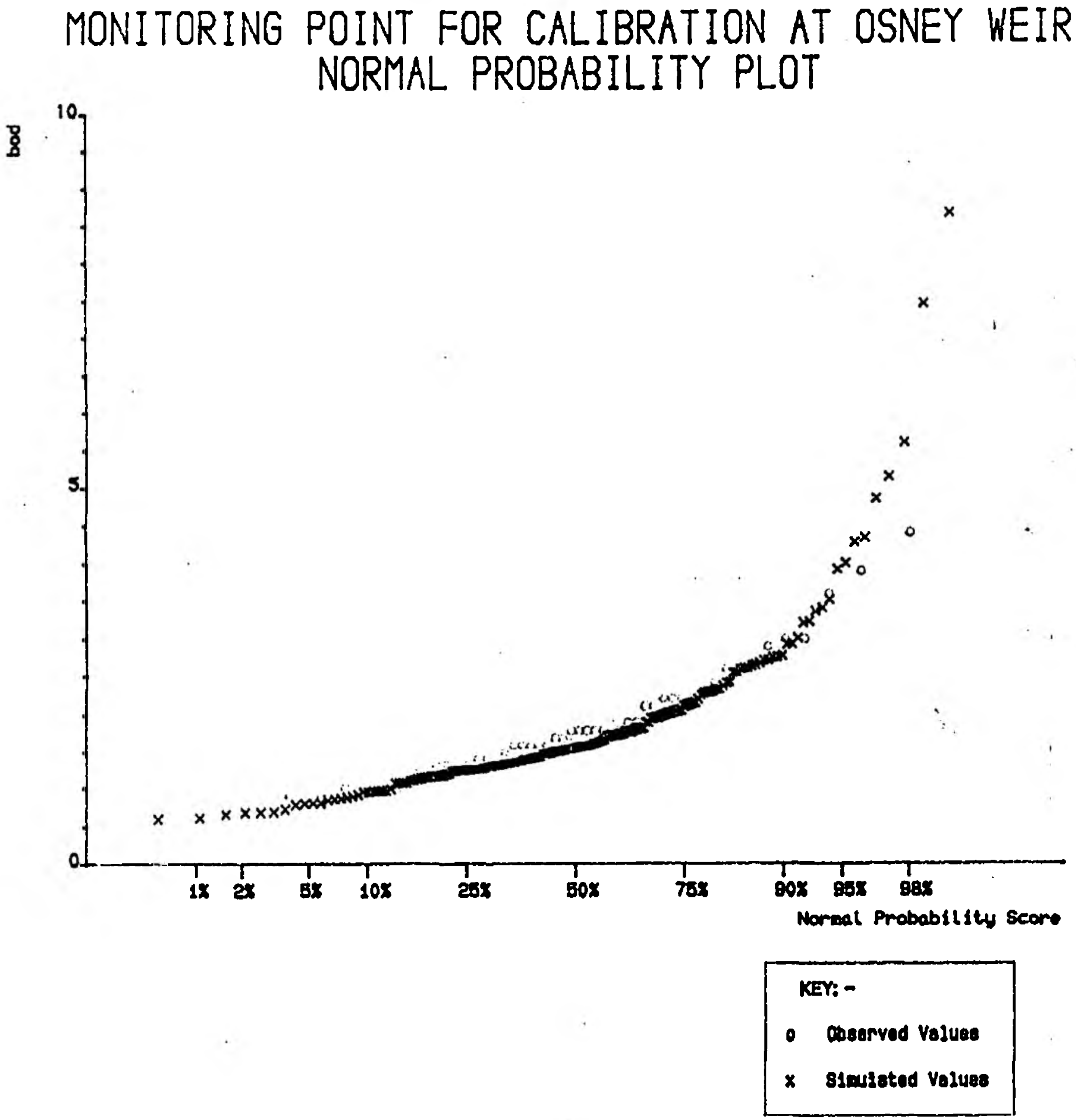
lower	Simulated actual	upper	(np)	observed (n)	(l)	(mm)
3.016	3.13		8.26		352	4.09
0.1709	0.2894					
0.0018	0.0034					
8.37	8.67					
91.73	92.83		80.0	76.6		

lower	Simulated actual	upper				
3.47	3.69	3.92	7.54		4.8	5.5
1.061	1.178	1.534				
0.0085	0.011	0.017				
6.73	7.99	8.28				
71.76	85.25	87.26	72.6	70.7		

lower	Simulated actual	upper
3.33	3.5	3.6
0.6557	0.7021	0.7488
0.007	0.008	0.009
8.92	8.96	9
94.96	95.3	95.35

lower	Simulated actual	upper				
2.88	3.08	3.38	7.2		4.6	5.2
0.43	0.493	0.5284				
0.0052	0.0063	0.0073				
8.54	8.64	8.69				
90.23	91.46	91.85	64.5	70.6		

Fig 1



MONITORING POINT FOR CALIBRATION AT OSNEY WEIR
NORMAL PROBABILITY PLOT
bod
10
5
0
1% 2% 5% 10% 25% 50% 75% 90% 95% 98%
Normal Probability Score
KEY: -
o Observed Values
x Simulated Values

Fig 2

MONITORING POINT AT ABINGDON WEIR
NORMAL PROBABILITY PLOT

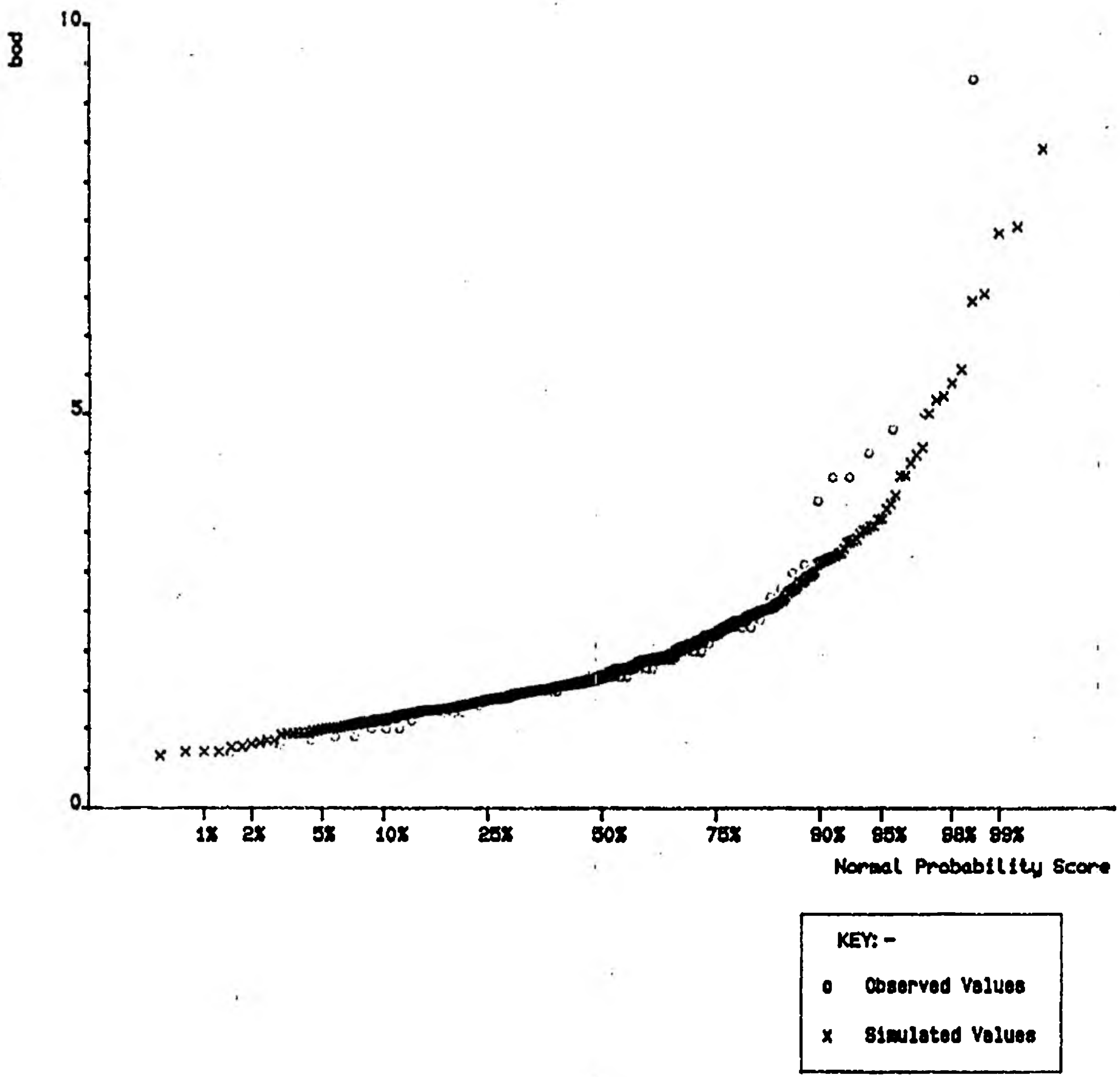


Fig 5

MONITORING POINT FOR CALIBRATION AT DAYS WEIR
NORMAL PROBABILITY PLOT

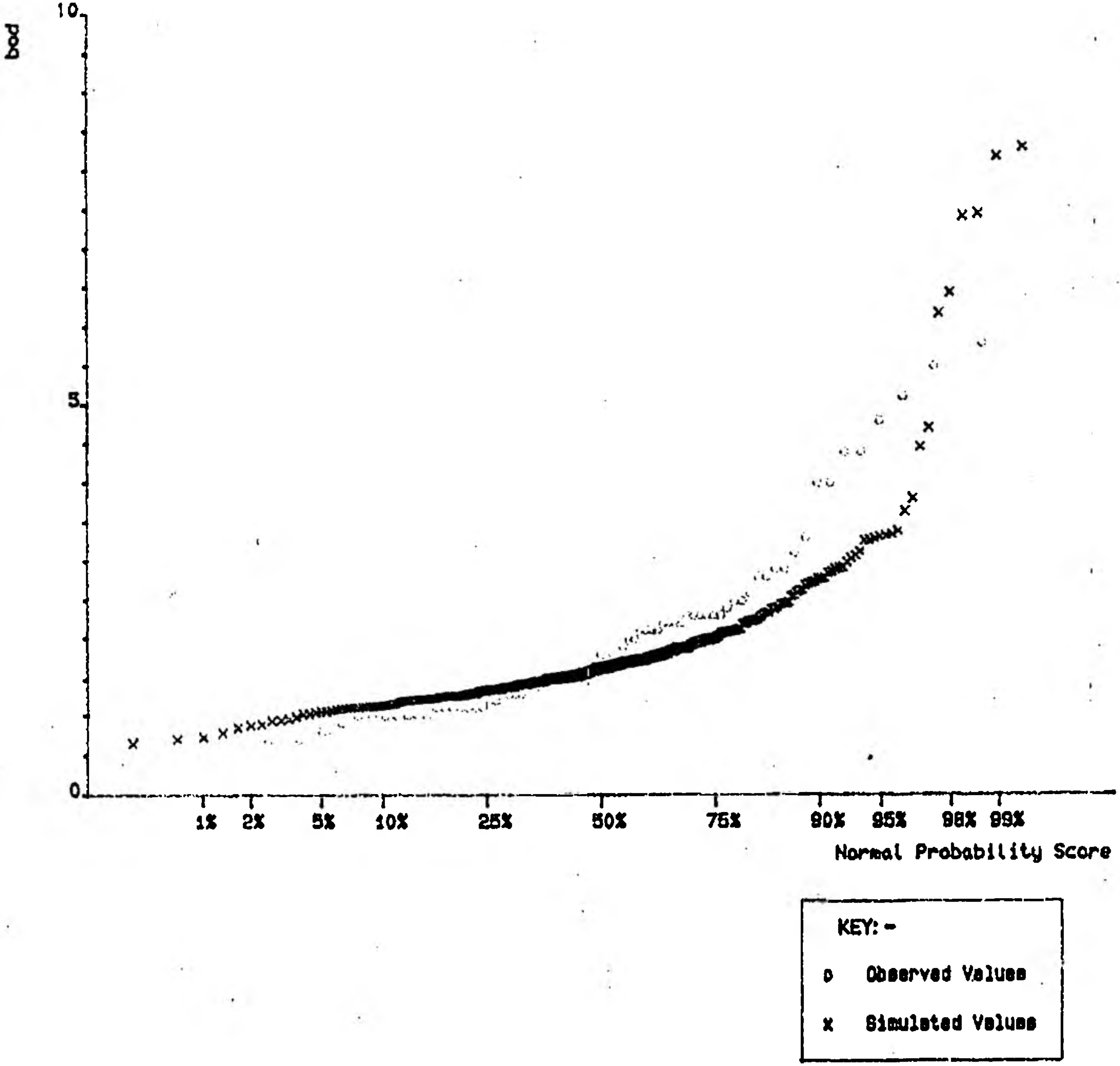


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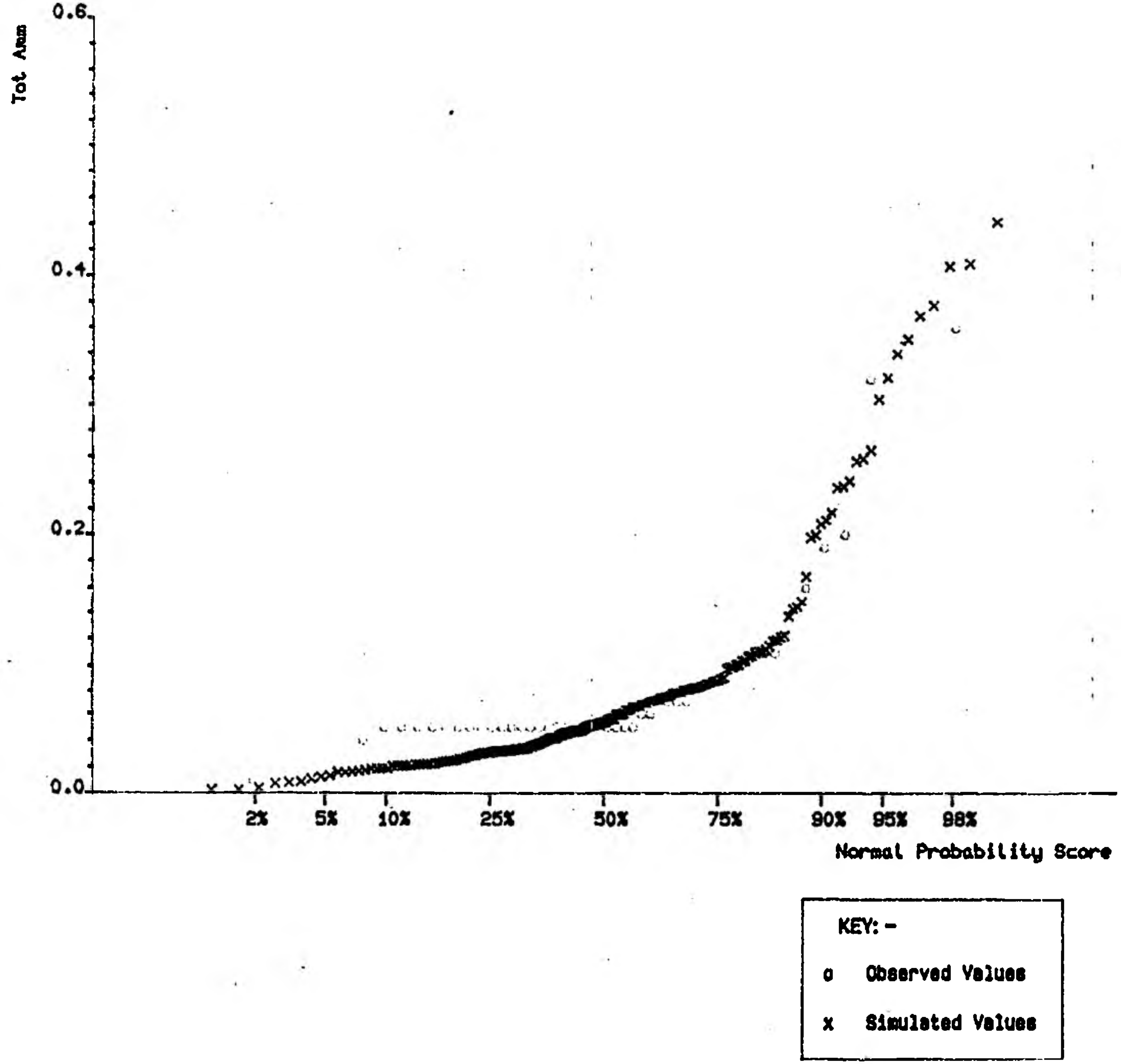
Fig

1.17

MONITORING POINT FOR CALIBRATION AT OSNEY WEIR
NORMAL PROBABILITY PLOT



MONITORING POINT AT ABINGDON WEIR
NORMAL PROBABILITY PLOT

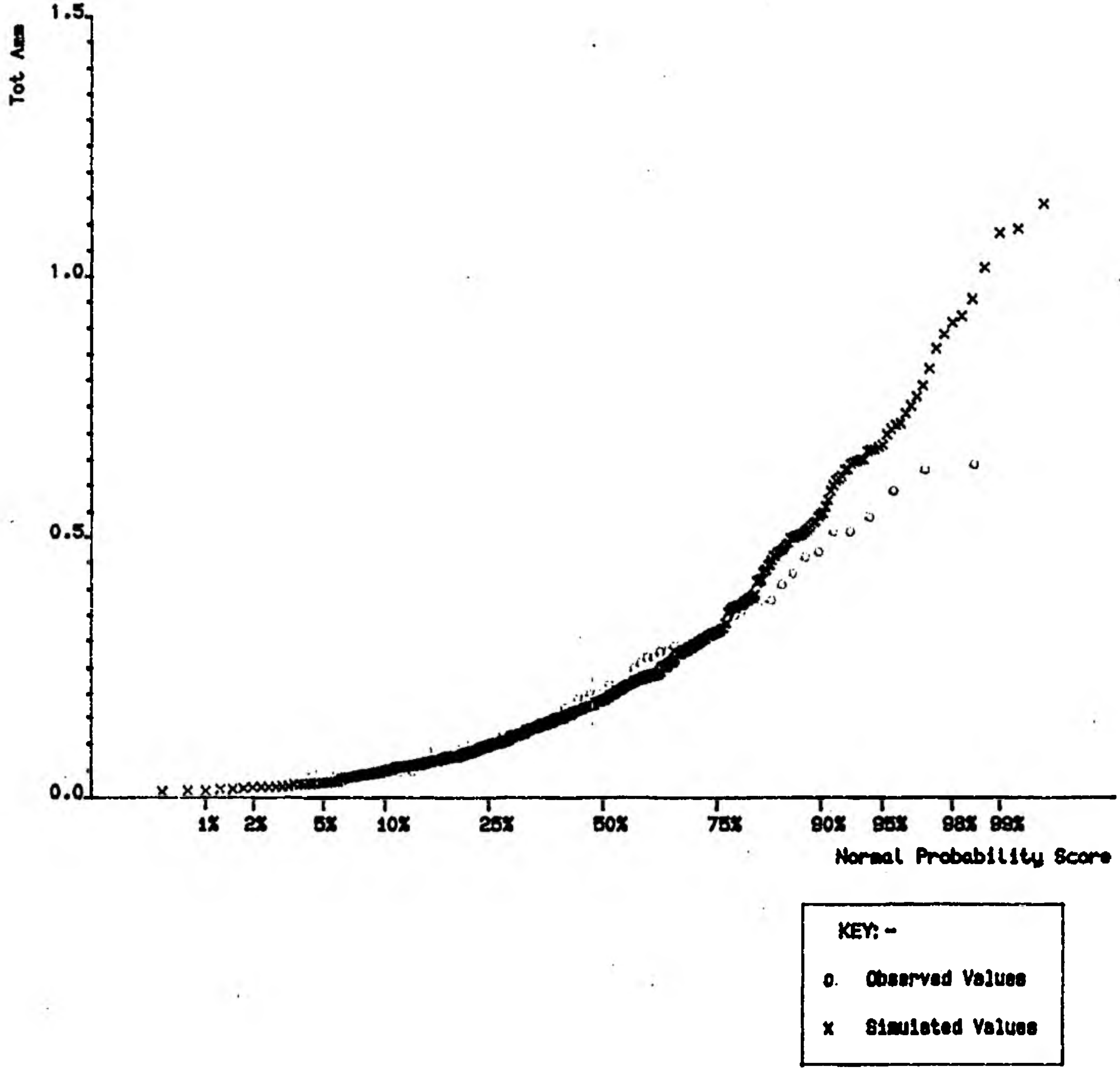


Fig 6

MONITORING POINT FOR CALIBRATION AT DAYS WEIR
NORMAL PROBABILITY PLOT

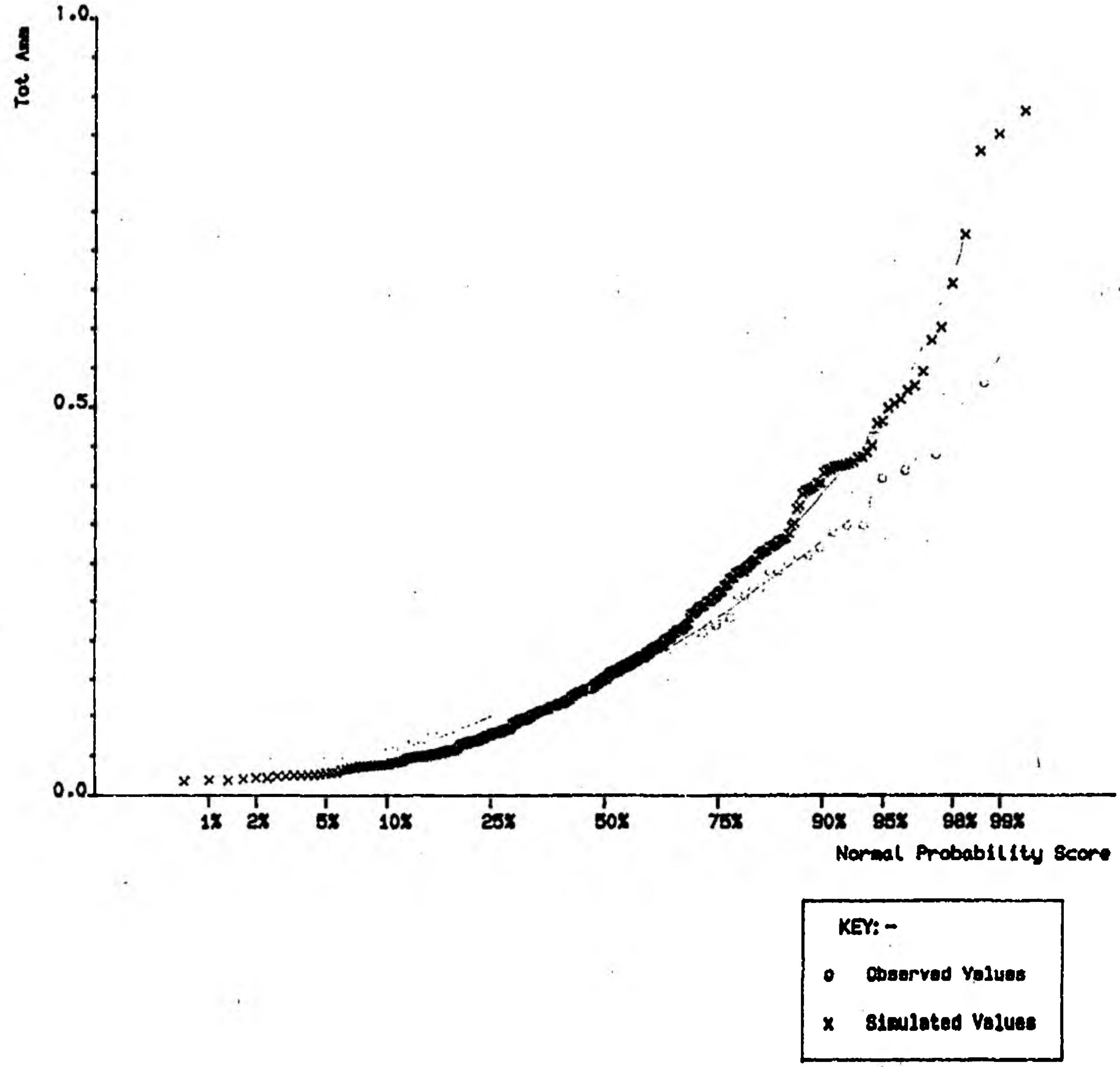


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Fig 7

MONITORING POINT FOR CALIBRATION AT OSNEY WEIR
LOGNORMAL PROBABILITY PLOT

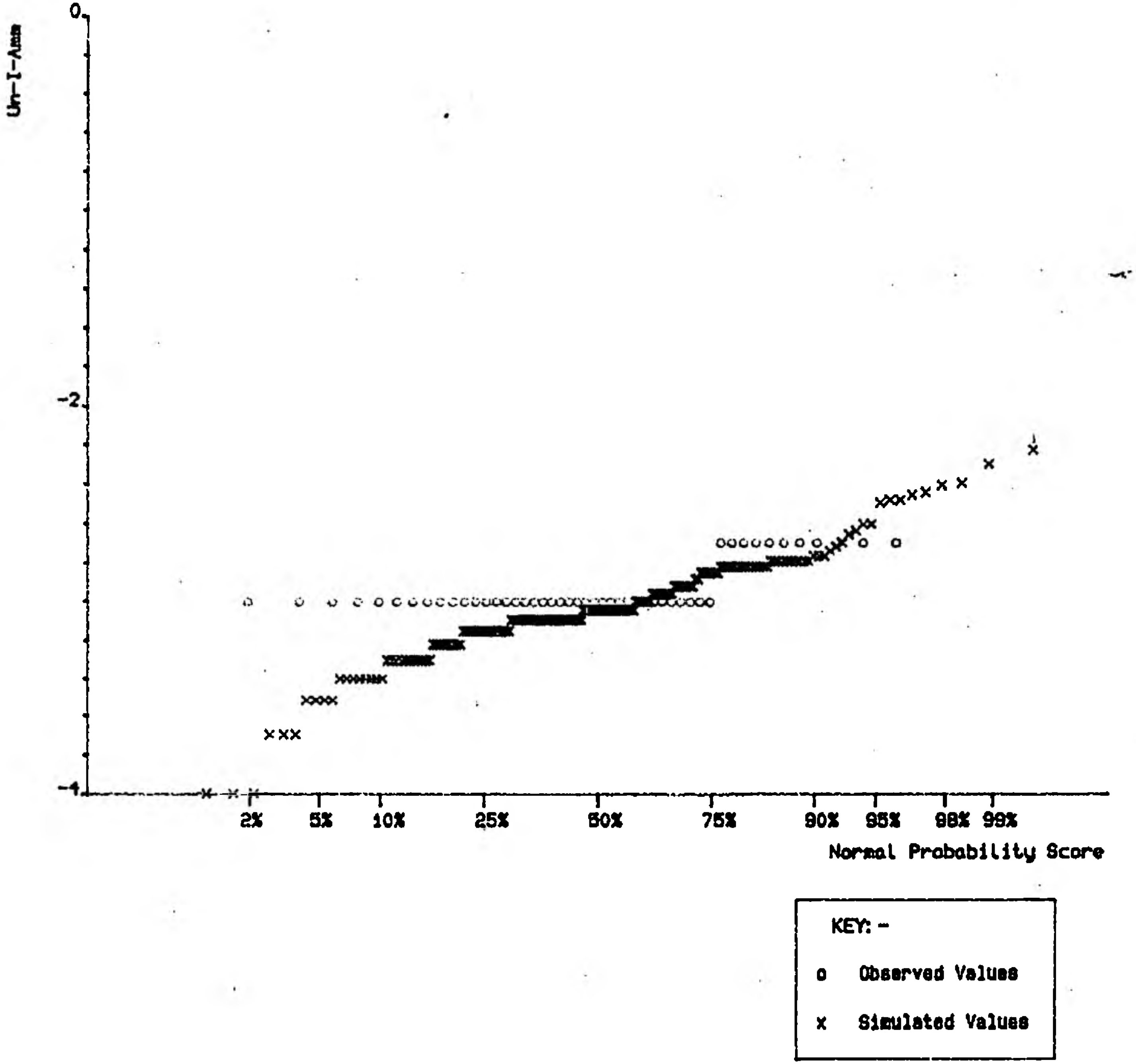

Fig 8

MONITORING POINT AT ABINGDON WEIR
LOGNORMAL PROBABILITY PLOT

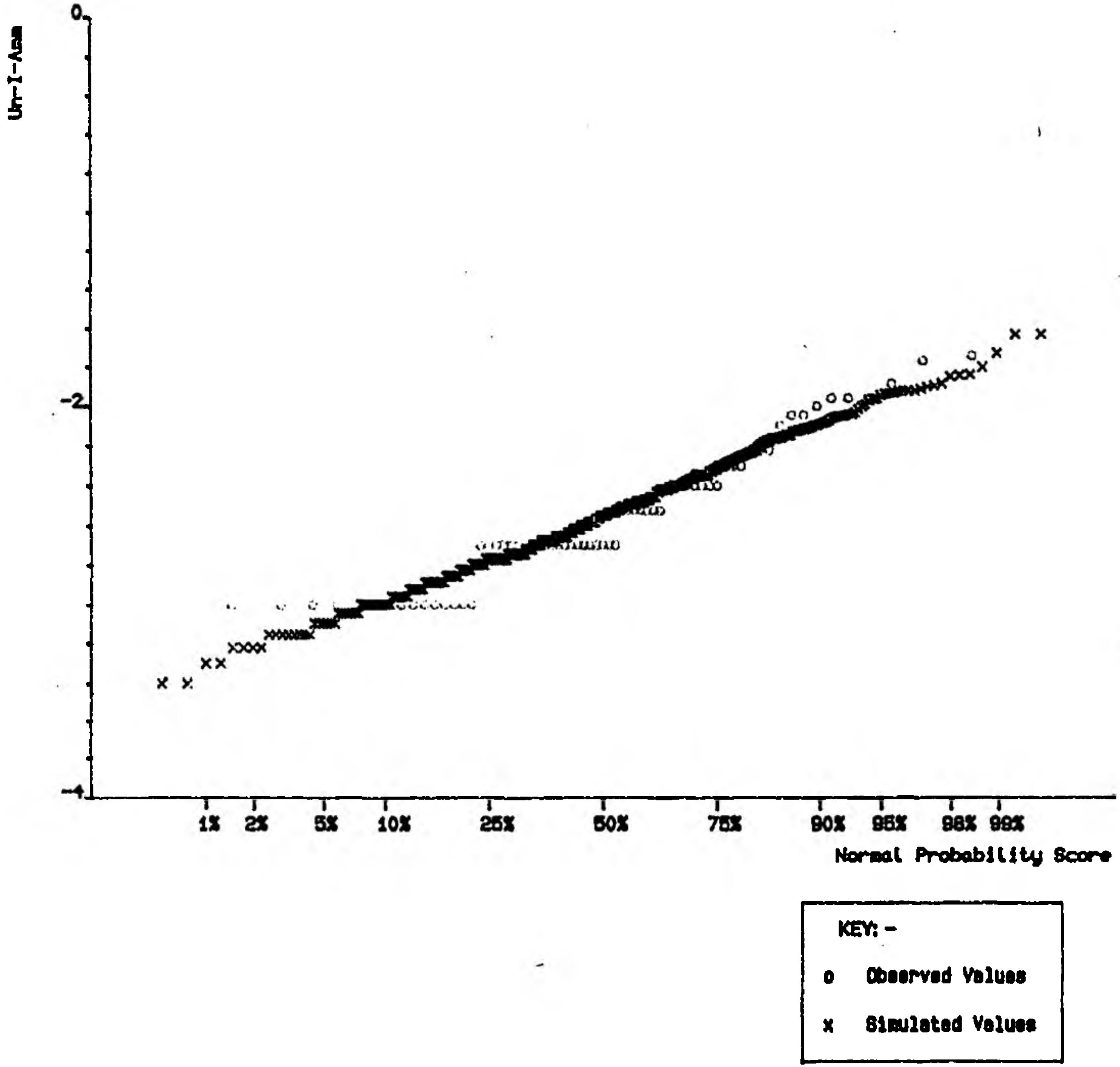

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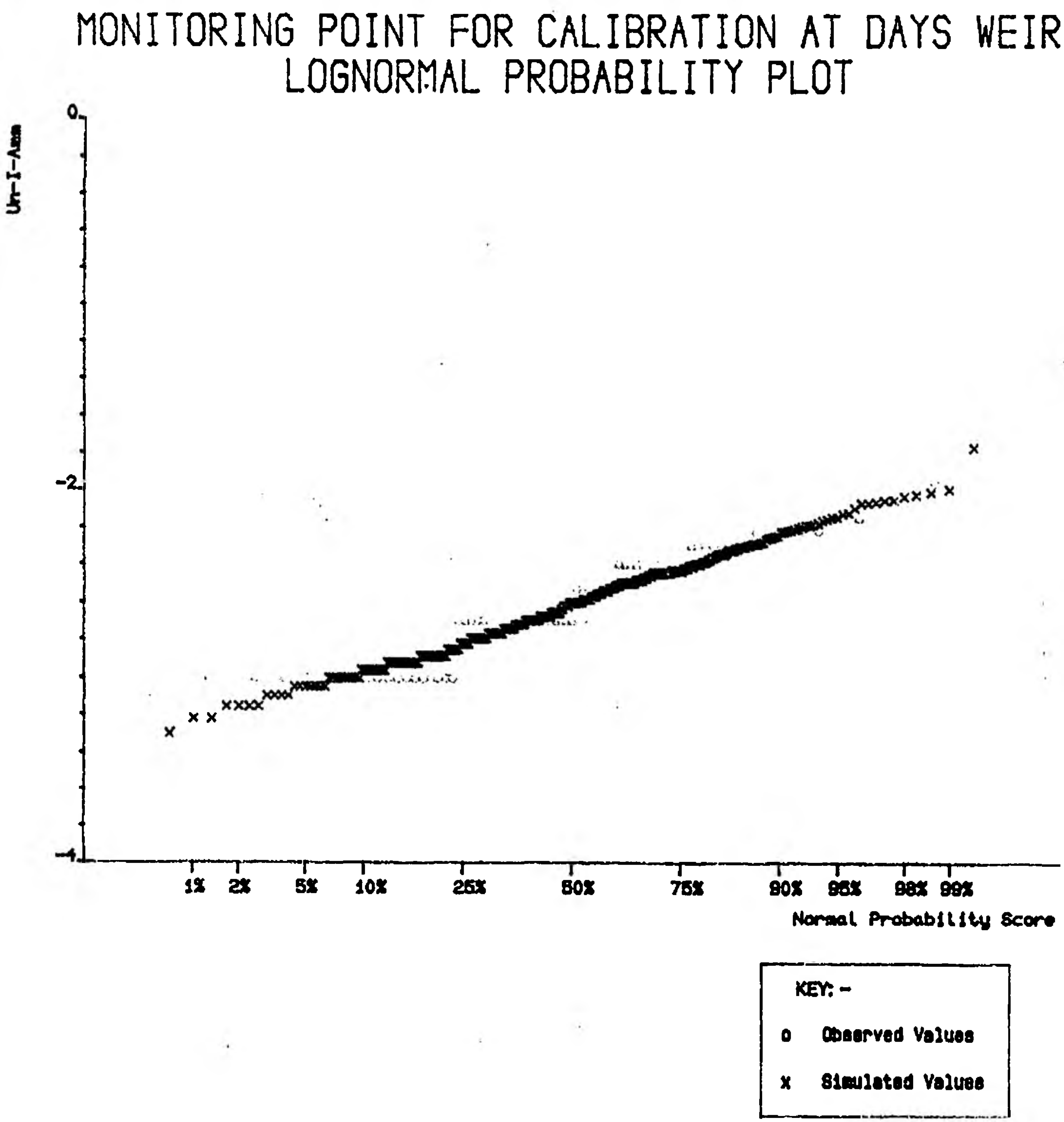
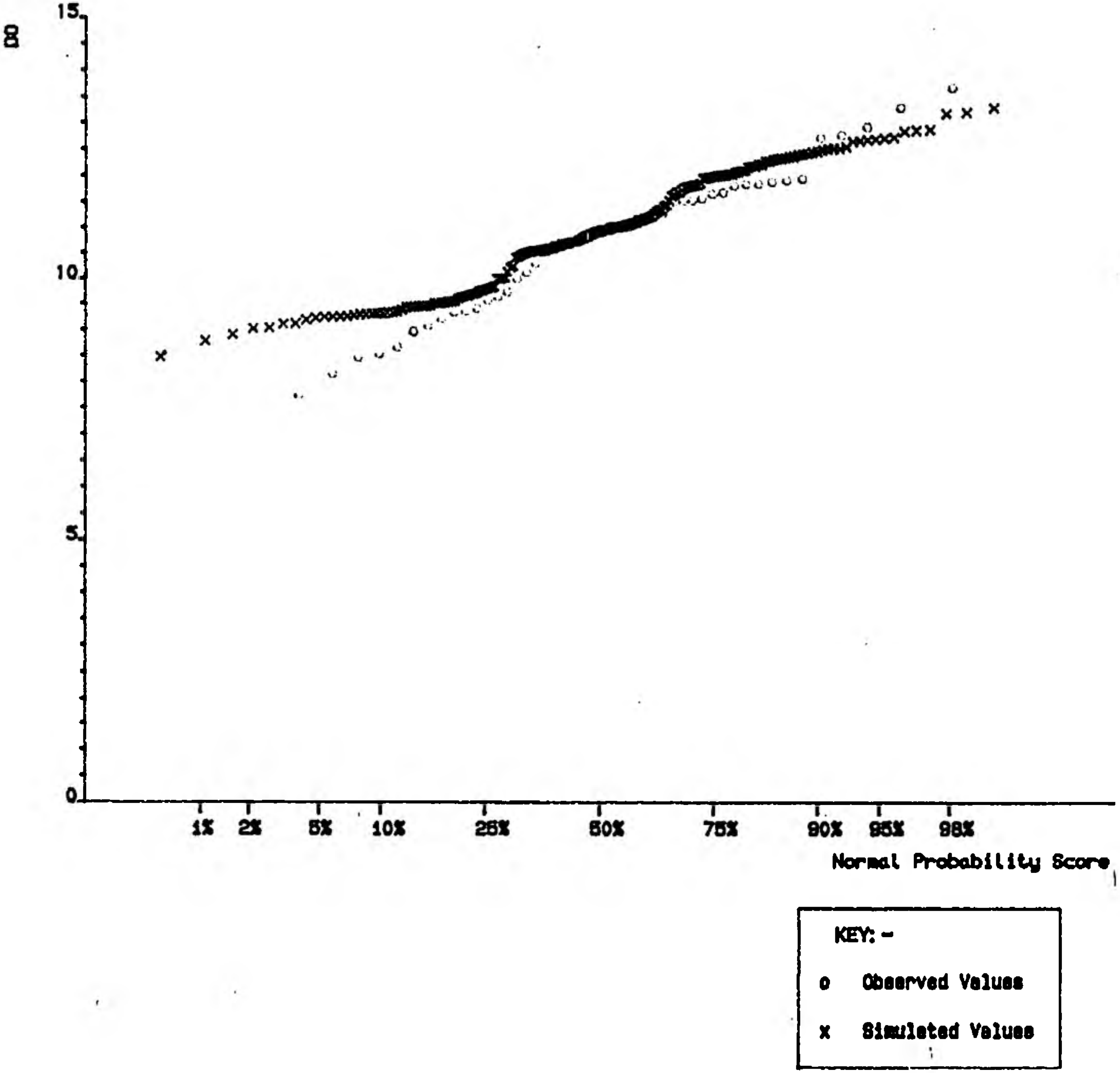
Fig 9



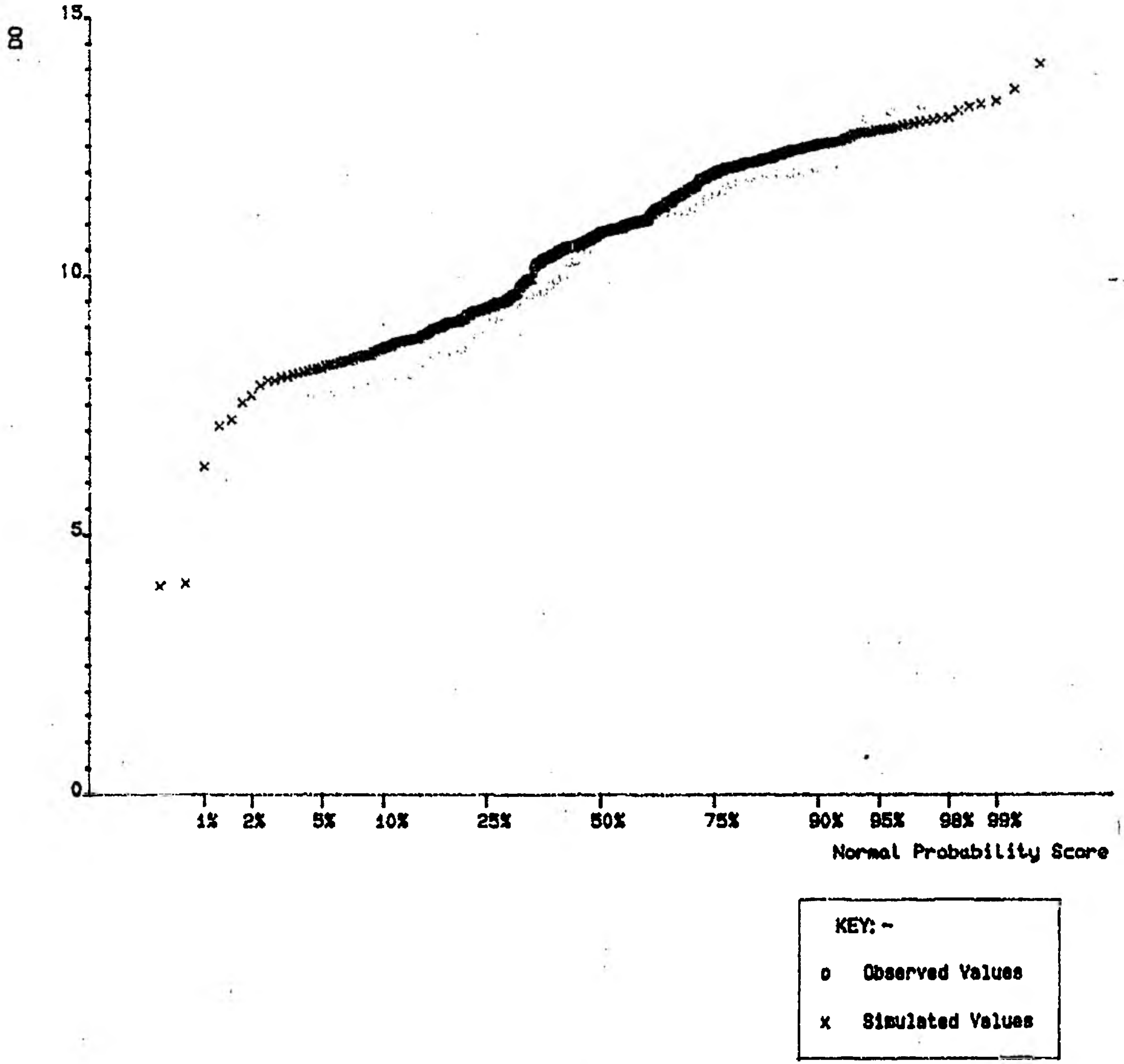
MONITORING POINT FOR CALIBRATION AT DAYS WEIR
LOGNORMAL PROBABILITY PLOT
Un-I-Amm
0
-2
-4
1% 2% 5% 10% 25% 50% 75% 90% 95% 98% 99%
Normal Probability Score
KEY: -
o Observed Values
x Simulated Values

Fig

MONITORING POINT FOR CALIBRATION AT OSNEY WEIR
NORMAL PROBABILITY PLOT



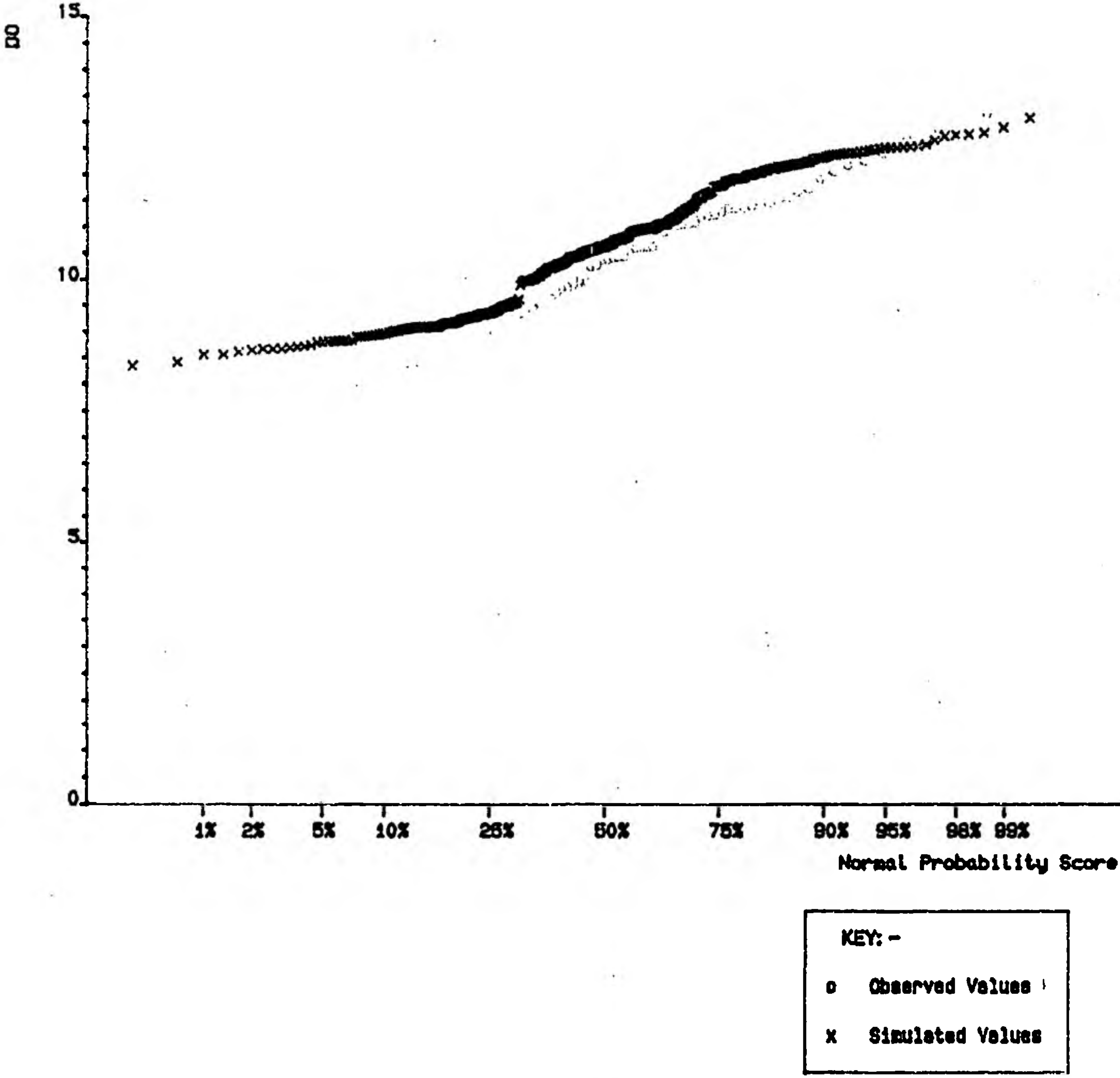
MONITORING POINT AT ABINGDON WEIR
NORMAL PROBABILITY PLOT



1.24

Fig 1

MONITORING POINT FOR CALIBRATION AT DAYS WEIR
NORMAL PROBABILITY PLOT



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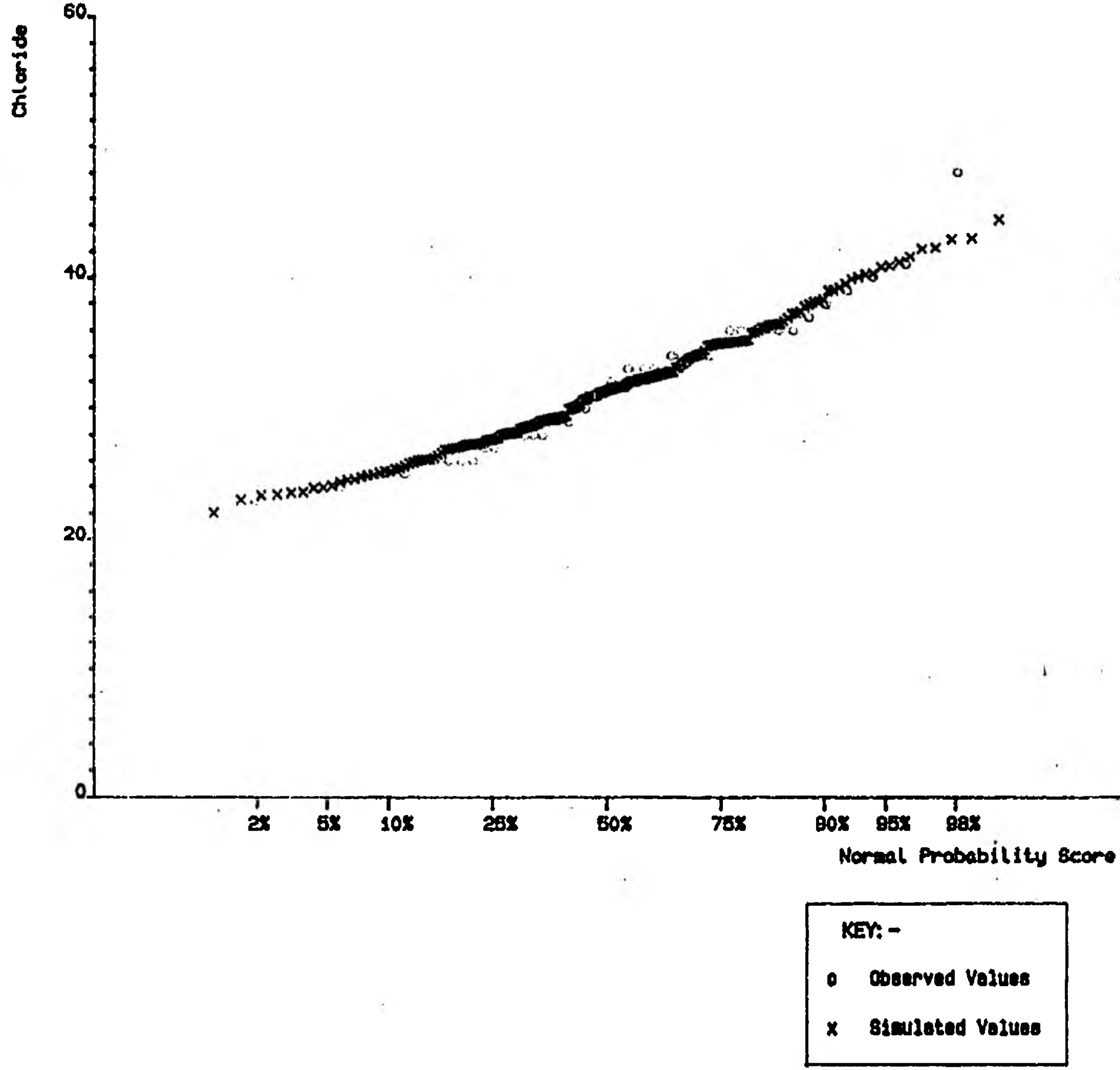
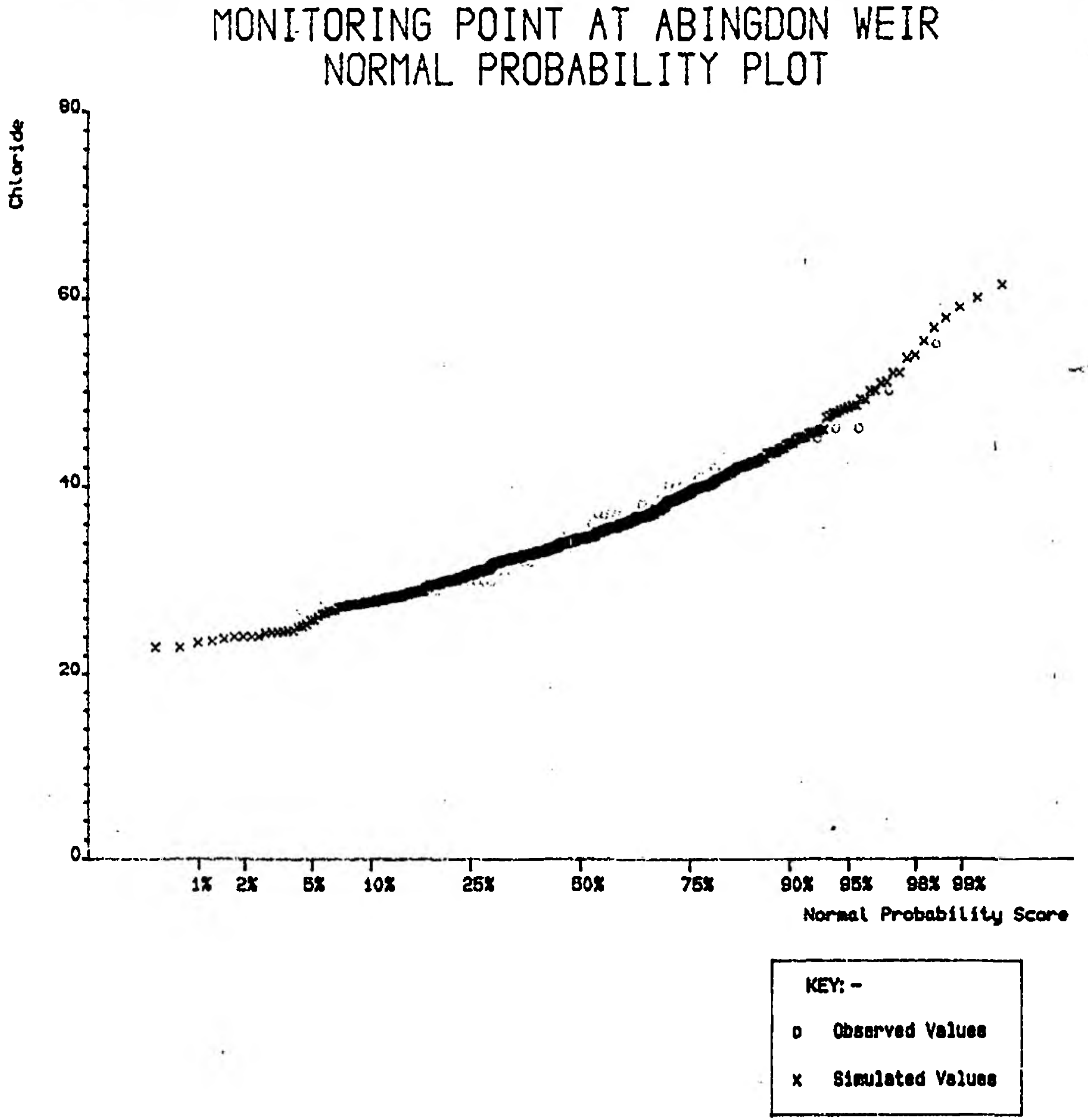
MONITORING POINT FOR CALIBRATION AT OSNEY WEIR
NORMAL PROBABILITY PLOT



1.26

Fig

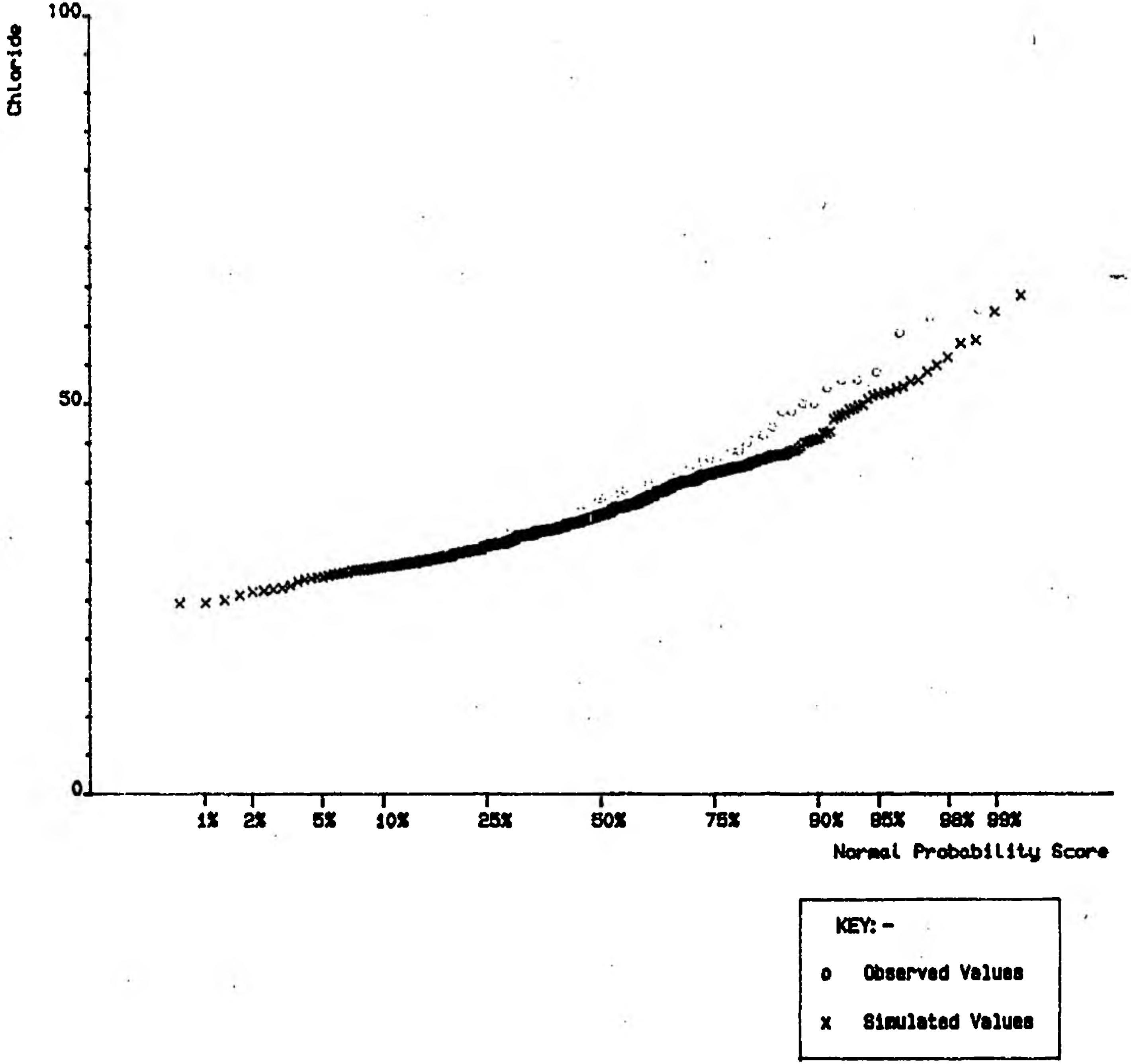


MONITORING POINT AT ABINGDON WEIR
NORMAL PROBABILITY PLOT
Chloride
80
60
40
20
0
1%
2%
5%
10%
25%
50%
75%
90%
95%
98%
99%
Normal Probability Score
KEY: -
o Observed Values
x Simulated Values

1.27

Fig

MONITORING POINT FOR CALIBRATION AT DAYS WEIR
NORMAL PROBABILITY PLOT

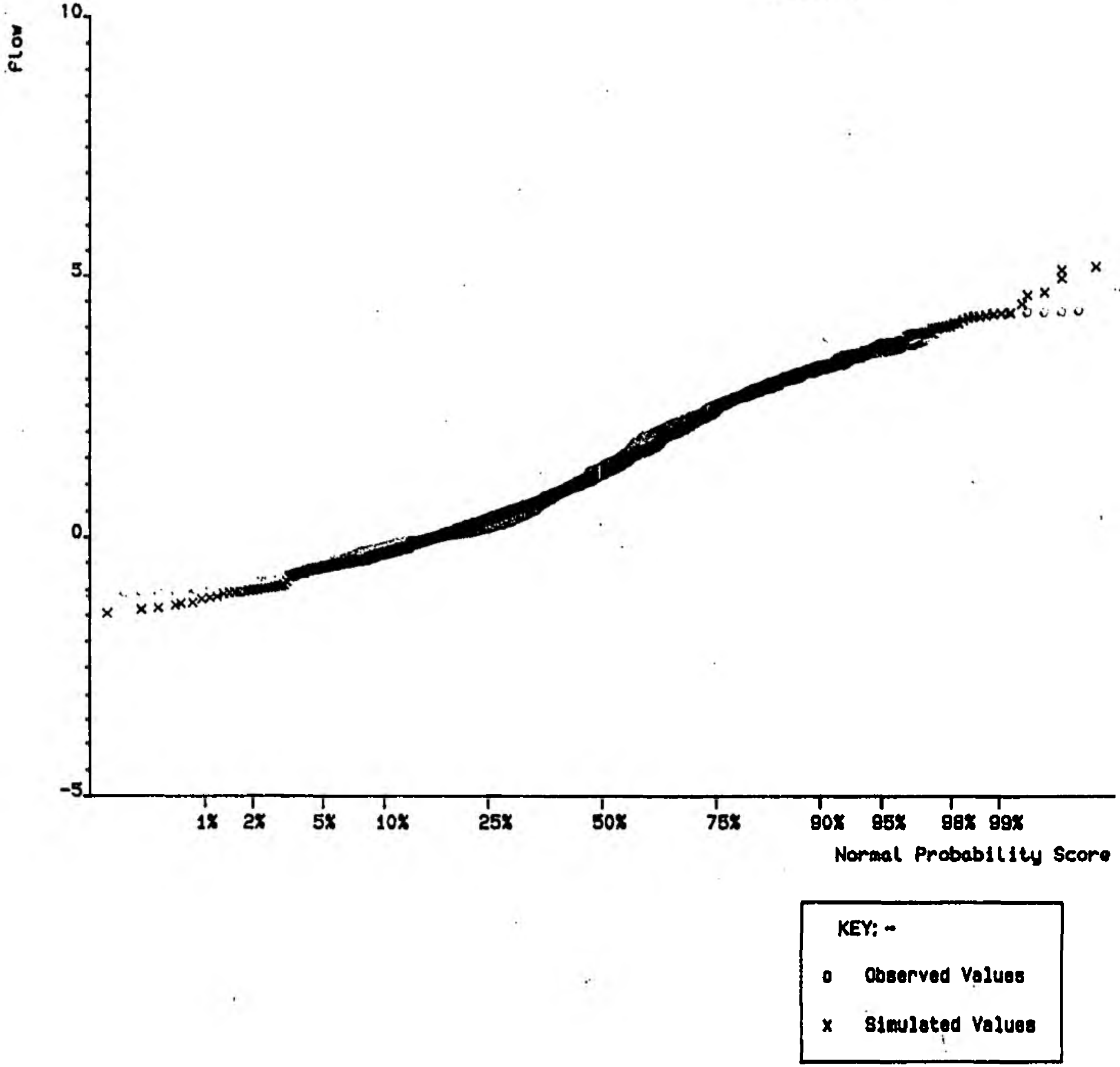


1·28

Fig

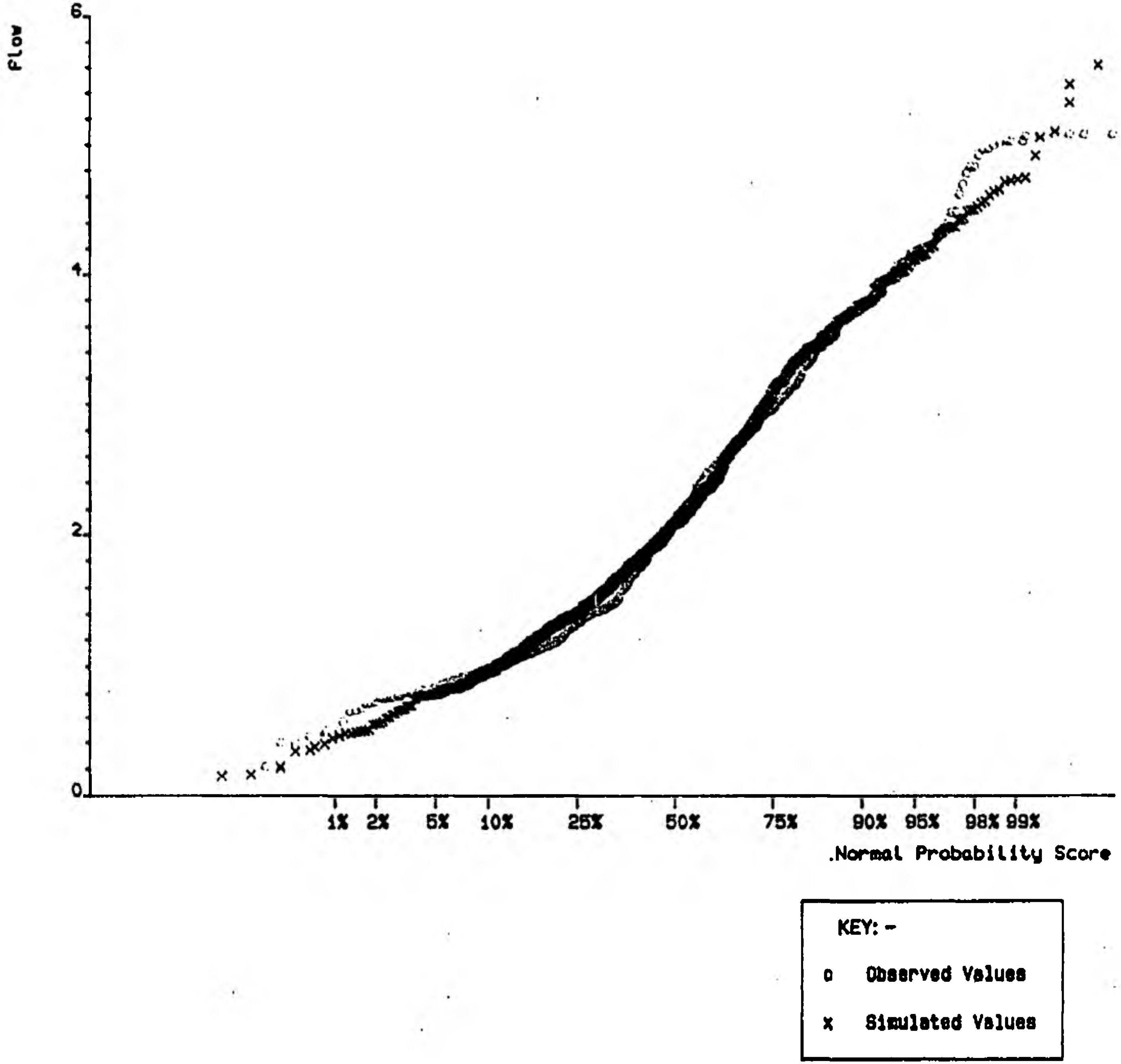
1.29

EYNSHAM WEIR(SINGLE DROP FREE FALL)
NORMAL PROBABILITY PLOT



Fig

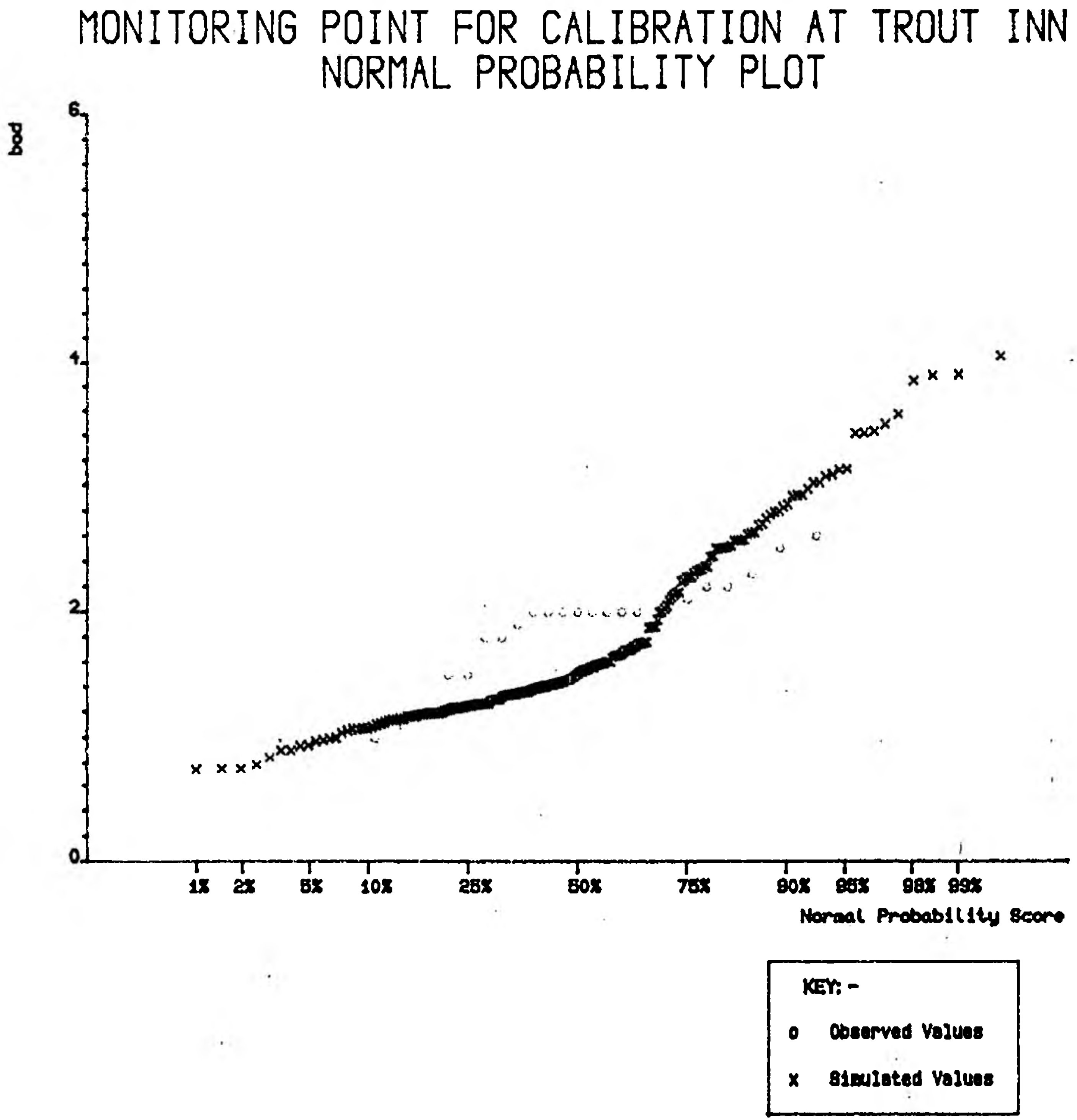
MONITORING POINT FOR CALIBRATION AT DAYS WEIR
NORMAL PROBABILITY PLOT



1.30

Fig 16

1.31



MONITORING POINT FOR CALIBRATION AT TROUT INN
NORMAL PROBABILITY PLOT
bod
6
4
2
0
1%
2%
5%
10%
25%
50%
75%
90%
95%
98%
99%
Normal Probability Score
KEY: -
o Observed Values
x Simulated Values

Fig

1.32

MONITORING POINT AT RADLEY COLLEGE BOATHOUSE
- NORMAL PROBABILITY PLOT

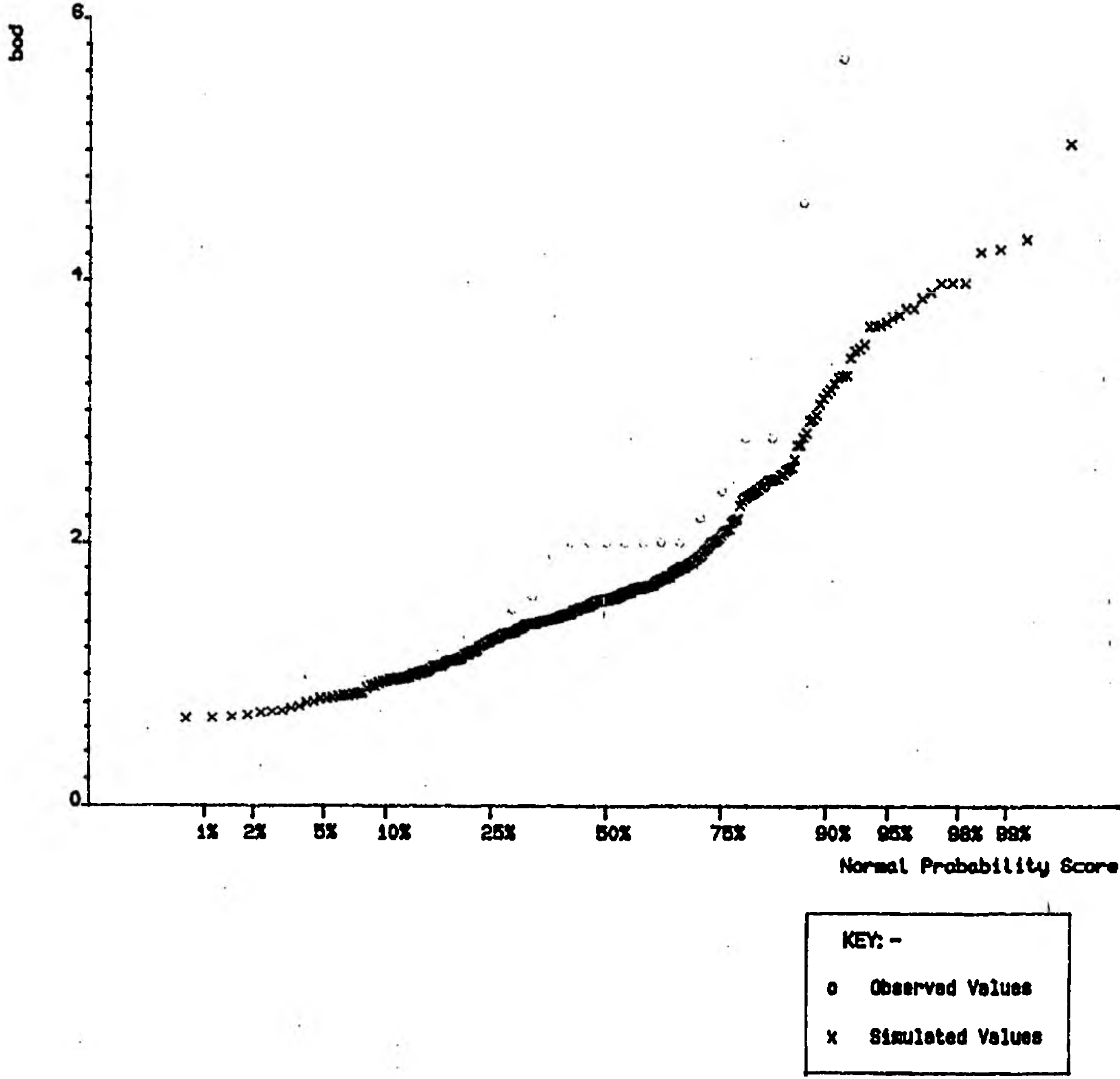
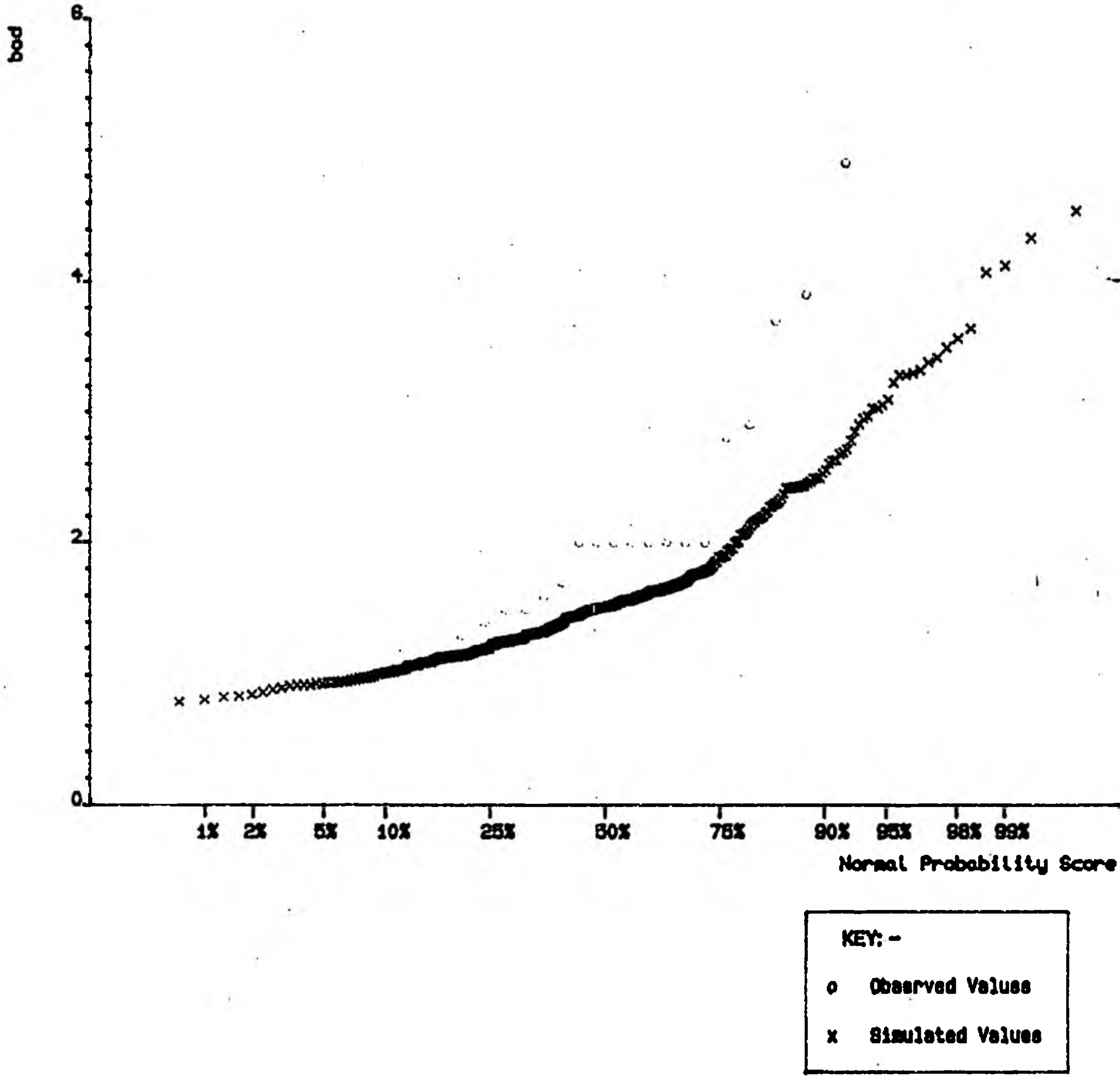


Fig 20

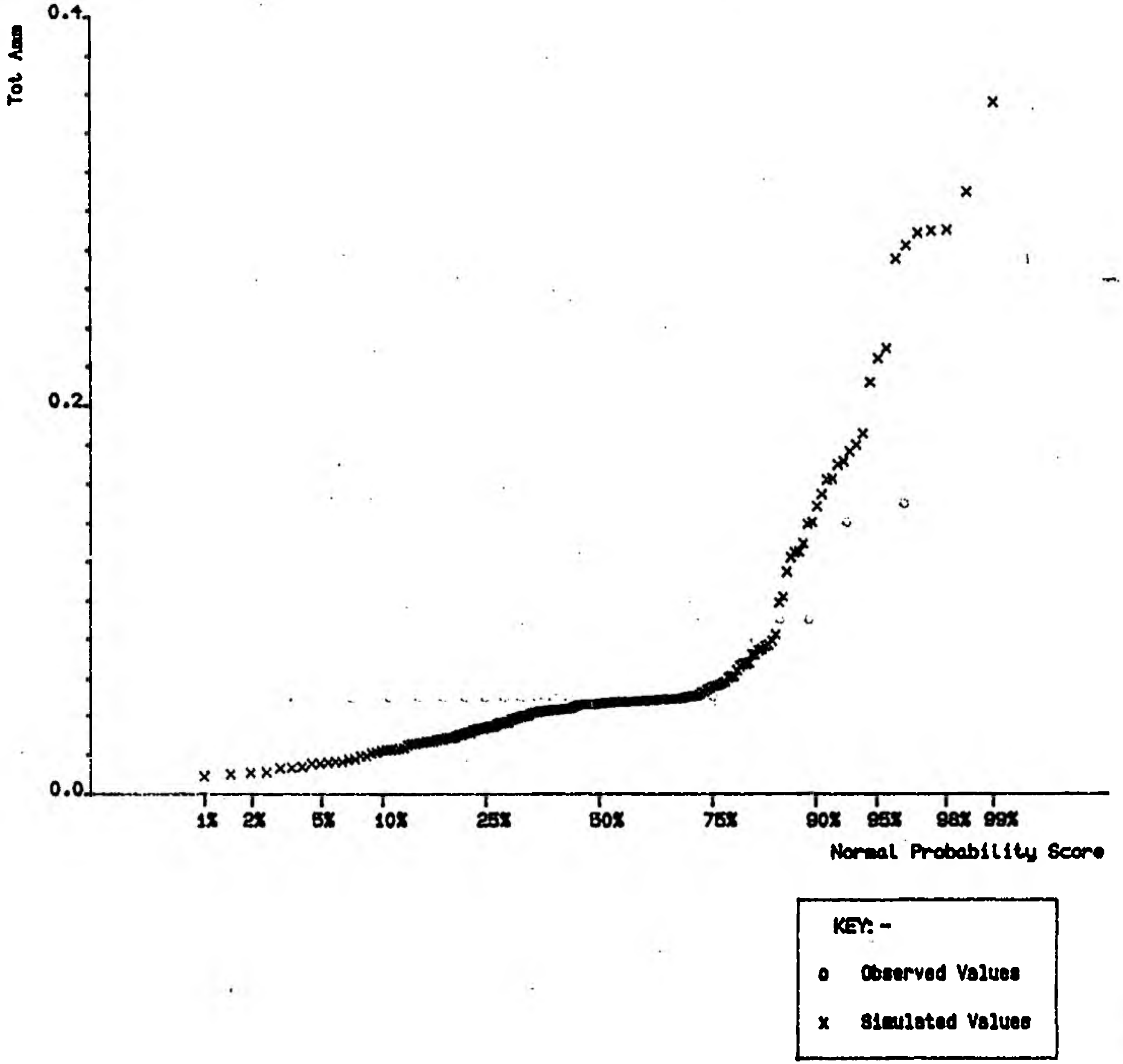
MONITORING POINT FOR CALIBRATION AT DAYS WEIR
NORMAL PROBABILITY PLOT



1 - 33

Fig 21

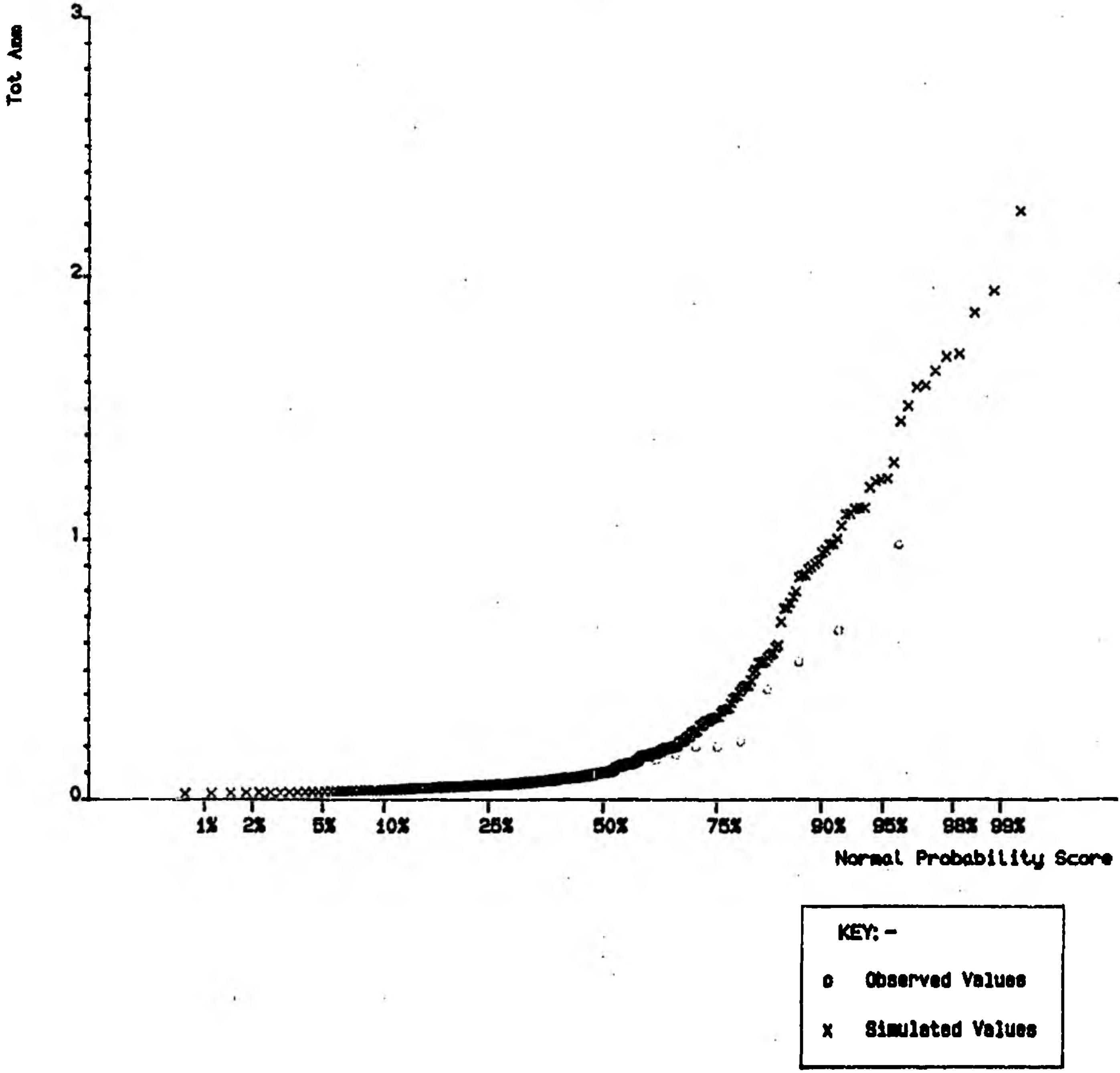
MONITORING POINT FOR CALIBRATION AT TROUT INN
NORMAL PROBABILITY PLOT



1.34

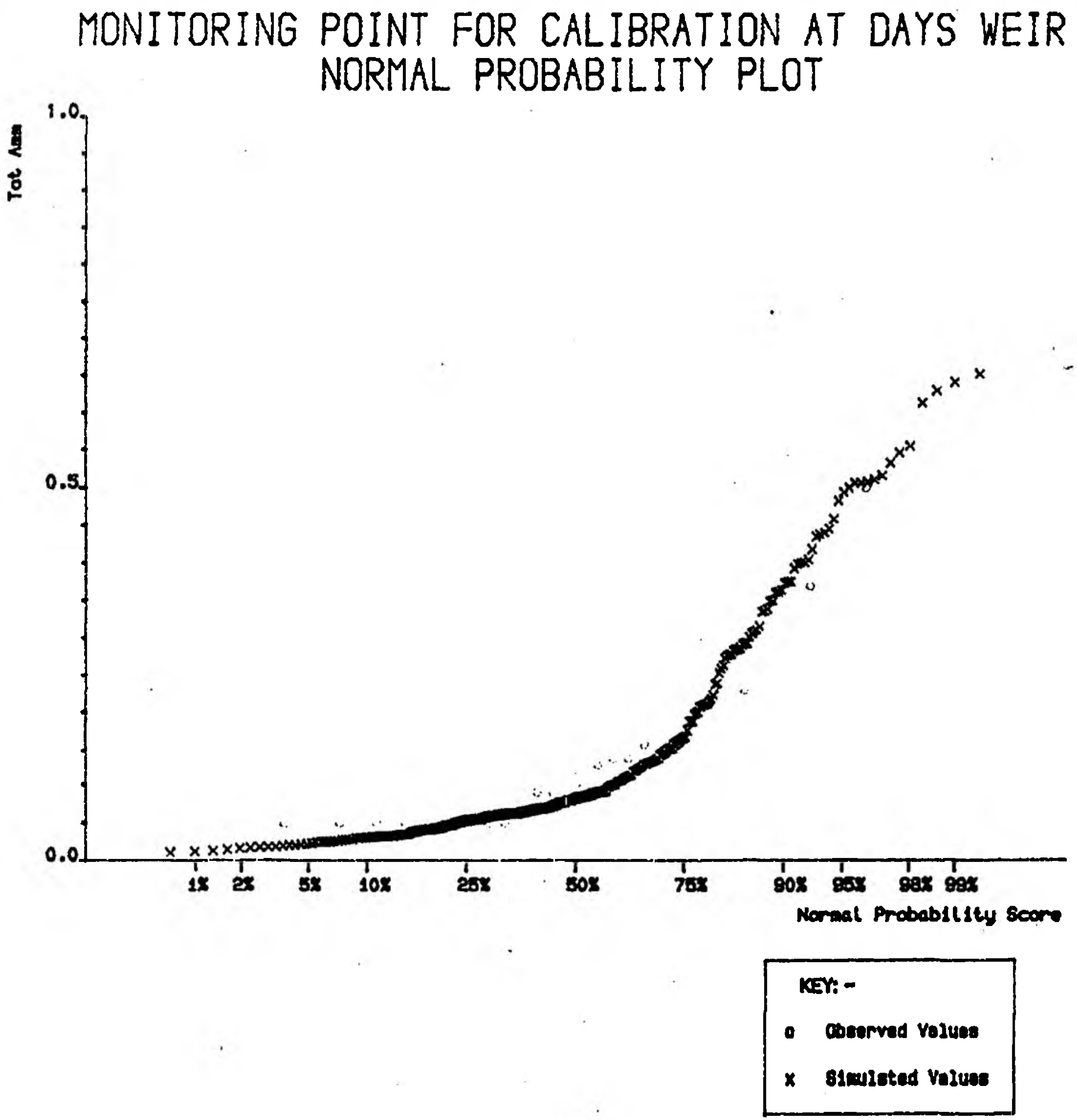
Fig 22.

MONITORING POINT AT RADLEY COLLEGE BOATHOUSE
NORMAL PROBABILITY PLOT



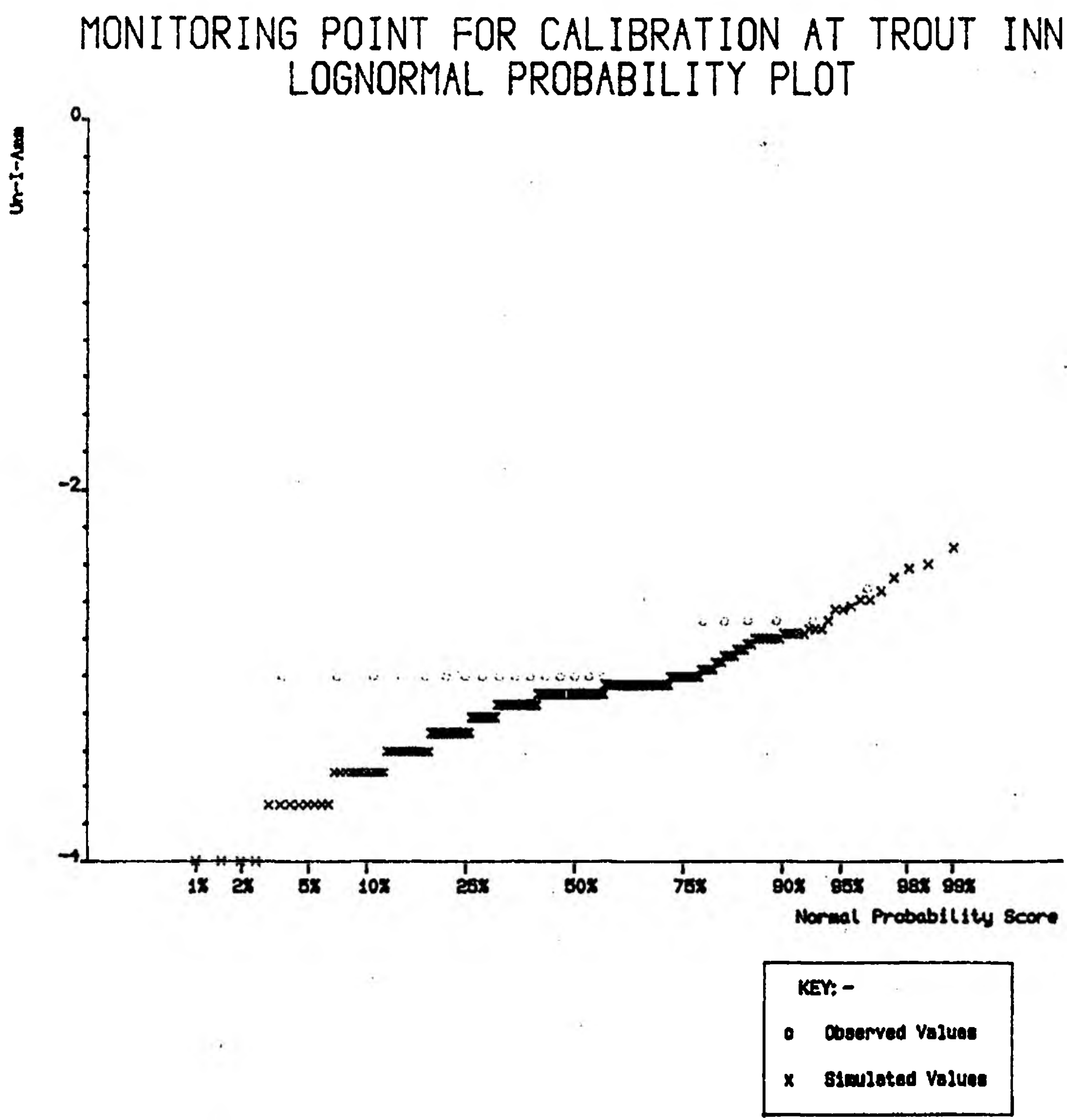
1.35

Fig 23.


MONITORING POINT FOR CALIBRATION AT DAYS WEIR
NORMAL PROBABILITY PLOT
Tot Amm
1.0
0.5
0.0
1%
2%
5%
10%
25%
50%
75%
90%
95%
98%
99%
Normal Probability Score
KEY: -
o Observed Values
x Simulated Values

1.36

Fig 2a

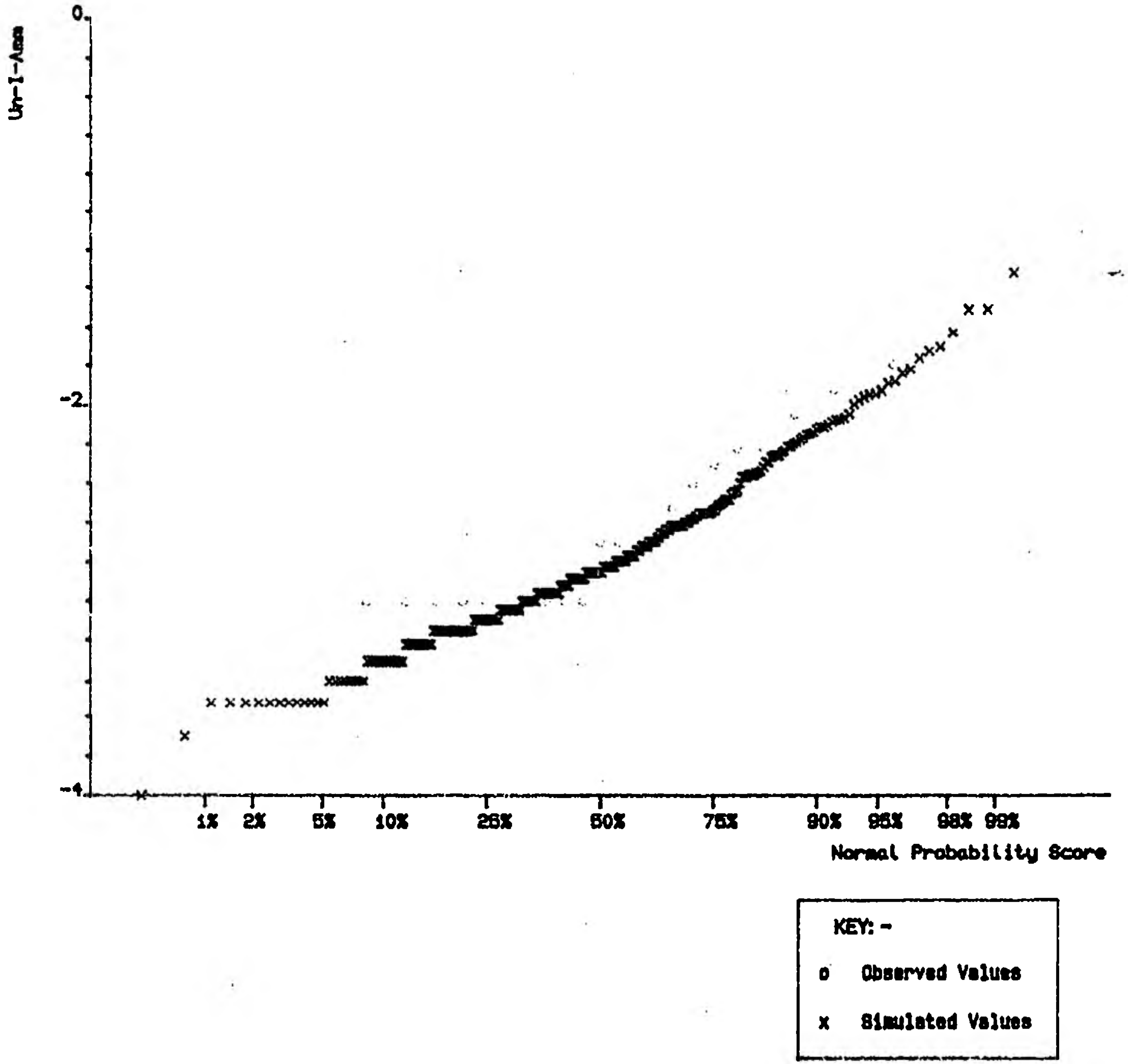


MONITORING POINT FOR CALIBRATION AT TROUT INN
LOGNORMAL PROBABILITY PLOT
Un-I-Amm
0
-2
-4
1%
2%
5%
10%
25%
50%
75%
90%
95%
98%
99%
Normal Probability Score
KEY: -
o Observed Values
x Simulated Values

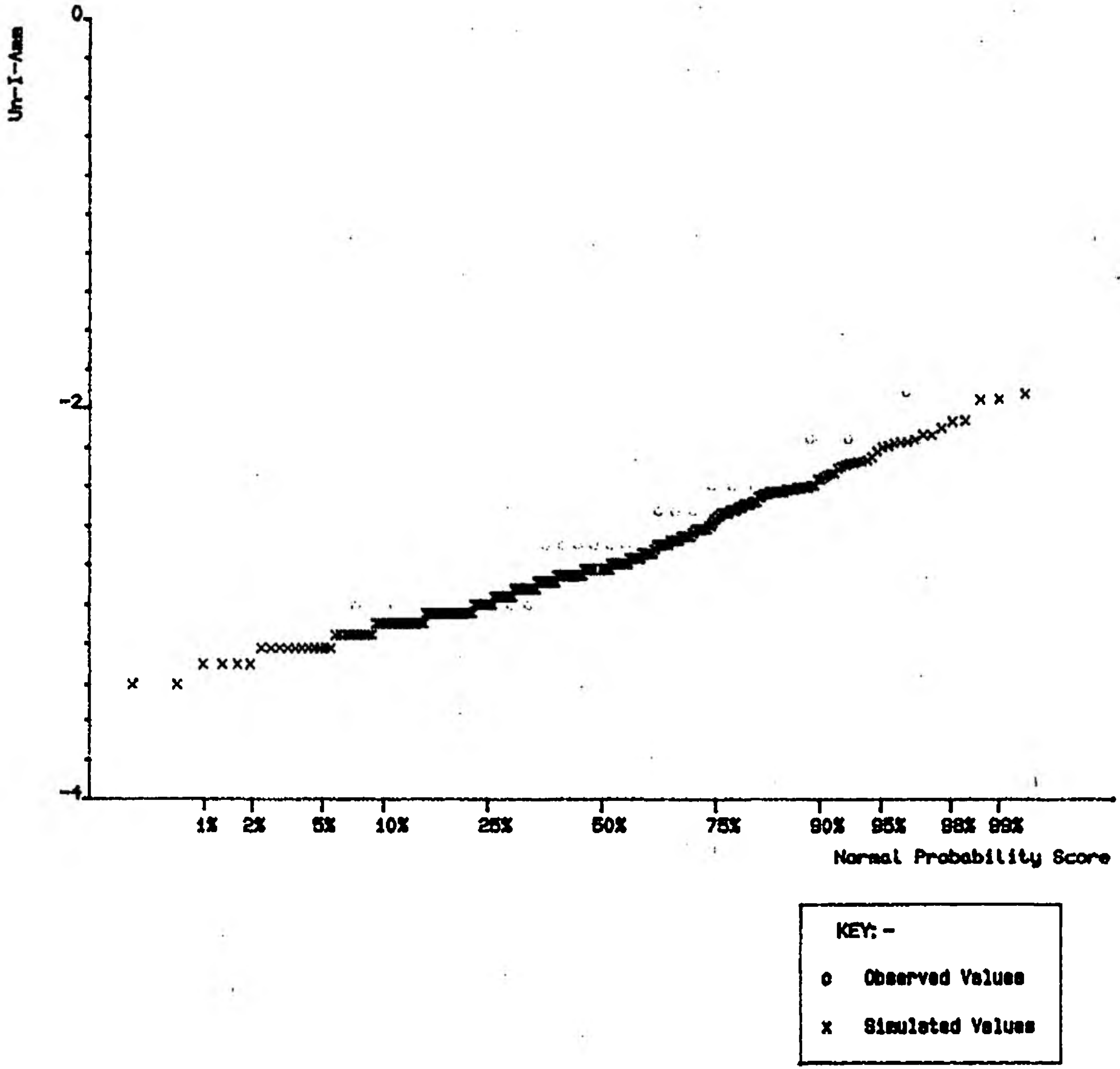
1.37

Fig 23

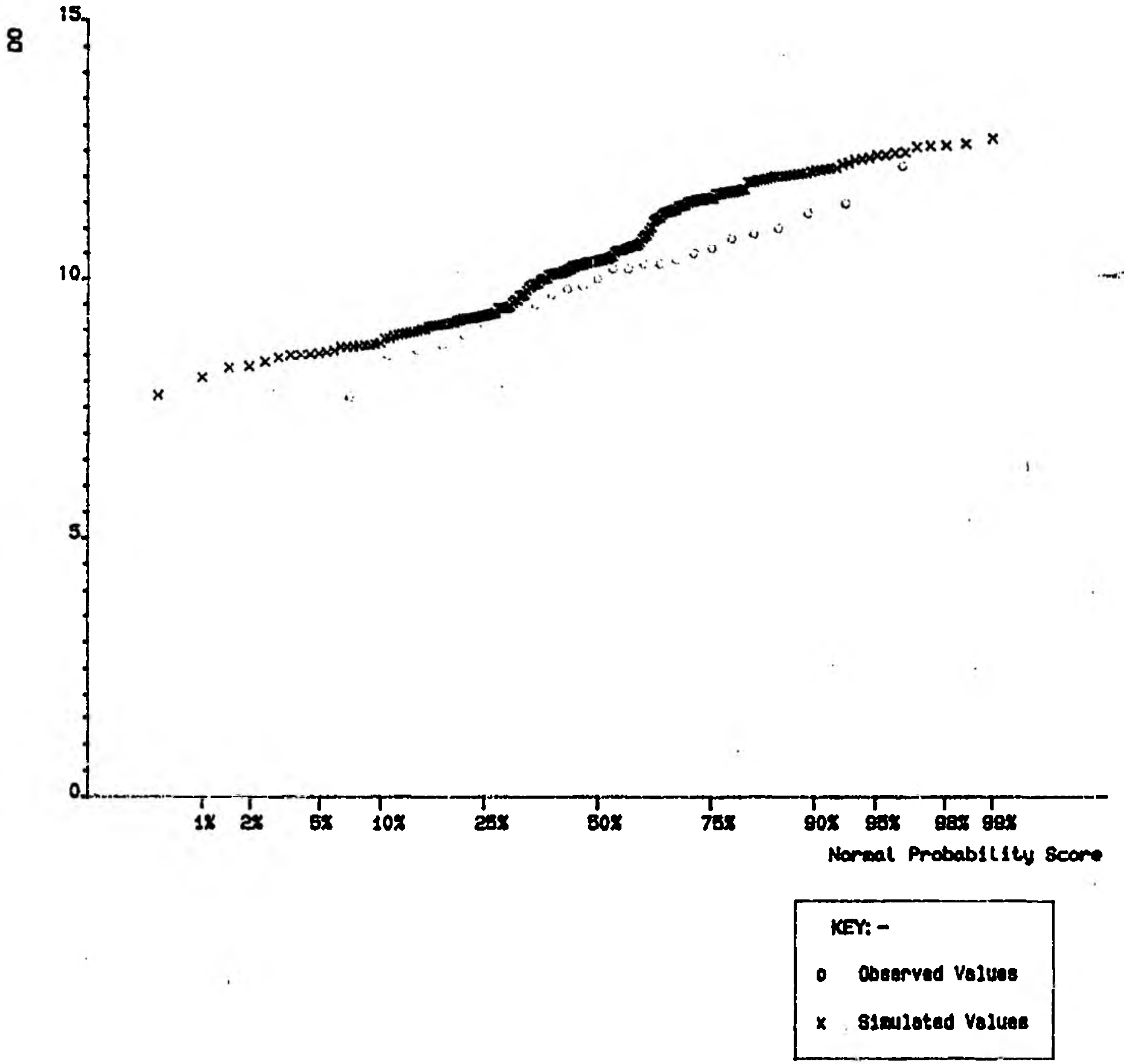
MONITORING POINT AT RADLEY COLLEGE BOATHOUSE
LOGNORMAL PROBABILITY PLOT



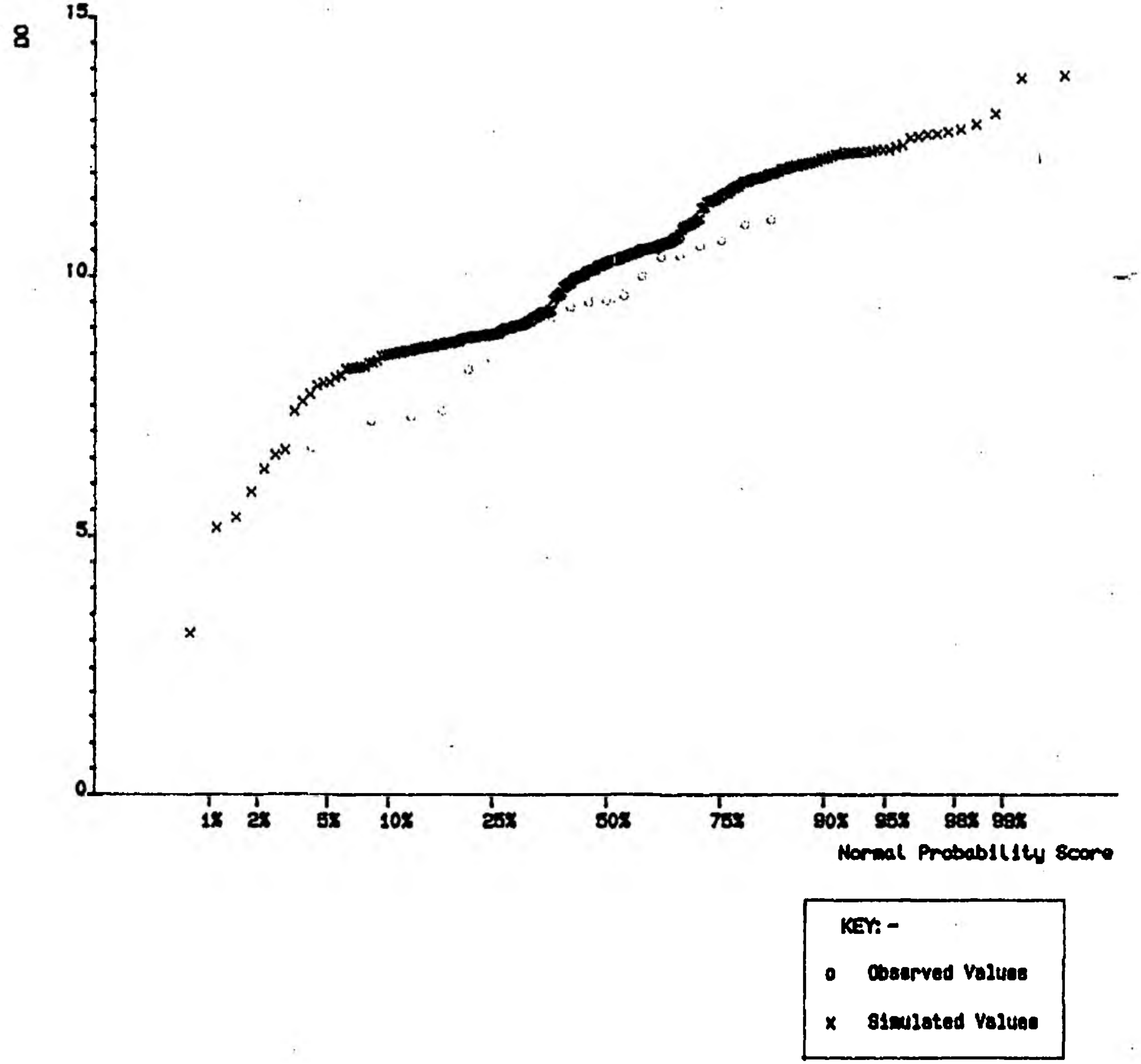
MONITORING POINT FOR CALIBRATION AT DAYS WEIR
LOGNORMAL PROBABILITY PLOT



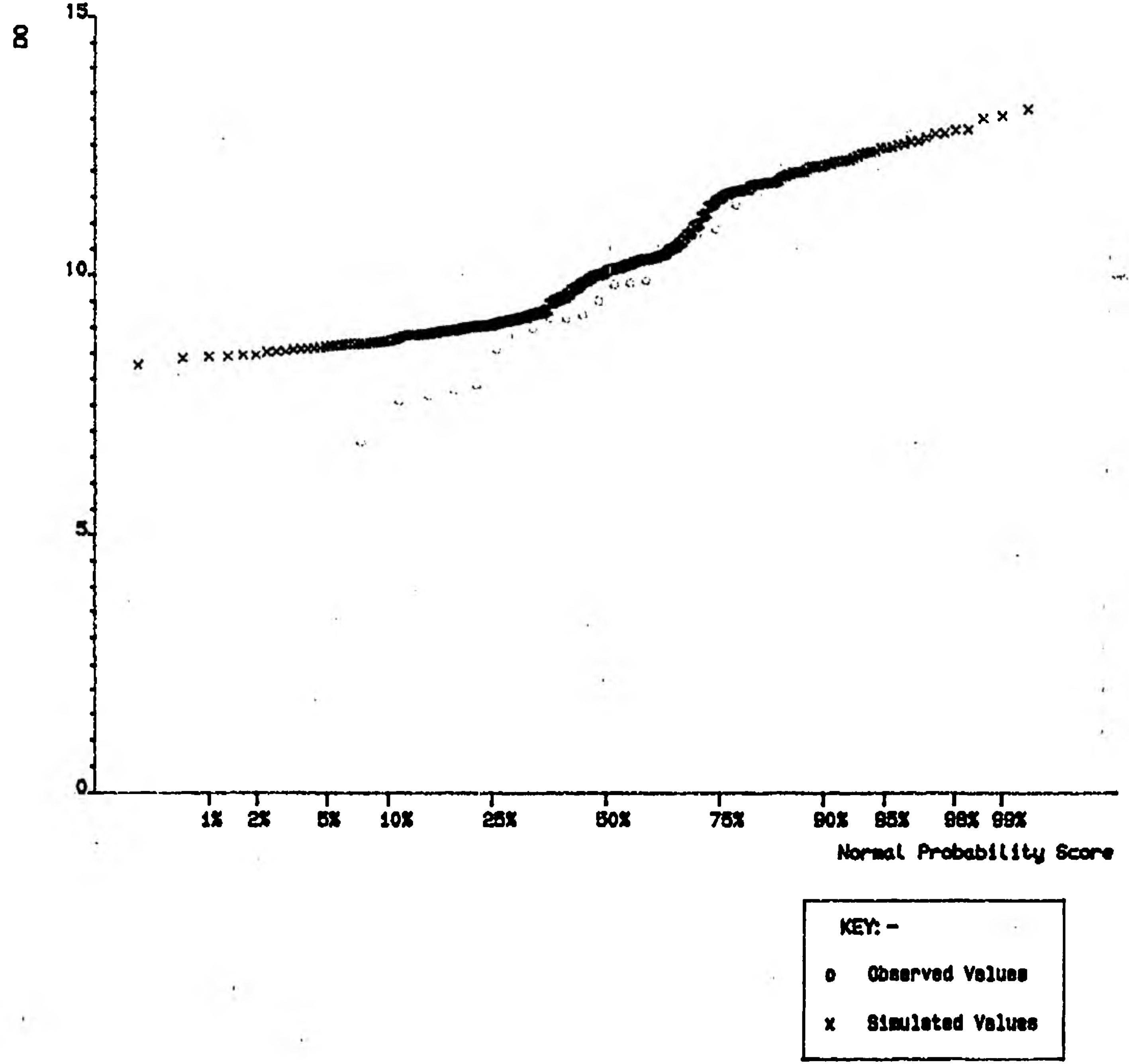
MONITORING POINT FOR CALIBRATION AT TROUT INN
NORMAL PROBABILITY PLOT



MONITORING POINT AT RADLEY COLLEGE BOATHOUSE
NORMAL PROBABILITY PLOT



MONITORING POINT FOR CALIBRATION AT DAYS WEIR
NORMAL PROBABILITY PLOT

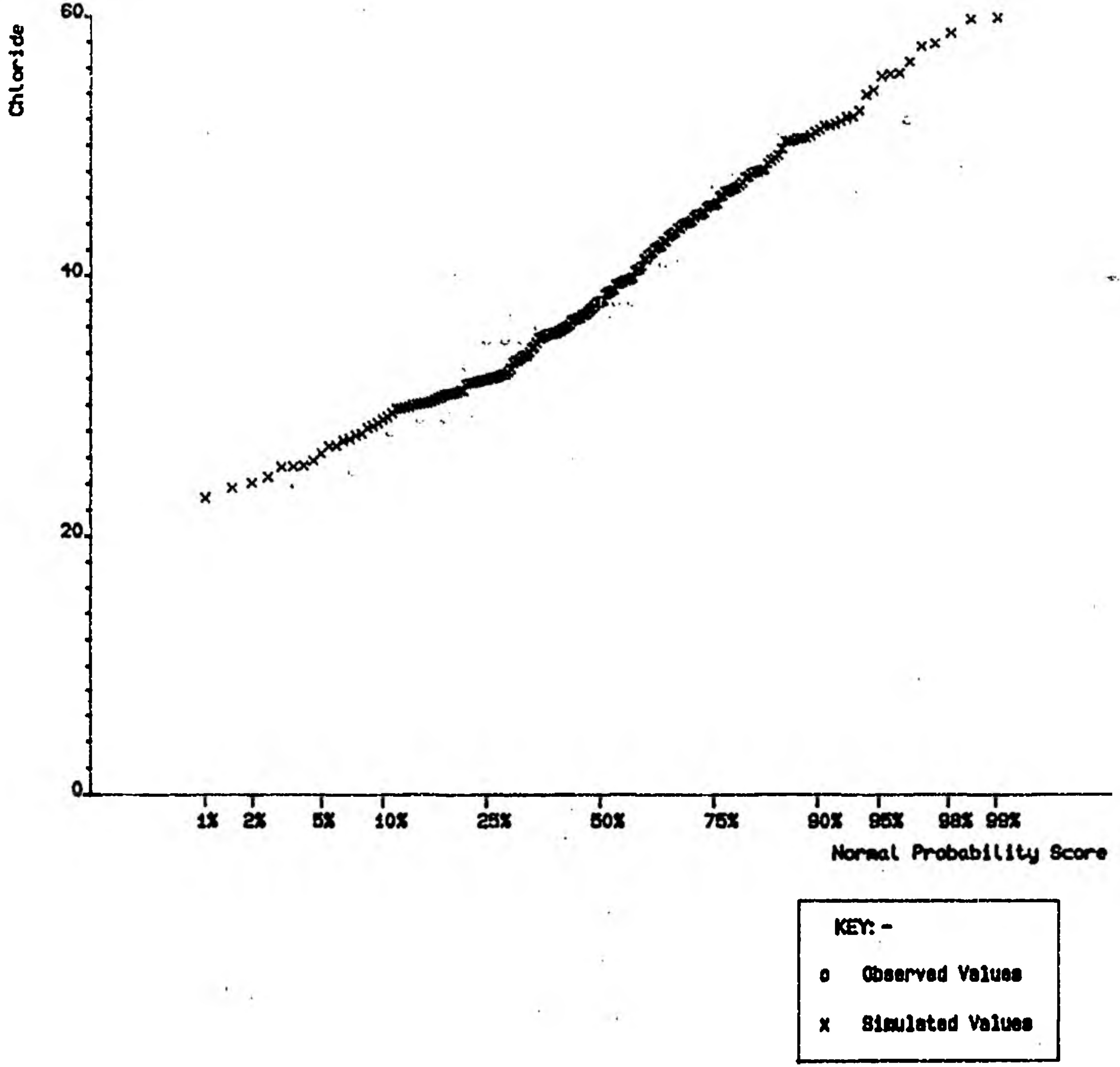


1.42

Fig 30

1.43

MONITORING POINT FOR CALIBRATION AT TROUT INN
NORMAL PROBABILITY PLOT



MONITORING POINT AT RADLEY COLLEGE BOATHOUSE
NORMAL PROBABILITY PLOT

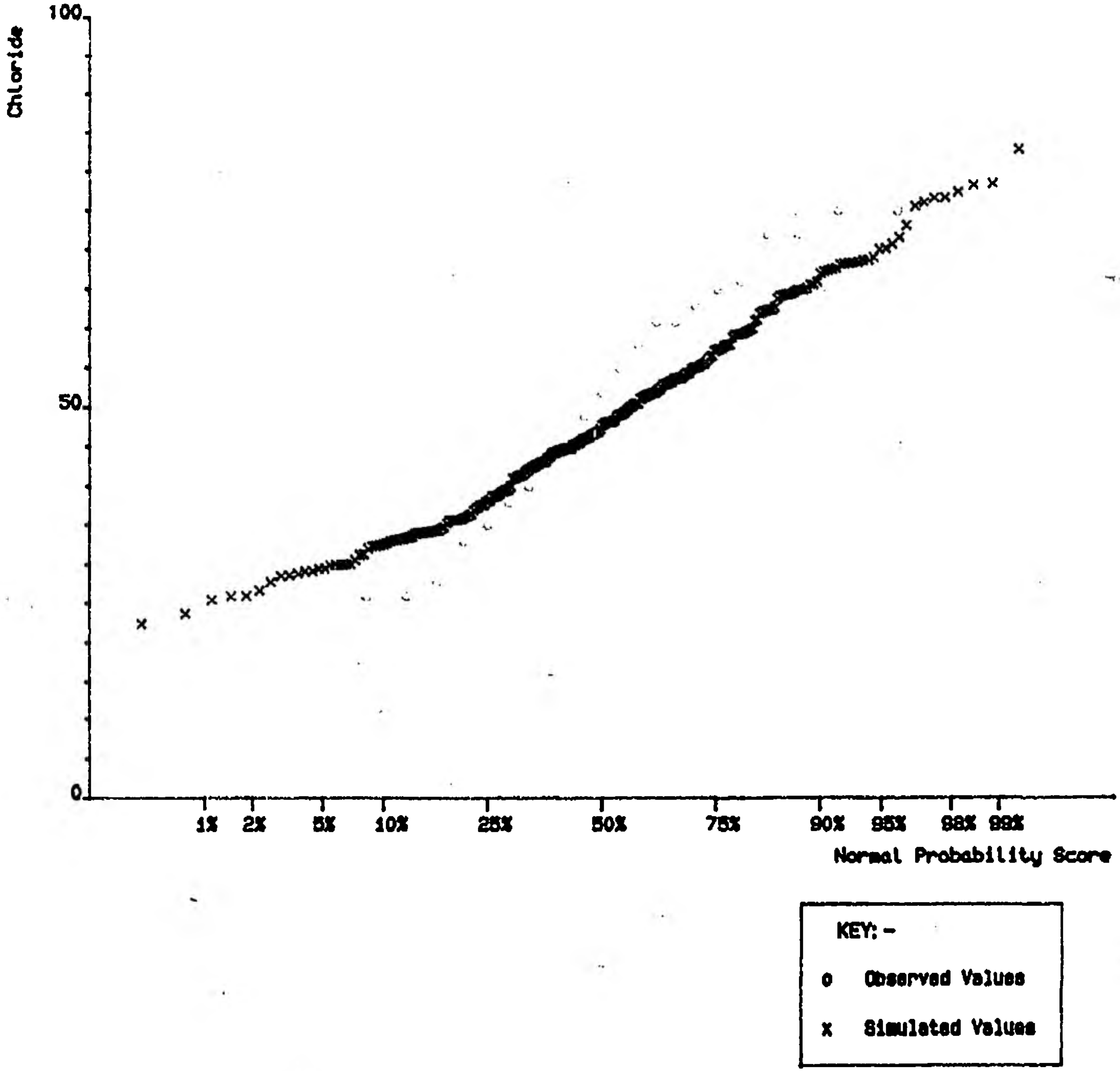
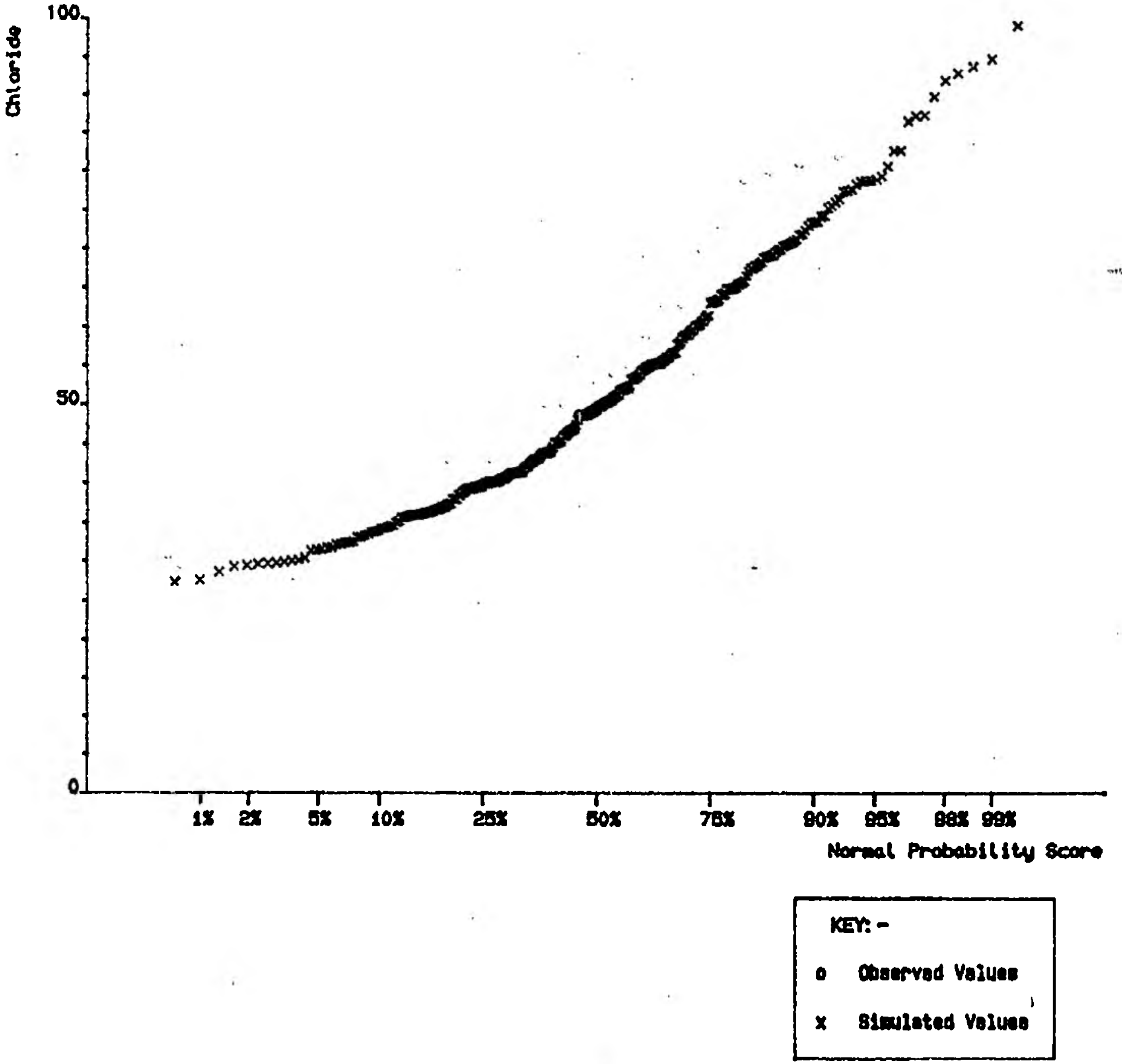


Fig 5.1

MONITORING POINT FOR CALIBRATION AT DAYS WEIR
NORMAL PROBABILITY PLOT



Appendix A.

Table A.
Source of flow data used in 1990/91 setup of model

Trib/Discharge/abst	data used
Eynsham	1990/91 g.s. data
South Leigh	scaled from 1984/1989
Stanton Harcourt	scaled from 1984/1989
Evenlode	1990/91 g.s. data
Cassington	scaled from 1984/1989
Oxford Canal	Scaled from 1990/91 cherwel
Cherwell	1990/91 g.s. data
Northfield Brook	scaled from 1984/1989
Culham Abst	licensed value
Ock	1990/91 g.s. data
Abingdon	scaled from 1984/1989
Ginge Brook	as for 1984/89
Harewell	licensed value
Didcot Abst	as for 1984/89
Didcot Discharge	as for 1984/89
Moor Ditch	as for 1984/89
Long Witt	as for 1984/89
Clifton Hampden	as for 1984/89
Burcot Brook	as for 1984/89

Table B. Source of quality data used in 1990/91 setup of model

	BOD	Ammonia	Chloride	DO	Temperature
Farmoor	90/91	90/91	90/91	90/91	scaled
South Leigh	scaled	scaled	scaled	as before	as before
Stanton Harcourt	scaled	scaled	scaled	as before	as before
Evenlode	90/91	scaled	90/91	90/91	as before
Cassington	90/91	90/91	scaled	as before	as before
Oxford Canal	90/91	90/91	scaled	90/91	as before
Cherwell	90/91	scaled	90/91	scaled	scaled
Northfield Brook	90/91	90/91	90/91	as before	scaled
Ock	90/91	scaled	scaled	90/91	as before
Abingdon	90/91	scaled	90/91	as before	as before
Ginge Brook	90/91	scaled	90/91	scaled	as before
Didcot Discharge	90/91	scaled	90/91	90/91	as before
Moor Ditch	90/91	scaled	scaled	scaled	as before
Long Witt	scaled	scaled	scaled	as before	as before
Clifton Hampden	scaled	scaled	scaled	as beforew	as before
Burcot Brook	scaled	scaled	scaled	scaled	as before

Notes

1. 90/91 implies actual 1990/91 data was used
2. Scaled implies 1984/89 data was scaled (using the ratio of the means) to the 1990/91 data
   i.e. scaling factor=mean of (1990/91)/ mean of (1984/89)
3. As before; implies the 1984/89 data is used.

Investigation of Effects of New Abstraction on the Quality of the River Thames, with Reference to BOD, Ammonia, and Dissolved Oxygen

Summary

This report attempts to assess the possible impact upon water quality of the proposed new reservoir abstraction near Abingdon, by using the Tomcat water quality model. A number of different options for maintaining the present water quality are then investigated including revising the Oxford STW consent and improving the water quality in the Ginge Brook. Finally the possibility of improving the water quality downstream of Oxford STW to a 1B classification is investigated.

Introduction

The previous modelling report considers the validity of the water quality model Tomcat set up by Thames Water for the river Thames between Farmoor and Days, concluded that both ammonia and un-ionised-ammonia were being modelled satisfactorily. BOD was being modelled satisfactorily for one time period but not for the calibration time period, whilst DO was poorly modelled particularly at the lower percentile range. It was decided that the model would be suitable for further work on abstraction simulation. The BOD and DO concentrations are both strongly affected by algae which are not represented in the model and further work will need doing in this area. The main thrust of this report will therefore be towards the ammonia determinands though BOD concentrations shall be investigated in the time period where it was well represented.

Effects of Abstraction

The proposed surface water abstraction is located 300m above the discharge of Abingdon STW to the River Thames. The abstraction appears to have the most significant impact on the water quality downstream of the Ginge Brook. The Ginge Brook carries the effluent of both Abingdon (old) STW and Drayton STW and enters the Thames 5.54km downstream of the proposed abstraction point.

Table 1 and 2 shows the results of the abstraction for various abstraction rates and flow constraints on the quality downstream of the Ginge Brook. Table 1 uses 1984/1989 data whilst table 2 uses 1990/91 data. Figs 1-6 plot the data for the 1984/1989 data whilst Figs 7-12 plot the 1990/91 data.

The plots of the mean water quality concentrations of ammonia, BOD and DO show deteriorating water quality as the quantity of water abstracted increases. The 95%ile plots are not so straight forward with water quality sometimes improving and sometimes deteriorating as the quantity of water abstracted increases. This fluctuation in the 95%ile values may be explained in terms of two physical processes. The first being that with a new abstraction, water quality downstream will deteriorate due to a lower diluting flow for any effluent discharges. The second process is that when water is abstracted from the river the time of travel of the remaining water increase. The increased time of travel (retention time) means that there is a longer time for BOD and ammonia to decay leading to a corresponding improvement in the quality. Both these phenomenon will have a larger influence at low flows and it is the balance between these process which may be resulting in the fluctuations of the 95%iles of the determinand distributions.

It may be seen though that apart for the 1984/89 BOD data (Fig. 2), and the 1990/91 DO data (Fig. 12) simulations all the abstractions scenarios are causing a deterioration in water quality. The magnitude of this deterioration is quite small and is shown in table A below.

Table A to show approximate % change due to abstractions.

	mean	95%ile
BOD	2.9	0.7
DO	0.6	1.0
Ammonia	8.0	5.2

However as stated previously, the BOD/DO model is very poor so reliance should only be placed on the ammonia results.

Modifying STW Discharges to Mitigate Effects of the Abstraction

In order to mitigate the effects of the abstractions on water quality the impact of the quality of the STW discharges on the river were investigated. The two principle STW's which have effect downstream of the Ginge Brook are Abingdon (old) and Oxford. Since neither of these STW are directly in the model it is necessary to develop a relationship between the tributary discharge into the Thames and the STW discharge into the tributary, or to extend the model to include the STW.

Regression analysis was conducted using same day data for the period September 1984-December 1991 for the two STW and their respective tributaries. This assumes diel variation to be small. It was not found possible to find a relationship between Abingdon STW and the Ginge Brook. This is possible due to the fact that the flow upstream of where the STW enters the Ginge Brook is large in comparison to the STW flow, which means that there are extra parameters (eg. upstream flow and quality) that need including in the regression analysis. It may be necessary therefore to extend the model to include Abingdon STW. For the purpose of this report improvements in terms of the Ginge Brook quality will be investigated which then need to translated into causal factors (eg. STW effluent quality) later.

A relationship was found between the quality of Oxford STW effluent and that in the Northfield Brook. The regression equations are:

for BOD	Northfield = 0.541 Oxford
for Ammonia	Northfield = 0.815 Oxford

It was decided to use no constant in the regression as this is more suitable for the scaling techniques used in Tomcat. An attempt was made to use Oxford STW data directly in the model in conjunction with the regression equations but this failed to produce any significant improvement in the model results.

The un-ionised ammonia data has not been included in the summary table as any increase in concentrations of this determinand is reduced when the ionised ammonia from the works is improved. The DO results have not been included due to the lack of confidence in this part of the model, particularly at the lower flows which the abstraction will produce. It is still of interest to briefly examine the DO results. Most abstraction scenarios appear to produce up to a 0.6% sat. decline in the DO mean for both the time periods, whilst producing a 0.9% sat. decline in the 5%ile central estimate. Both these reductions appear to be partially or fully reversed by the improvements in BOD and ammonia from Oxford STW.

Tables 3 & 4 shows the results of improving the quality of the Northfield Brook data (and thus Oxford STW) and Ginge Brook data, for each time period respectively.

In most cases the quality of the inputs from these tributaries have been improved in 10% steps. These 10% steps produce approximately a 0.01mg/l change in the 95%ile concentration of the ammonia and BOD downstream of Ginge Brook. Since the size of the confidence interval about the 95%ile concentration produced by the model is approximately 0.1mg/l, it was felt inappropriate to use a smaller step size.

Tables 5 & 6 summarize the improvements required in order for the effects of the abstraction to be mitigated. The actual quality of the effluent discharge for the respective time periods has been multiplied by the appropriate scaling factor give a central estimate of what the quality of the discharge should be. The confidence interval at Oxford STW has been calculated by firstly using the regression equation to scale the Northfield Brook confidence interval (this assumes Oxford and Northfield have the same shape distribution) and then multiplying this confidence interval by the appropriate scaling factor.

The appropriate scaling factor is chosen from tables 3 & 4 such that the water quality downstream of the Ginge Brook is the same or improved as the quality without the abstraction present. The error in the scaling factor is 0.05 (half the step size) which corresponds to approximately 2mg/l change in the BOD from Oxford (1984/89 time period) and 0.9mg/l change in the ammonia from Oxford (both time periods).

Table B, shows the most stringent percentage improvements required in the water quality from Oxford STW and Ginge Brook. These are the maximum improvement required in order that if the abstraction had been operating during 1984/89 and 1990/91 for the river to achieve the same quality as it actually did.

The variability due to the error in the scaling factor has not been used in this table.

Table B to show percentage improvements in quality required.

	BOD	Ammonia
Oxford Effluent	20%	20%
Ginge BK	30%	30%

The actual 95%ile quality of the effluent from Oxford STW during 1984/89 was 52mg/l for BOD and 18mg/l for ammonia. During 1990/91 the ammonia achieved a 95%ile quality of 13.6mg/d. The % improvements may be applied to these figures in order to show that a BOD consent of 42mg/l for the 1984/89 time period would be necessary to maintain quality and for the 1990/91 time period a consent standard of 10.9mg/l for ammonia would be necessary to maintain quality,.

Reviewing Consents to Mitigate the Effects of the Abstraction

The above work uses current performance at Oxford STW. Legally the quality can be of poorer quality so the impact of the STW working to consent limits was considered next. In order to do this it is necessary to adjust the actual data from Oxford up to the consented concentrations. Table 7 shows the adjustments which must be made in order to simulate the STW works operating at its consent limit.

Tables 8 & 9 show the modelled quality in the River Thames with Oxford operating at its consented quality for both time periods. Also shown are a number of abstraction scenarios along with attempts to mitigate the effects of the abstraction by improving the quality from Oxford STW and the Northfield Brook. For the 1984/89 time period and 1990/91 time period the mean BOD rises above 2.0mg/l which is the guideline value for a class 1B river. In order for the BOD mean to be reduced below 2.0mg/l a scaling factor of 0.6 (equivalent consent of 45mg/l) is required.

Table 10 & 11 show a summary of the improvements in the consented quality at Oxford STW and the water quality of the Ginge Brook required to compensate for various abstraction scenarios. Since for the 1990/91 period the model predicts the lower confidence limit on the 95%ile of ammonia to be greater than 0.7mg/l, Table 11 also shows the scaling factors required in order for the river to comply with its RQO.

The most stringent central estimate required for the Oxford STW consent are shown in table C below. Also shown are the % improvements in the Ginge Brook required to compensate for the abstraction if Oxford STW is operating at its present consent standard.

Table C

	BOD	Ammonia
Oxford Consent	64(mg/l)	16(mg/l)
Ginge BK Quality	70%	70%

If the lower confidence interval of the 95%ile is used for the Oxford works the most stringent consent standard for BOD becomes 50mg/l and for ammonia becomes 15mg/l.

The maximum consent at Oxford STW for a given abstraction is shown in Table 12.

The 0.05 error in the scaling factor could lead to a further 1mg/l improvement in the ammonia consent and 4mg/l improvement in the BOD consent being necessary.

Improving Classification of River Thames

At present the River Thames between the Cherwell and Ock has a water quality objective of 2A.

According to the model the river will be meeting a class 1B for all water quality determinands if Oxford STW were operating at its consent limit, apart from for ammonia downstream of the Northfield Brook. It is possible to use the lower limit of the 95%ile confidence interval to estimate what improvements to the work would be necessary in order to the River Thames to meet a 1B classification. For the 1984/89 time period under study scaling the STW ammonia by 0.6 (consent 13mg/l central estimate) reduces the ammonia lower 95%ile limit from 1.03mg/l to 0.69mg/l. For the 1990/91 time period scaling the STW ammonia by 0.45 (consent 9mg/l central estimate) reduces the ammonia lower 95%ile limit from 1.43mg/l to 0.68mg/l.

If such improvement work were to take place at Oxford STW an improvement in quality of this magnitude would therefore both mitigate the effects of the proposed abstraction and also enable the River Thames to be classified as a 1B river.

Conclusions

The following conclusions may be drawn.

a. The proposed new abstraction would cause a deterioration of water quality in the River Thames, of up to 3% for BOD and 8% for ammonia.

b. In order for there to be no deterioration in predicted water quality for the worst case abstraction scenario a reduction of 20% in the ammonia consent standard for Oxford STW, from 20mg/l to 16mg/l would be required. This assumes Oxford STW to be working at its consent standard. Over the last few years, Oxford STW performance is much better than consent standards, and the water quality better than 'predicted'.

The corresponding reduction is required to maintain the quality in the river is from 13 to 11mg/l. An improvement of approximately 15% would be required in the BOD consent standard (from 75 to 64) to maintain present river quality. This BOD figure though is based upon an aspect of the model which has not been fully validated. If the 95% confidence interval lower limit were to be used to calculate the consent change, ie. allowing for more error, the ammonia consent would need improving to 15mg/l whilst the BOD would need improving to 53mg/l.

c. The water quality may alternatively be prevented from deteriorating by improving the quality of the Ginge Brook by 30% for ammonia and 30% for BOD.

d. The model shows that a 65% improvement in the ammonia consent at Oxford STW (to 9mg/l central estimate, 8.3mg/l lower estimate) would enable the River Thames to achieve a 1B classification downstream of the Northfield Brook.

e. Though the model shows a deterioration in DO the actual effect of the abstraction is difficult to assess due to the failure of the model to simulate DO accurately.

Further Work

1. The effects of the new abstraction on DO and BOD need further investigation.

2. Changes in the seasonal concentrations of ammonia due to the new abstraction need to be explored.

3. A relationship between the water quality of Ginge Brook with Abingdon (old) STW needs to developed.

M Tinsley
28/10/92
/LJ...

List of Tables and Figures.

Table 1

Abstraction Simulations.
Water quality downstream of Ginge Brook
1984/89 data.

ABSTRACTION(Ml/day)			TRIB' SCALING		BOD(mg/l)		
		% of time				95%ile	
rate	constraint	abst' reduced	N'field	Ginge	mean	low	mid
0	0	0	1	1	1.974	3.409	3.519
2000	650	74.07	1	1	2.008	3.439	3.52
2000	550	72.11	1	1	2.017	3.444	3.545
2000	450	70.72	1	1	2.032	3.442	3.543
1500	650	66.78	1	1	2.003	3.44	3.51
1500	550	64.24	1	1	2.011	3.447	3.528
1500	450	62.27	1	1	2.023	3.446	3.536
1200	650	60.19	1	1	1.999	3.431	3.509
1200	550	58.68	1	1	2.006	3.432	3.529
1200	450	55.9	1	1	2.017	3.431	3.535
1000	650	55.9	1	1	1.996	3.423	3.511
1000	550	52.55	1	1	2.002	3.424	3.528
1000	450	49.19	1	1	2.011	3.414	3.527
800	650	49.19	1	1	1.992	3.41	3.513
800	550	45.83	1	1	1.997	3.409	3.523
800	450	42.94	1	1	2.004	3.409	3.522

			AMMONIA(mg/l)		UN-I-AMMONIA(mg/l)		DO(%sat)	
			95%ile			95%ile		5%ile
upp	mean	low	mid	upp	mean	mid	mean	mid
4.087	0.2535	0.6297	0.6575	0.7214	0.00376	0.01005	95.77	88.88
4.081	0.2703	0.6471	0.6875	0.738	0.00394	0.01031	95.24	88.71
4.079	0.2746	0.656	0.6835	0.7389	0.00398	0.01035	95.11	88.41
4.076	0.2812	0.6651	0.6916	0.7473	0.00405	0.01059	94.93	88.16
4.083	0.2675	0.6407	0.6692	0.7391	0.00391	0.0101	95.33	88.74
4.081	0.2712	0.6449	0.6717	0.7403	0.00395	0.01018	95.23	88.42
4.08	0.2767	0.6486	0.6831	0.7463	0.004	0.01026	95.07	88.18
4.084	0.2655	0.6388	0.669	0.7366	0.00389	0.01009	95.39	88.74
4.083	0.2687	0.6418	0.669	0.7369	0.00392	0.01012	95.3	88.33
4.082	0.2738	0.6478	0.6839	0.7394	0.00397	0.01021	95.17	88.18
4.085	0.2642	0.6345	0.668	0.7329	0.00387	0.01009	95.44	88.75
4.084	0.2669	0.6413	0.669	0.735	0.0039	0.01012	95.35	88.34
4.083	0.2709	0.6459	0.6845	0.7397	0.00394	0.01022	95.24	88.25
4.085	0.2623	0.6346	0.6666	0.7317	0.00385	0.0101	95.49	88.76
4.085	0.2644	0.6404	0.6686	0.7343	0.00387	0.01014	95.43	88.36
4.084	0.2675	0.6459	0.684	0.7393	0.0039	0.01017	95.33	88.26

Table 2

Abstraction Simulations.
Water quality downstream of Ginge Brook.
1990/1991 data

ABSTRACTION(Ml/day)			TRIB' SCALING				BOD(mg/l)
		% of time					95%ile
rate	constraint	abst' reduced	N'field	Ginge	mean	low	mid
2000	650	83.56	1	1	1.812	3.35	3.482
2000	550	81.94	1	1	1.818	3.361	3.495
2000	450	81.37	1	1	1.827	3.365	3.508
1500	650	78.13	1	1	1.809	3.346	3.486
1500	550	77.43	1	1	1.814	3.356	3.495
1500	450	75.93	1	1	1.822	3.355	3.512
1200	650	74.77	1	1	1.807	3.337	3.488
1200	550	74.19	1	1	1.812	3.346	3.497
1200	450	73.03	1	1	1.819	3.345	3.515
1000	650	73.03	1	1	1.806	3.329	3.489
1000	550	71.53	1	1	1.81	3.334	3.498
1000	450	70.49	1	1	1.817	3.345	3.508
800	650	70.49	1	1	1.805	3.33	3.491
800	550	68.63	1	1	1.809	3.336	3.499
800	450	67.01	1	1	1.815	3.347	3.503

			AMMONIA(mg/l)			UN-I-AMMONIA(mg/l)	DO(%sat)	
			95%ile			95%ile		5%ile
upp	mean	low	mid	upp	mean	mid	mean	mid
3.645	0.2346	0.6946	0.7422	0.7982	0.00272	0.00806	94.22	85.9
3.661	0.2391	0.7001	0.7511	0.8146	0.00278	0.00819	94.15	85.94
3.664	0.2461	0.7006	0.7716	0.8471	0.00287	0.0085	94.01	85.89
3.642	0.2323	0.6955	0.7419	0.7955	0.0027	0.00796	94.29	85.91
3.648	0.2363	0.7011	0.7486	0.8044	0.00275	0.00811	94.23	85.96
3.651	0.2425	0.7018	0.7595	0.8205	0.00284	0.00836	94.1	85.9
3.644	0.2308	0.6958	0.7316	0.7929	0.00268	0.00796	94.33	85.92
3.65	0.2343	0.6956	0.7359	0.7968	0.00273	0.0081	94.28	85.97
3.649	0.2399	0.6994	0.7464	0.8134	0.0028	0.00817	94.16	85.92
3.645	0.2297	0.6844	0.7274	0.7826	0.00267	0.00794	94.36	85.92
3.644	0.2328	0.6859	0.7317	0.7932	0.00271	0.00793	94.31	85.98
3.643	0.2381	0.6881	0.7398	0.812	0.00278	0.00814	94.21	85.92
3.636	0.2285	0.6788	0.7244	0.783	0.00265	0.00794	94.39	85.92
3.635	0.2313	0.6783	0.7299	0.7936	0.00269	0.00794	94.35	85.98
3.635	0.236	0.687	0.7367	0.7984	0.00275	0.00815	94.25	85.92

Table 3.

Abstraction Simulations with scaled STW data.
Water quality downstream of Ginge Brook
1984/89 data.

ABSTRACTION(Ml/day)			TRIB' SCALING		BOD(mg/l) 95%ile		
rate	constraint	% of time abst' reduced	N'field	Ginge	mean	low	mid
0	0	0	1	1	1.974	3.409	3.519
1200	650	60.19	1	1	1.999	3.431	3.509
1200	650	60.19	0.9	1	1.981	3.395	3.495
1200	650	60.19	0.8	1	1.963	3.383	3.484
1200	650	60.19	1	0.8	1.977	3.401	3.5
1200	650	60.19	1	0.7	1.966	3.395	3.493
1200	550	58.68	1	1	2.006	3.432	3.529
1200	550	58.68	0.9	1	1.988	3.404	3.496
1200	550	58.68	0.8	1	1.97	3.382	3.483
1200	550	58.68	1	0.8	1.982	3.403	3.507
1200	550	58.68	1	0.7	1.97	3.394	3.498
1200	450	55.9	1	1	2.017	3.431	3.535
1200	450	55.9	0.9	1	1.999	3.404	3.495
1200	450	55.9	0.8	1	1.981	3.381	3.482
1200	450	55.9	1	0.8	1.99	3.405	3.508
1200	450	55.9	1	0.7	1.977	3.397	3.497
1000	650	55.9	1	1	1.996	3.423	3.511
1000	650	55.9	0.9	1	1.978	3.396	3.496
1000	650	55.9	0.8	1	1.96	3.377	3.485
1000	650	55.9	1	0.8	1.975	3.403	3.502
1000	650	55.9	1	0.7	1.965	3.396	3.494

			AMMONIA(mg/l)		UN-I-AMMONIA(mg/l)		DO(%sat)	
			95%ile			95%ile		5%ile
upp	mean	low	mid	upp	mean	mid	mean	mid
4.087	0.2535	0.6297	0.6575	0.7214	0.00376	0.01005	95.77	88.88
4.084	0.2655	0.6388	0.669	0.7366	0.00389	0.01009	95.39	88.74
4.067	0.252	0.6023	0.6299	0.7001	0.00367	0.00943	95.57	89.29
4.048	0.2386	0.5705	0.6048	0.6697	0.00345	0.00861	95.73	89.91
4.069	0.2551	0.6112	0.6439	0.704	0.00375	0.00978	95.39	88.74
4.061	0.2499	0.5984	0.6333	0.6976	0.00369	0.00946	95.39	88.74
4.083	0.2687	0.6418	0.669	0.7369	0.00392	0.01012	95.3	88.33
4.066	0.2554	0.6053	0.6333	0.6998	0.0037	0.00943	95.47	89.04
4.047	0.242	0.5726	0.606	0.6711	0.00349	0.00888	95.64	89.7
4.068	0.2574	0.612	0.6437	0.7031	0.00378	0.00983	95.3	88.33
4.06	0.2518	0.6028	0.6331	0.6948	0.00371	0.00965	95.3	88.33
4.082	0.2738	0.6478	0.6839	0.7394	0.00397	0.01021	95.17	88.18
4.064	0.2606	0.6208	0.6505	0.7017	0.00376	0.00969	95.34	88.95
4.046	0.2474	0.5914	0.6172	0.6717	0.00355	0.00895	95.52	89.66
4.067	0.2613	0.6215	0.6504	0.7083	0.00381	0.00991	95.17	88.18
4.058	0.255	0.6026	0.6406	0.691	0.00374	0.00969	95.17	88.18
4.085	0.2642	0.6345	0.668	0.7329	0.00387	0.01009	95.44	88.75
4.066	0.2507	0.5985	0.6281	0.6989	0.00365	0.00936	95.61	89.28
4.048	0.2372	0.5665	0.6046	0.6649	0.00344	0.00861	95.78	89.92
4.07	0.2541	0.6094	0.6436	0.7044	0.00374	0.00979	95.44	88.75
4.062	0.2491	0.5985	0.6335	0.698	0.00368	0.00947	95.44	88.75

Table 3 ctd.

ABSTRACTION(Ml/day)			TRIB' SCALING				BOD(mg/l)
		% of time					95%ile
rate	constraint	abst' reduced	N'field	Ginge	mean	low	mid
1000	550	52.55	1	1	2.002	3.424	3.528
1000	550	52.55	0.9	1	1.984	3.402	3.495
1000	550	52.55	0.8	1	1.966	3.376	3.484
1000	550	52.55	1	0.8	1.98	3.404	3.508
1000	550	52.55	1	0.7	1.968	3.395	3.5
1000	450	49.19	1	1	2.011	3.414	3.527
1000	450	49.19	0.9	1	1.993	3.398	3.495
1000	450	49.19	0.8	1	1.976	3.375	3.483
1000	450	49.19	1	0.8	1.987	3.397	3.507
1000	450	49.19	1	0.7	1.974	3.394	3.499
800	650	49.19	1	1	1.992	3.41	3.513
800	650	49.19	0.9	1	1.974	3.391	3.497
800	650	49.19	0.8	1	1.956	3.375	3.486
800	650	49.19	1	0.8	1.973	3.4	3.503
800	650	49.19	1	0.7	1.963	3.397	3.496
800	550	45.83	1	1	1.997	3.409	3.523
800	550	45.83	0.9	1	1.979	3.396	3.496
800	550	45.83	0.8	1	1.961	3.375	3.486
800	550	45.83	1	0.8	1.976	3.399	3.507
800	550	45.83	1	0.7	1.966	3.396	3.502
800	450	42.94	1	1	2.004	3.409	3.522
800	450	42.94	0.9	1	1.987	3.396	3.495
800	450	42.94	0.8	1	1.969	3.374	3.485
800	450	42.94	1	0.8	1.982	3.399	3.507
800	450	42.94	1	0.7	1.971	3.396	3.502

			AMMONIA(mg/l)		UN-I-AMMONIA(mg/l)		DO(%sat)	
			95%ile			95%ile		5%ile
upp	mean	low	mid	upp	mean	mid	mean	mid
4.084	0.2669	0.6413	0.669	0.735	0.0039	0.01012	95.35	88.34
4.066	0.2535	0.6039	0.6333	0.6987	0.00368	0.00938	95.53	89.05
4.047	0.2401	0.5705	0.6055	0.6654	0.00347	0.00887	95.7	89.7
4.069	0.2561	0.6103	0.6434	0.7036	0.00376	0.00984	95.35	88.34
4.061	0.2507	0.6021	0.6333	0.6953	0.00369	0.00965	95.35	88.34
4.083	0.2709	0.6459	0.6845	0.7397	0.00394	0.01022	95.24	88.25
4.065	0.2576	0.6135	0.6503	0.7001	0.00373	0.0095	95.42	88.96
4.046	0.2444	0.5785	0.6174	0.6671	0.00351	0.00888	95.59	89.67
4.068	0.2591	0.6221	0.6491	0.7089	0.00379	0.00992	95.24	88.25
4.06	0.2532	0.6022	0.6395	0.6916	0.00372	0.00972	95.24	88.25
4.085	0.2623	0.6346	0.6666	0.7317	0.00385	0.0101	95.49	88.76
4.067	0.2488	0.5989	0.6286	0.6961	0.00363	0.00936	95.66	89.28
4.048	0.2353	0.5652	0.604	0.6625	0.00341	0.00861	95.83	89.93
4.07	0.2527	0.6084	0.6434	0.7049	0.00373	0.00979	95.49	88.76
4.063	0.2479	0.5986	0.6337	0.6985	0.00367	0.00948	95.49	88.76
4.085	0.2644	0.6404	0.6686	0.7343	0.00387	0.01014	95.43	88.36
4.066	0.251	0.6043	0.6338	0.6987	0.00365	0.00942	95.6	89.09
4.047	0.2375	0.566	0.6059	0.6651	0.00344	0.00867	95.77	89.97
4.07	0.2542	0.6089	0.6435	0.7041	0.00374	0.0099	95.43	88.36
4.062	0.2492	0.6017	0.6335	0.6958	0.00368	0.00966	95.43	88.36
4.084	0.2675	0.6459	0.684	0.7393	0.0039	0.01017	95.33	88.26
4.065	0.2542	0.6126	0.6489	0.7003	0.00369	0.0095	95.51	88.97
4.047	0.2408	0.5758	0.6169	0.6653	0.00347	0.00886	95.68	89.69
4.069	0.2565	0.6133	0.6489	0.7093	0.00377	0.00989	95.33	88.26
4.062	0.251	0.6016	0.6387	0.6921	0.0037	0.00971	95.33	88.26

Table 4

Abstraction Simulations with scaled STW data.
Water quality downstream of Ginge Brook.
1990/1991 data

ABSTRACTION(Ml/day)			TRIB' SCALING				BOD(mg/l)
		% of time					95%ile
rate	constraint	abst' reduced	N'field	Ginge	mean	low	mid
0	0	0	1	1	1.796	3.309	3.488
1200	650	74.77	1	1	1.807	3.337	3.488
1200	650	74.77	0.95	1	1.799	3.318	3.47
1200	650	74.77	0.9	1	1.791	3.303	3.456
1200	650	74.77	0.8	1	1.775	3.265	3.444
1200	650	74.77	1	0.9	1.793	3.313	3.469
1200	650	74.77	1	0.8	1.779	3.297	3.454
1200	650	74.77	1	0.7	1.764	3.285	3.449
1200	550	74.19	1	1	1.812	3.346	3.497
1200	550	74.19	0.95	1	1.804	3.325	3.482
1200	550	74.19	0.9	1	1.796	3.307	3.47
1200	550	74.19	0.8	1	1.78	3.282	3.449
1200	550	74.19	1	0.9	1.797	3.317	3.47
1200	550	74.19	1	0.8	1.782	3.301	3.455
1200	550	74.19	1	0.7	1.767	3.286	3.448
1200	450	73.03	1	1	1.819	3.345	3.515
1200	450	73.03	0.95	1	1.811	3.326	3.502
1200	450	73.03	0.9	1	1.804	3.308	3.486
1200	450	73.03	0.8	1	1.788	3.282	3.451
1200	450	73.03	1	0.9	1.803	3.321	3.474
1200	450	73.03	1	0.8	1.787	3.299	3.454
1200	450	73.03	1	0.7	1.77	3.284	3.45
1000	650	73.03	1	1	1.806	3.329	3.489
1000	650	73.03	0.95	1	1.798	3.313	3.472
1000	650	73.03	0.9	1	1.79	3.304	3.458
1000	650	73.03	0.8	1	1.774	3.262	3.445
1000	650	73.03	1	0.9	1.792	3.314	3.471
1000	650	73.03	1	0.8	1.778	3.298	3.455

			AMMONIA(mg/l)		UN-I-AMMONIA(mg/l)		DO(%sat)	
			95%ile			95%ile		5%ile
upp	mean	low	mid	upp	mean	mid	mean	mid
3.585	0.2212	0.6556	0.7007	0.7465	0.00255	0.00788	94.56	85.93
3.644	0.2308	0.6958	0.7316	0.7929	0.00268	0.00796	94.33	85.92
3.63	0.2265	0.6762	0.714	0.7751	0.00264	0.00777	94.42	86.18
3.609	0.2222	0.6562	0.6913	0.7561	0.0026	0.00766	94.51	86.71
3.567	0.2136	0.61	0.6494	0.7212	0.00252	0.00718	94.68	87.61
3.613	0.2219	0.6719	0.7189	0.7566	0.00257	0.00775	94.33	85.92
3.575	0.213	0.6542	0.6934	0.7257	0.00246	0.00761	94.33	85.92
3.542	0.204	0.6252	0.6667	0.6947	0.00234	0.00727	94.33	85.92
3.65	0.2343	0.6956	0.7359	0.7968	0.00273	0.0081	94.28	85.97
3.642	0.23	0.6775	0.7203	0.7806	0.00269	0.00795	94.36	86.23
3.629	0.2257	0.6584	0.6965	0.7659	0.00265	0.00777	94.45	86.73
3.587	0.2172	0.6184	0.6616	0.7333	0.00257	0.00747	94.62	87.62
3.627	0.225	0.6717	0.7244	0.7643	0.00261	0.00775	94.28	85.97
3.585	0.2157	0.6568	0.7007	0.7322	0.00249	0.00763	94.28	85.97
3.54	0.2064	0.6273	0.6685	0.6999	0.00237	0.00731	94.28	85.97
3.649	0.2399	0.6994	0.7464	0.8134	0.0028	0.00817	94.16	85.92
3.645	0.2357	0.6843	0.7277	0.7992	0.00276	0.00802	94.25	86.14
3.639	0.2315	0.661	0.7099	0.7842	0.00272	0.0079	94.34	86.71
3.611	0.223	0.6209	0.674	0.7433	0.00265	0.00767	94.51	87.66
3.639	0.23	0.6788	0.7298	0.7771	0.00268	0.00797	94.16	85.92
3.599	0.2201	0.6664	0.7059	0.7415	0.00255	0.00768	94.16	85.92
3.541	0.2101	0.6298	0.6683	0.7145	0.00242	0.00733	94.16	85.92
3.645	0.2297	0.6844	0.7274	0.7826	0.00267	0.00794	94.36	85.92
3.632	0.2254	0.6678	0.7041	0.7678	0.00263	0.00775	94.45	86.2
3.611	0.2211	0.6457	0.6804	0.7535	0.00259	0.00762	94.54	86.71
3.568	0.2125	0.6103	0.6394	0.7173	0.00251	0.00713	94.71	87.61
3.613	0.2209	0.6635	0.7141	0.7519	0.00255	0.00772	94.36	85.92
3.576	0.2121	0.6513	0.6817	0.7199	0.00244	0.00752	94.36	85.92

Table 4 ctd.

ABSTRACTION(Ml/day)			TRIB' SCALING				BOD(mg/l)
		% of time					95%ile
rate	constraint	abst' reduced	N'field	Ginge	mean	low	mid
1000	550	71.53	1	1	1.81	3.334	3.498
1000	550	71.53	0.95	1	1.802	3.312	3.483
1000	550	71.53	0.9	1	1.794	3.303	3.471
1000	550	71.53	0.8	1	1.778	3.267	3.45
1000	550	71.53	1	0.9	1.796	3.319	3.471
1000	550	71.53	1	0.8	1.781	3.303	3.456
1000	550	71.53	1	0.7	1.766	3.287	3.45
1000	450	70.49	1	1	1.817	3.345	3.508
1000	450	70.49	0.95	1	1.81	3.324	3.497
1000	450	70.49	0.9	1	1.802	3.306	3.487
1000	450	70.49	0.8	1	1.786	3.277	3.453
1000	450	70.49	1	0.9	1.802	3.322	3.474
1000	450	70.49	1	0.8	1.786	3.301	3.456
1000	450	70.49	1	0.7	1.77	3.286	3.452
800	650	70.49	1	1	1.805	3.33	3.491
800	650	70.49	0.95	1	1.797	3.314	3.473
800	650	70.49	0.9	1	1.789	3.305	3.459
800	650	70.49	0.8	1	1.773	3.264	3.446
800	650	70.49	1	0.9	1.791	3.316	3.472
800	650	70.49	1	0.8	1.778	3.299	3.457
800	650	70.49	1	0.7	1.764	3.288	3.452
800	550	68.63	1	1	1.809	3.336	3.499
800	550	68.63	0.95	1	1.801	3.314	3.483
800	550	68.63	0.9	1	1.793	3.304	3.469
800	550	68.63	0.8	1	1.777	3.268	3.445
800	550	68.63	1	0.9	1.794	3.321	3.472
800	550	68.63	1	0.8	1.78	3.305	3.458
800	550	68.63	1	0.7	1.766	3.289	3.452

2.13

0

			AMMONIA(mg/l)		UN-I-AMMONIA(mg/l)		DO(%sat)	
			95%ile			95%ile		5%ile
upp	mean	low	mid	upp	mean	mid	mean	mid
3.644	0.2328	0.6859	0.7317	0.7932	0.00271	0.00793	94.31	85.98
3.639	0.2286	0.6716	0.7139	0.7753	0.00267	0.00776	94.4	86.23
3.629	0.2243	0.6567	0.6899	0.7563	0.00263	0.00765	94.48	86.73
3.589	0.2157	0.6184	0.6461	0.7295	0.00255	0.00728	94.66	87.62
3.627	0.2237	0.6667	0.721	0.7617	0.00259	0.00772	94.31	85.98
3.586	0.2146	0.6519	0.6979	0.7294	0.00248	0.00759	94.31	85.98
3.542	0.2055	0.6251	0.6669	0.6993	0.00236	0.00727	94.31	85.98
3.643	0.2381	0.6881	0.7398	0.812	0.00278	0.00814	94.21	85.92
3.638	0.2339	0.6724	0.7203	0.7952	0.00274	0.00795	94.3	86.14
3.631	0.2296	0.6565	0.7046	0.7765	0.0027	0.00779	94.38	86.71
3.606	0.2212	0.6228	0.6604	0.7378	0.00262	0.00755	94.56	87.66
3.633	0.2284	0.6735	0.729	0.7746	0.00265	0.00779	94.21	85.92
3.598	0.2187	0.6516	0.7057	0.7351	0.00253	0.00766	94.21	85.92
3.543	0.209	0.6249	0.6667	0.7097	0.00241	0.00735	94.21	85.92
3.636	0.2285	0.6788	0.7244	0.783	0.00265	0.00794	94.39	85.92
3.625	0.2241	0.6553	0.7019	0.7584	0.00261	0.00773	94.48	86.21
3.611	0.2198	0.6314	0.6791	0.7381	0.00257	0.00755	94.57	86.72
3.57	0.2112	0.6044	0.6396	0.7072	0.00249	0.00711	94.74	87.62
3.61	0.2198	0.6639	0.7048	0.7522	0.00254	0.00772	94.39	85.92
3.575	0.2112	0.6517	0.6808	0.72	0.00243	0.00753	94.39	85.92
3.545	0.2026	0.6191	0.6523	0.6932	0.00232	0.00718	94.39	85.92
3.635	0.2313	0.6783	0.7299	0.7936	0.00269	0.00794	94.35	85.98
3.626	0.227	0.6554	0.7093	0.7758	0.00265	0.00777	94.43	86.24
3.613	0.2227	0.6325	0.6862	0.7567	0.00261	0.00762	94.52	86.73
3.576	0.2141	0.6042	0.6465	0.7186	0.00253	0.00722	94.69	87.62
3.612	0.2224	0.6667	0.7138	0.7622	0.00258	0.00773	94.35	85.98
3.576	0.2135	0.6522	0.6904	0.7297	0.00246	0.00759	94.35	85.98
3.544	0.2045	0.619	0.6608	0.6997	0.00235	0.00728	94.35	85.98

Table 5.

Summary of effluent quality modifications
required to compensate for various abstraction scenarios,
using 1984/89 data.

Oxford effluent

Abstraction (ML/day)	Flow constraint ML/day	Scaling factor to compensate for abstraction. BOD mean	95%ile	Equivalent 95%ile BOD low	mid	Scaling factor to compensate for abstraction. Ammonia mean	95%ile	Equivalent 95%ile Ammonia low	mid
0	0	1	1	37.19	45.02			19.21	19.69
1200	650	0.85	*	31.61	38.27	0.9	0.95	17.29	17.72
1200	550	0.8	0.95	29.75	36.02	0.9	0.95	17.29	17.72
1200	450	0.8	0.95	29.75	36.02	0.85	0.9	16.33	16.74
1000	650	0.9	*	33.47	40.52	0.9	0.95	17.29	17.72
1000	550	0.85	0.95	31.61	38.27	0.9	0.95	17.29	17.72
1000	450	0.8	0.95	29.75	36.02	0.85	0.9	16.33	16.74
800	650	0.9	*	33.47	40.52	0.9	0.95	17.29	17.72
800	550	0.9	1	33.47	40.52	0.9	0.95	17.29	17.72
800	450	0.85	1	31.61	38.27	0.9	0.9	17.29	17.72

Ginge Brook effluent

Abstraction (ML/day)	Flow constraint ML/day	Scaling factor to compensate for abstraction. BOD mean	95%ile	Scaling factor to compensate for abstraction. Ammonia mean	95%ile
1200	650	0.8	*	0.75	0.9
1200	550	0.75	0.9	0.75	0.9
1200	450	0.7	0.9	0.7	0.8
1000	650	0.8	*	0.8	0.9
1000	550	0.75	0.9	0.75	0.9
1000	450	0.7	0.9	0.7	0.8
800	650	0.8	*	0.8	0.9
800	550	0.8	1	0.8	0.9
800	450	0.7	1	0.75	0.8

Table 6.

Table 6.

Summary of effluent quality modifications required to compensate for various abstraction scenarios, using actual 1990/1991 data

Oxford effluent

Abstraction (ML/day)	Flow constraint ML/day	Scaling factor to compensate for abstraction. BOD mean	Scaling factor to compensate for abstraction. BOD 95%ile	Equivalent 95%ile BOD low	Equivalent 95%ile BOD mid	Scaling factor to compensate for abstraction. Ammonia mean	Scaling factor to compensate for abstraction. Ammonia 95%ile	Equivalent 95%ile Ammonia low	Equivalent 95%ile Ammonia mid
0	0	1	1	21.76	24.66			15.90	17.24
1200	650	0.9	1	19.58	22.19	0.9	0.9	14.31	15.52
1200	550	0.9	0.95	19.58	22.19	0.85	0.9	13.52	14.65
1200	450	0.8	0.9	17.41	19.73	0.8	0.8	12.72	13.79
1000	650	0.95	1	20.67	23.43	0.9	0.9	14.31	15.52
1000	550	0.9	0.95	19.58	22.19	0.85	0.9	13.52	14.65
1000	450	0.85	0.9	18.50	20.96	0.8	0.9	12.72	13.79
800	650	0.95	1	20.67	23.43	0.9	0.95	14.31	15.52
800	550	0.9	0.95	19.58	22.19	0.9	0.95	14.31	15.52
800	450	0.9	0.9	19.58	22.19	0.85	0.9	13.52	14.65

Ginge Brook effluent

Abstraction (ML/day)	Flow constraint ML/day	Scaling factor to compensate for abstraction. BOD mean	Scaling factor to compensate for abstraction. BOD 95%ile	Scaling factor to compensate for abstraction. Ammonia mean	Scaling factor to compensate for abstraction. Ammonia 95%ile
1200	650	0.9	1	0.9	0.8
1200	550	0.9	0.95	0.85	0.8
1200	450	0.8	0.9	0.8	0.75
1000	650	0.9	1	0.9	0.85
1000	550	0.9	0.95	0.9	0.8
1000	450	0.9	0.9	0.8	0.8
800	650	0.9	1	0.9	0.9
800	550	0.9	0.95	0.9	0.85
800	450	0.9	0.9	0.85	0.8

Table 7.

Scaling factors for Oxford STW to simulate works operating at consent limit.

1984/89 data

	consent	Northfield Bk %ile in Tomcat	Inferred at Oxford STW	Scaling factor
BOD	75	24.36	45.03	1.67
ammonia	20	16.05	19.69	1.02

1990/91 data

	consent	Northfield Bk %ile in Tomcat	Inferred at Oxford STW	Scaling factor
BOD	75	13.34	24.66	3.04
ammonia	20	14.05	17.23	1.16

All figures are 95%iles and and are given in mg/l.

Table 8.

Abstraction Simulations with scaled STW data.
Water Quality downstream of Ginge Brook.
1984/1989 data

ABSTRACTION(Ml/day)			TRIB' SCALING				BOD(mg/l)
		% of time					95%ile
rate	constraint	abst' reduced	N'field	Ginge	mean	low	mid
0	0	0	1	1	2.096	3.542	3.788
1200	650	60.19	1	1	2.118	3.535	3.794
1200	650	60.19	0.9	1	2.089	3.511	3.737
1200	650	60.19	0.8	1	2.059	3.495	3.657
1200	650	60.19	1	0.8	2.097	3.528	3.769
1200	650	60.19	1	0.7	2.086	3.523	3.756
1200	550	58.68	1	1	2.125	3.541	3.796
1200	550	58.68	0.9	1	2.095	3.51	3.737
1200	550	58.68	0.8	1	2.066	3.494	3.66
1200	550	58.68	1	0.8	2.101	3.529	3.768
1200	550	58.68	1	0.7	2.09	3.522	3.754
1200	450	55.9	1	1	2.135	3.551	3.799
1200	450	55.9	0.9	1	2.106	3.514	3.738
1200	450	55.9	0.8	1	2.076	3.499	3.664
1200	450	55.9	1	0.8	2.109	3.537	3.766
1200	450	55.9	1	0.7	2.096	3.528	3.75
1000	650	55.9	1	1	2.116	3.536	3.794
1000	650	55.9	0.9	1	2.086	3.511	3.731
1000	650	55.9	0.8	1	2.056	3.496	3.656
1000	650	55.9	1	0.8	2.095	3.529	3.77
1000	650	55.9	1	0.7	2.085	3.524	3.755
1000	550	52.55	1	1	2.122	3.543	3.795
1000	550	52.55	0.8	1	2.062	3.495	3.657

			AMMONIA(mg/l)		UN-I-AMMONIA(mg/l)		DO(%sat)	
			95%ile			95%ile		5%ile
upp	mean	low	mid	upp	mean	mid	mean	mid
4.336	0.2563	0.6357	0.6637	0.7285	0.0038	0.01017	95.68	88.65
4.316	0.2682	0.6454	0.6737	0.7432	0.00393	0.01023	95.3	88.59
4.21	0.2544	0.6079	0.6374	0.7075	0.00371	0.00955	95.48	89.16
4.141	0.2407	0.577	0.6084	0.6738	0.00348	0.00872	95.66	89.71
4.302	0.2577	0.6176	0.6515	0.7146	0.0038	0.00991	95.3	88.59
4.295	0.2525	0.6049	0.6412	0.7082	0.00373	0.0096	95.3	88.59
4.309	0.2714	0.6474	0.6744	0.744	0.00396	0.01027	95.2	88.23
4.208	0.2578	0.6122	0.6397	0.7073	0.00374	0.00955	95.38	88.86
4.14	0.2442	0.5788	0.6108	0.6742	0.00352	0.00898	95.56	89.47
4.295	0.2601	0.6186	0.6513	0.7127	0.00382	0.00999	95.2	88.23
4.287	0.2545	0.6084	0.641	0.7052	0.00375	0.00979	95.2	88.23
4.301	0.2764	0.6536	0.694	0.7491	0.00402	0.01032	95.07	87.85
4.207	0.2629	0.6277	0.6557	0.7082	0.0038	0.00976	95.26	88.66
4.139	0.2495	0.5961	0.6236	0.6766	0.00358	0.00905	95.44	89.48
4.284	0.2639	0.6287	0.655	0.7156	0.00386	0.01007	95.07	87.85
4.272	0.2576	0.6082	0.6449	0.7011	0.00378	0.00984	95.07	87.85
4.318	0.2669	0.6428	0.6719	0.7414	0.00391	0.01024	95.34	88.6
4.21	0.2531	0.6058	0.6377	0.7053	0.00369	0.00949	95.52	89.17
4.142	0.2393	0.5711	0.6072	0.6707	0.00347	0.00873	95.7	89.71
4.304	0.2568	0.6151	0.6503	0.7151	0.00379	0.00992	95.34	88.6
4.298	0.2518	0.605	0.6413	0.7087	0.00372	0.00961	95.34	88.6
4.312	0.2695	0.647	0.6745	0.7445	0.00394	0.01027	95.26	88.21
4.141	0.2422	0.5761	0.6087	0.6706	0.0035	0.00893	95.62	89.48

Table 8 ctd.

ABSTRACTION(Ml/day)			TRIB' SCALING			BOD(mg/l)	
		% of time				95%ile	
rate	constraint	abst' reduced	N'field	Ginge	mean	low	mid
1000	450	49.19	1	1	2.13	3.552	3.794
1000	450	49.19	0.9	1	2.1	3.509	3.731
1000	450	49.19	0.8	1	2.071	3.494	3.656
1000	450	49.19	1	0.8	2.106	3.538	3.768
1000	450	49.19	1	0.7	2.093	3.53	3.753
800	650	49.19	1	1	2.113	3.537	3.792
800	650	49.19	0.9	1	2.083	3.512	3.727
800	650	49.19	0.8	1	2.053	3.497	3.651
800	650	49.19	1	0.8	2.093	3.53	3.771
800	650	49.19	1	0.7	2.083	3.526	3.754
800	550	45.83	1	1	2.117	3.537	3.791
800	550	45.83	0.9	1	2.087	3.511	3.727
800	550	45.83	0.8	1	2.057	3.496	3.651
800	550	45.83	1	0.8	2.096	3.529	3.77
800	550	45.83	1	0.7	2.086	3.525	3.753
800	450	42.94	1	1	2.124	3.536	3.791
800	450	42.94	0.9	1	2.094	3.51	3.726
800	450	42.94	0.8	1	2.064	3.495	3.65
800	450	42.94	1	0.8	2.101	3.529	3.77
800	450	42.94	1	0.7	2.09	3.524	3.752

			AMMONIA(mg/l)		UN-I-AMMONIA(mg/l)		DO(%sat)	
			95%ile			95%ile		5%ile
upp	mean	low	mid	upp	mean	mid	mean	mid
4.304	0.2735	0.6527	0.694	0.7483	0.00398	0.01038	95.14	87.93
4.208	0.26	0.6179	0.6558	0.7076	0.00377	0.00962	95.33	88.76
4.14	0.2465	0.5835	0.6242	0.6714	0.00355	0.00901	95.51	89.49
4.287	0.2617	0.6292	0.6551	0.7158	0.00383	0.01008	95.14	87.93
4.275	0.2558	0.6083	0.6439	0.7017	0.00376	0.00987	95.14	87.93
4.32	0.265	0.6429	0.6705	0.7411	0.0039	0.01025	95.39	88.61
4.21	0.2512	0.6062	0.6381	0.7023	0.00367	0.0095	95.57	89.18
4.143	0.2374	0.5695	0.6067	0.6679	0.00345	0.00873	95.75	89.72
4.307	0.2554	0.6141	0.649	0.7151	0.00377	0.00993	95.39	88.61
4.3	0.2506	0.6052	0.6416	0.7092	0.00371	0.00962	95.39	88.61
4.314	0.2671	0.6461	0.6746	0.7426	0.00392	0.01029	95.33	88.21
4.21	0.2534	0.6124	0.6406	0.7048	0.00369	0.00956	95.51	88.87
4.142	0.2397	0.5715	0.609	0.6709	0.00347	0.00878	95.69	89.72
4.3	0.2569	0.6146	0.6493	0.713	0.00379	0.01005	95.33	88.21
4.293	0.2518	0.6074	0.6414	0.7063	0.00372	0.0098	95.33	88.21
4.306	0.2702	0.651	0.6912	0.7475	0.00395	0.01033	95.23	87.93
4.209	0.2566	0.617	0.6542	0.7072	0.00373	0.00962	95.42	88.77
4.142	0.243	0.5807	0.6223	0.6711	0.00351	0.00896	95.6	89.5
4.29	0.2592	0.6192	0.655	0.7156	0.00381	0.01004	95.23	87.93
4.278	0.2537	0.6073	0.6433	0.7023	0.00374	0.00986	95.23	87.93

Table 9.

Abstraction Simulations with scaled STW data.
Water quality downstream of Ginge Brook
1990/91 data

ABSTRACTION(Ml/day)			TRIB' SCALING		BOD(mg/l)		
		% of time					95%ile
rate	constraint	abst' reduced	N'field	Ginge	mean	low	mid
			1	1	2.127	3.866	3.987
1200	650	74.77	1	1	2.133	3.873	4.01
1200	650	74.77	0.95	1	2.109	3.813	3.981
1200	650	74.77	0.9	1	2.085	3.77	3.955
1200	650	74.77	0.8	1	2.036	3.679	3.848
1200	650	74.77	0.7	1	1.988	3.594	3.751
1200	650	74.77	1	0.9	2.119	3.845	3.992
1200	650	74.77	1	0.8	2.105	3.83	3.972
1200	650	74.77	1	0.7	2.09	3.809	3.946
1200	550	74.19	1	1	2.136	3.871	4.016
1200	550	74.19	0.95	1	2.112	3.814	3.991
1200	550	74.19	0.9	1	2.088	3.77	3.961
1200	550	74.19	0.8	1	2.039	3.681	3.855
1200	550	74.19	0.7	1	1.991	3.597	3.753
1200	550	74.19	1	0.9	2.121	3.835	3.991
1200	550	74.19	1	0.8	2.106	3.822	3.971
1200	550	74.19	1	0.7	2.091	3.805	3.937
1200	450	73.03	1	1	2.141	3.891	4.028
1200	450	73.03	0.95	1	2.117	3.824	4
1200	450	73.03	0.9	1	2.093	3.782	3.956
1200	450	73.03	0.8	1	2.045	3.7	3.854
1200	450	73.03	0.7	1	1.997	3.621	3.759
1200	450	73.03	1	0.9	2.125	3.855	3.99
1200	450	73.03	1	0.8	2.108	3.818	3.961
1200	450	73.03	1	0.7	2.092	3.794	3.935

			AMMONIA(mg/l)		UN-I-AMMONIA(mg/l)		DO(%sat)	
			95%ile			95%ile		5%ile
upp	mean	low	mid	upp	mean	mid	mean	mid
4.228	0.2352	0.704	0.7598	0.8172	0.00268	0.00853	94.03	84.24
4.232	0.2445	0.7466	0.7904	0.843	0.0028	0.0087	93.79	84.2
4.174	0.2396	0.7296	0.7679	0.8253	0.00276	0.00846	93.92	84.73
4.108	0.2346	0.7115	0.7503	0.8045	0.00271	0.0082	94.03	85.23
3.991	0.2246	0.6675	0.7044	0.7667	0.00262	0.00773	94.26	86.11
3.899	0.2146	0.6143	0.6547	0.724	0.00253	0.00725	94.49	87.23
4.211	0.2356	0.7345	0.7606	0.8122	0.00269	0.00849	93.79	84.2
4.197	0.2267	0.7078	0.7315	0.7894	0.00258	0.00814	93.79	84.2
4.167	0.2178	0.6809	0.7153	0.7644	0.00247	0.00765	93.79	84.2
4.237	0.248	0.7456	0.805	0.8582	0.00285	0.0087	93.73	84.27
4.178	0.243	0.7293	0.7775	0.8318	0.0028	0.00846	93.86	84.81
4.112	0.238	0.7075	0.7537	0.8076	0.00276	0.00823	93.97	85.27
3.997	0.2281	0.6684	0.7099	0.7742	0.00267	0.00785	94.2	86.15
3.902	0.2182	0.6234	0.6662	0.7381	0.00258	0.00751	94.43	87.3
4.212	0.2387	0.7351	0.7777	0.8257	0.00273	0.00856	93.73	84.27
4.191	0.2294	0.7076	0.7505	0.7926	0.00261	0.00817	93.73	84.27
4.165	0.2201	0.6814	0.719	0.7641	0.0025	0.00765	93.73	84.27
4.231	0.2534	0.7569	0.8143	0.8728	0.00292	0.009	93.62	84.27
4.174	0.2485	0.7338	0.7912	0.8528	0.00288	0.00871	93.74	84.81
4.115	0.2436	0.7138	0.7617	0.8324	0.00283	0.00836	93.86	85.22
4.012	0.2338	0.674	0.718	0.7934	0.00274	0.00798	94.09	86.08
3.921	0.224	0.6248	0.6773	0.7499	0.00266	0.00769	94.32	87.24
4.209	0.2435	0.7352	0.7812	0.8342	0.0028	0.00864	93.62	84.27
4.181	0.2336	0.7087	0.7536	0.7993	0.00267	0.00825	93.62	84.27
4.159	0.2237	0.6839	0.7272	0.7774	0.00255	0.00773	93.62	84.27

Table 9 ctd.

ABSTRACTION(Ml/day)			TRIB' SCALING		BOD(mg/l) 95%ile		
rate	constraint	% of time abst' reduced	N'field	Ginge	mean	low	mid
1000	650	73.03	1	1	2.132	3.875	4.007
1000	650	73.03	0.95	1	2.108	3.815	3.981
1000	650	73.03	0.9	1	2.084	3.771	3.932
1000	650	73.03	0.8	1	2.035	3.68	3.843
1000	650	73.03	0.7	1	1.987	3.589	3.75
1000	650	73.03	1	0.9	2.118	3.847	3.986
1000	650	73.03	1	0.8	2.105	3.832	3.973
1000	650	73.03	1	0.7	2.091	3.811	3.941
1000	550	71.53	1	1	2.135	3.865	4.016
1000	550	71.53	0.95	1	2.111	3.816	3.982
1000	550	71.53	0.9	1	2.087	3.772	3.931
1000	550	71.53	0.8	1	2.038	3.683	3.843
1000	550	71.53	1	0.9	2.121	3.837	3.985
1000	550	71.53	1	0.8	2.106	3.824	3.972
1000	450	70.49	1	1	2.14	3.866	4.018
1000	450	70.49	0.95	1	2.116	3.817	3.981
1000	450	70.49	0.9	1	2.092	3.784	3.93
1000	450	70.49	0.8	1	2.043	3.699	3.839
1000	450	70.49	0.7	1	1.996	3.619	3.761
1000	450	70.49	1	0.9	2.124	3.838	3.984
1000	450	70.49	1	0.8	2.108	3.82	3.958
1000	450	70.49	1	0.7	2.092	3.796	3.934

			AMMONIA(mg/l)		UN-I-AMMONIA(mg/l)		DO(%sat)	
			95%ile			95%ile		5%ile
upp	mean	low	mid	upp	mean	mid	mean	mid
4.234	0.2434	0.7421	0.7899	0.8373	0.00279	0.00863	93.82	84.2
4.176	0.2384	0.7207	0.7633	0.8158	0.00274	0.0084	93.94	84.73
4.11	0.2334	0.6992	0.7439	0.8033	0.0027	0.00813	94.06	85.24
3.993	0.2235	0.6585	0.6929	0.7615	0.00261	0.00768	94.29	86.12
3.895	0.2135	0.6146	0.6455	0.7223	0.00252	0.00719	94.51	87.23
4.213	0.2347	0.7193	0.7611	0.8098	0.00268	0.00839	93.82	84.2
4.199	0.2259	0.7034	0.7319	0.789	0.00257	0.00812	93.82	84.2
4.169	0.2171	0.6719	0.7148	0.7647	0.00246	0.00765	93.82	84.2
4.239	0.2465	0.7441	0.8054	0.8534	0.00283	0.00866	93.77	84.28
4.18	0.2416	0.72	0.7773	0.8305	0.00279	0.00841	93.89	84.82
4.114	0.2366	0.7003	0.7495	0.8058	0.00274	0.00813	94.01	85.28
3.999	0.2267	0.6656	0.704	0.767	0.00265	0.00771	94.23	86.16
4.214	0.2374	0.7191	0.7776	0.8206	0.00272	0.0085	93.77	84.28
4.193	0.2283	0.7032	0.7443	0.7918	0.0026	0.00817	93.77	84.28
4.231	0.2517	0.7459	0.8128	0.8662	0.0029	0.00884	93.66	84.27
4.175	0.2468	0.7287	0.7917	0.8512	0.00286	0.00849	93.79	84.82
4.117	0.2418	0.7062	0.7622	0.8304	0.00281	0.00826	93.91	85.23
4.013	0.232	0.6668	0.712	0.787	0.00272	0.00785	94.13	86.08
3.92	0.2222	0.6255	0.6649	0.7432	0.00263	0.0076	94.36	87.24
4.211	0.242	0.7189	0.7801	0.8321	0.00278	0.00865	93.66	84.27
4.184	0.2323	0.7012	0.746	0.7998	0.00265	0.0083	93.66	84.27
4.161	0.2226	0.676	0.7247	0.7779	0.00253	0.00776	93.66	84.27

Table 9 ctd.

ABSTRACTION(Ml/day)			TRIB' SCALING				BOD(mg/l)
		% of time					95%ile
rate	constraint	abst' reduced	N'field	Ginge	mean	low	mid
800	650	70.49	1	1	2.132	3.863	4.006
800	650	70.49	0.95	1	2.107	3.817	3.965
800	650	70.49	0.9	1	2.083	3.773	3.927
800	650	70.49	0.8	1	2.034	3.676	3.845
800	650	70.49	0.7	1	1.986	3.584	3.752
800	650	70.49	1	0.9	2.118	3.848	3.986
800	650	70.49	1	0.8	2.104	3.833	3.972
800	650	70.49	1	0.7	2.091	3.813	3.94
800	550	68.63	1	1	2.134	3.863	4.006
800	550	68.63	0.95	1	2.11	3.818	3.965
800	550	68.63	0.9	1	2.086	3.773	3.926
800	550	68.63	0.8	1	2.037	3.676	3.845
800	550	68.63	0.7	1	1.989	3.584	3.754
800	550	68.63	1	0.9	2.12	3.839	3.985
800	550	68.63	1	0.8	2.106	3.827	3.971
800	550	68.63	1	0.7	2.091	3.809	3.934
800	450	67.01	1	1	2.138	3.858	4.006
800	450	67.01	0.95	1	2.114	3.824	3.964
800	450	67.01	0.9	1	2.09	3.783	3.925
800	450	67.01	0.8	1	2.042	3.69	3.841
800	450	67.01	0.7	1	1.994	3.612	3.762
800	450	67.01	1	0.9	2.123	3.842	3.984
800	450	67.01	1	0.8	2.108	3.826	3.959
800	450	67.01	1	0.7	2.093	3.801	3.933

			AMMONIA(mg/l)		UN-I-AMMONIA(mg/l)		DO(%sat)	
			95%ile			95%ile		5%ile
upp	mean	low	mid	upp	mean	mid	mean	mid
4.234	0.2423	0.7329	0.7763	0.8375	0.00278	0.00863	93.85	84.2
4.177	0.2373	0.7168	0.7595	0.8163	0.00273	0.00841	93.98	84.74
4.112	0.2323	0.6972	0.7409	0.8037	0.00268	0.00814	94.09	85.24
3.994	0.2222	0.6448	0.6907	0.7495	0.00259	0.00765	94.32	86.12
3.897	0.2122	0.6072	0.6459	0.7109	0.0025	0.00716	94.55	87.23
4.215	0.2336	0.7104	0.7589	0.8102	0.00267	0.00839	93.85	84.2
4.201	0.225	0.6941	0.731	0.7895	0.00256	0.00813	93.85	84.2
4.171	0.2164	0.6691	0.7151	0.7651	0.00245	0.00766	93.85	84.2
4.237	0.2451	0.7333	0.793	0.8472	0.00281	0.00867	93.81	84.28
4.185	0.2401	0.7191	0.7658	0.8296	0.00277	0.00842	93.93	84.82
4.119	0.2351	0.6964	0.7445	0.8063	0.00272	0.00813	94.05	85.29
4	0.2251	0.6453	0.6988	0.7674	0.00263	0.0077	94.27	86.16
3.906	0.2152	0.6071	0.6517	0.7232	0.00254	0.00727	94.5	87.3
4.215	0.2361	0.7103	0.7727	0.8199	0.0027	0.0085	93.81	84.28
4.195	0.2272	0.6924	0.7359	0.7922	0.00259	0.00817	93.81	84.28
4.169	0.2183	0.6689	0.7158	0.7649	0.00247	0.00765	93.81	84.28
4.236	0.2496	0.7333	0.8059	0.8554	0.00287	0.00876	93.71	84.28
4.187	0.2447	0.722	0.7869	0.8325	0.00283	0.00847	93.83	84.82
4.125	0.2398	0.7054	0.7581	0.8086	0.00279	0.00827	93.95	85.24
4.014	0.2299	0.6574	0.7093	0.7763	0.0027	0.00786	94.18	86.08
3.919	0.22	0.614	0.6646	0.7374	0.00261	0.0076	94.41	87.24
4.223	0.2402	0.7099	0.7775	0.8288	0.00275	0.00863	93.71	84.28
4.187	0.2307	0.6929	0.7437	0.8001	0.00264	0.00826	93.71	84.28
4.168	0.2213	0.6709	0.7252	0.7784	0.00252	0.00772	93.71	84.28

Table 10.

Summary of effluent quality modifications
required to compensate for various abstraction scenarios,
using consent concentration 1984/89 data

Oxford effluent

Abstraction (ML/day)	Flow constraint ML/day	Scaling factor to compensate for abstraction. BOD mean	95%ile	Equivalent 95%ile BOD low	mid	Scaling factor to compensate for abstraction. Ammonia mean	95%ile	Equivalent 95%ile ammonia low	mid
0	0	1	1	62.1	75.2	-	-	19.6	20.1
1200	650	0.9	0.95	55.89	67.68	0.9	0.95	17.64	18.09
1200	550	0.9	0.95	55.89	67.68	0.85	0.95	16.66	17.09
1200	450	0.9	0.95	55.89	67.68	0.85	0.9	16.66	17.09
1000	650	0.9	0.95	55.89	67.68	0.9	0.95	17.64	18.09
1000	550	0.9	0.95	55.89	67.68	0.85	0.95	16.66	17.09
1000	450	0.9	0.95	55.89	67.68	0.85	0.9	16.66	17.09
800	650	0.9	0.95	55.89	67.68	0.9	0.95	17.64	18.09
800	550	0.9	0.95	55.89	67.68	0.9	0.95	17.64	18.09
800	450	0.9	0.95	55.89	67.68	0.9	0.9	17.64	18.09

Ginge Brook effluent

Abstraction (ML/day)	Flow constraint ML/day	Scaling factor to compensate for abstraction. BOD mean	95%ile	Scaling factor to compensate for abstraction. Ammonia mean	95%ile
1200	650	0.8	*	0.75	0.9
1200	550	0.75	0.9	0.75	0.9
1200	450	0.7	0.9	0.7	0.8
1000	650	0.8	*	0.8	0.9
1000	550	0.75	0.9	0.75	0.9
1000	450	0.7	0.9	0.7	0.8
800	650	0.8	*	0.8	0.9
800	550	0.8	1	0.8	0.9
800	450	0.7	1	0.75	0.8

Table 11.

ummary of effluent quality modifications
equired to compensate for various abstraction scenarios,
using consent concentration 1990/1991 data

xford effluent

bstraction (ML/day)	Flow constraint ML/day	Scaling factor to compensate for abstraction. BOD mean	BOD 95%ile	Equivalent 95%ile BOD low	BOD mid	Scaling factor to compensate for abstraction. Ammonia mean	Ammonia 95%ile	Factor to achieve RQO for ammonia	Equivalent 95%ile ammonia low	ammonia mid
0	0	1	1	66.1	75	1	1		18.44	20.0
1200	650	1	0.95	62.80	71.25	0.9	0.925	0.85	15.67	17.0
1200	550	1	0.95	62.80	71.25	0.9	0.9	0.85	15.67	17.0
1200	450	0.975	0.95	62.80	71.25	0.8	0.9	0.85	14.75	16.0
1000	650	1	0.95	62.80	71.25	0.925	0.95	0.90	16.60	18.0
1000	550	1	0.95	62.80	71.25	0.9	0.925	0.85	15.67	17.0
1000	450	0.975	0.95	62.80	71.25	0.85	0.9	0.85	15.67	17.0
800	650	1	0.95	62.80	71.25	0.925	0.95	0.90	16.60	18.0
800	550	1	0.95	62.80	71.25	0.9	0.925	0.90	16.60	18.0
800	450	0.95	0.95	62.80	71.25	0.9	0.9	0.85	15.67	17.0

inge Brook effluent

bstraction (ML/day)	Flow constraint ML/day	Scaling factor to compensate for abstraction. BOD mean	BOD 95%ile	Scaling factor to compensate for abstraction. Ammonia mean	Ammonia 95%ile	
1200	650	1	0.9	0.9	0.9	0.75
1200	550	0.9	0.9	0.9	0.85	0.75
1200	450	0.9	0.85	0.8	0.8	0.75
1000	650	1	0.9	0.9	0.9	0.75
1000	550	0.9	0.9	0.9	0.85	0.75
1000	450	0.9	0.9	0.8	0.8	0.75
800	650	1	0.9	0.9	0.9	0.85
800	550	0.9	0.9	0.9	0.85	0.8
800	450	0.9	0.9	0.85	0.85	0.8

Table 12.
Maximum improvements to consent at Oxford Stw required in order to mitigate the effects of the new abstraction.

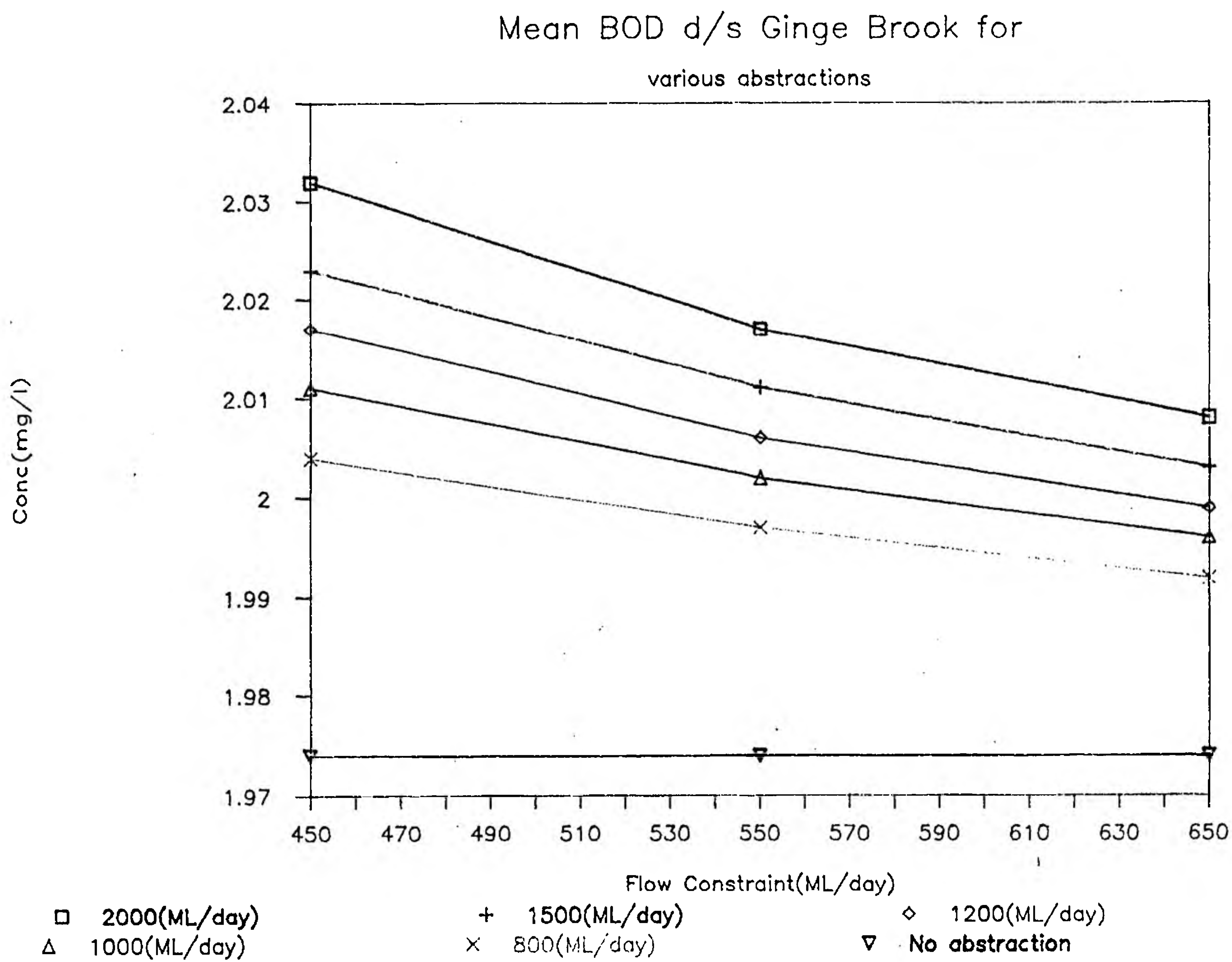
Abstraction (ML/day)	Flow constraint (ML/day)	Consent required BOD(mg/l) low	mid
1200	650	55.89	67.68
1200	550	55.89	67.68
1200	450	52.79	63.92
1000	650	55.89	67.68
1000	550	55.89	67.68
1000	450	55.89	67.68
800	650	55.89	67.68
800	550	55.89	67.68
800	450	55.89	67.68

2.24

Consent required

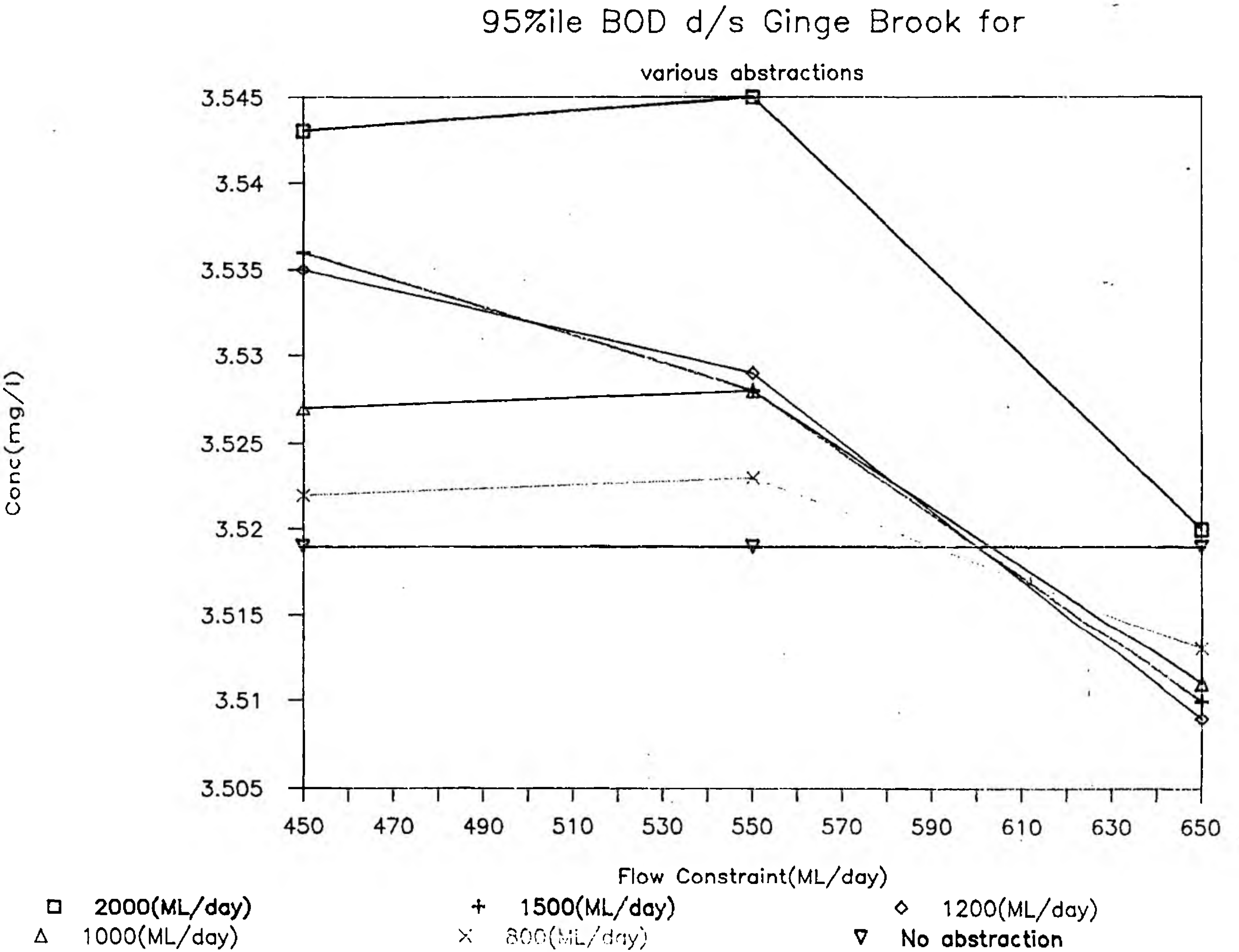
Ammonia(mg/l) low	mid
15.67	17.00
15.67	17.00
14.75	16.00
17.64	18.09
16.66	17.09
16.66	17.09
16.60	18.00
16.60	18.00
15.67	17.00

Fig 1.


Mean BOD d/s Ginge Brook for
various abstractions
Conc (mg/l)
2.04
2.03
2.02
2.01
2
1.99
1.98
1.97
450
470
490
510
530
550
570
590
610
630
650
Flow Constraint(ML/day)
2000(ML/day)
1500(ML/day)
1200(ML/day)
1000(ML/day)
800(ML/day)
No abstraction

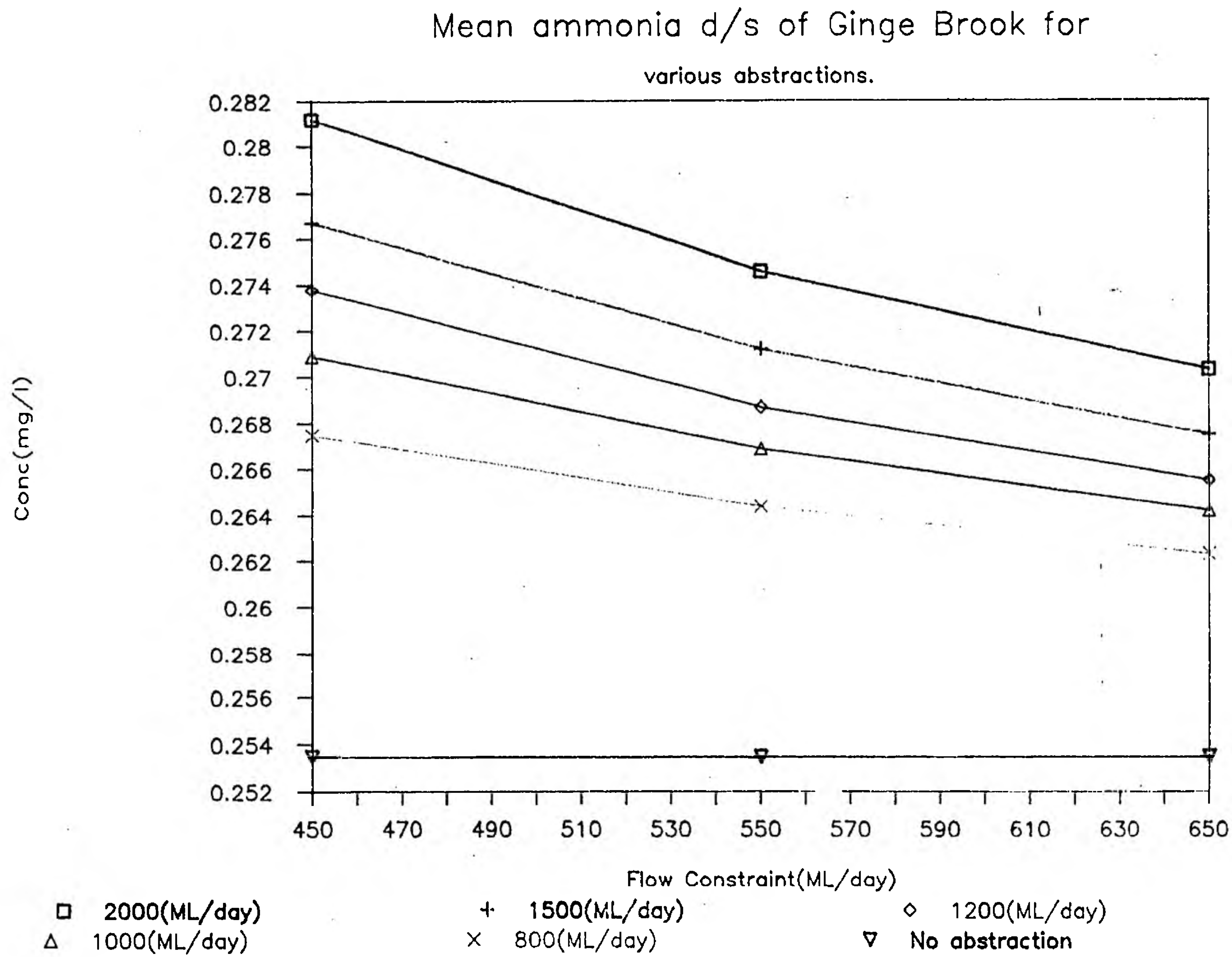
2.25

Fig 2


95%ile BOD d/s Ginge Brook for
various abstractions
Conc(mg/l)
3.545
3.54
3.535
3.53
3.525
3.52
3.515
3.51
3.505
450
470
490
510
530
550
570
590
610
630
650
Flow Constraint(ML/day)
2000(ML/day)
1500(ML/day)
1200(ML/day)
1000(ML/day)
800(ML/day)
No abstraction

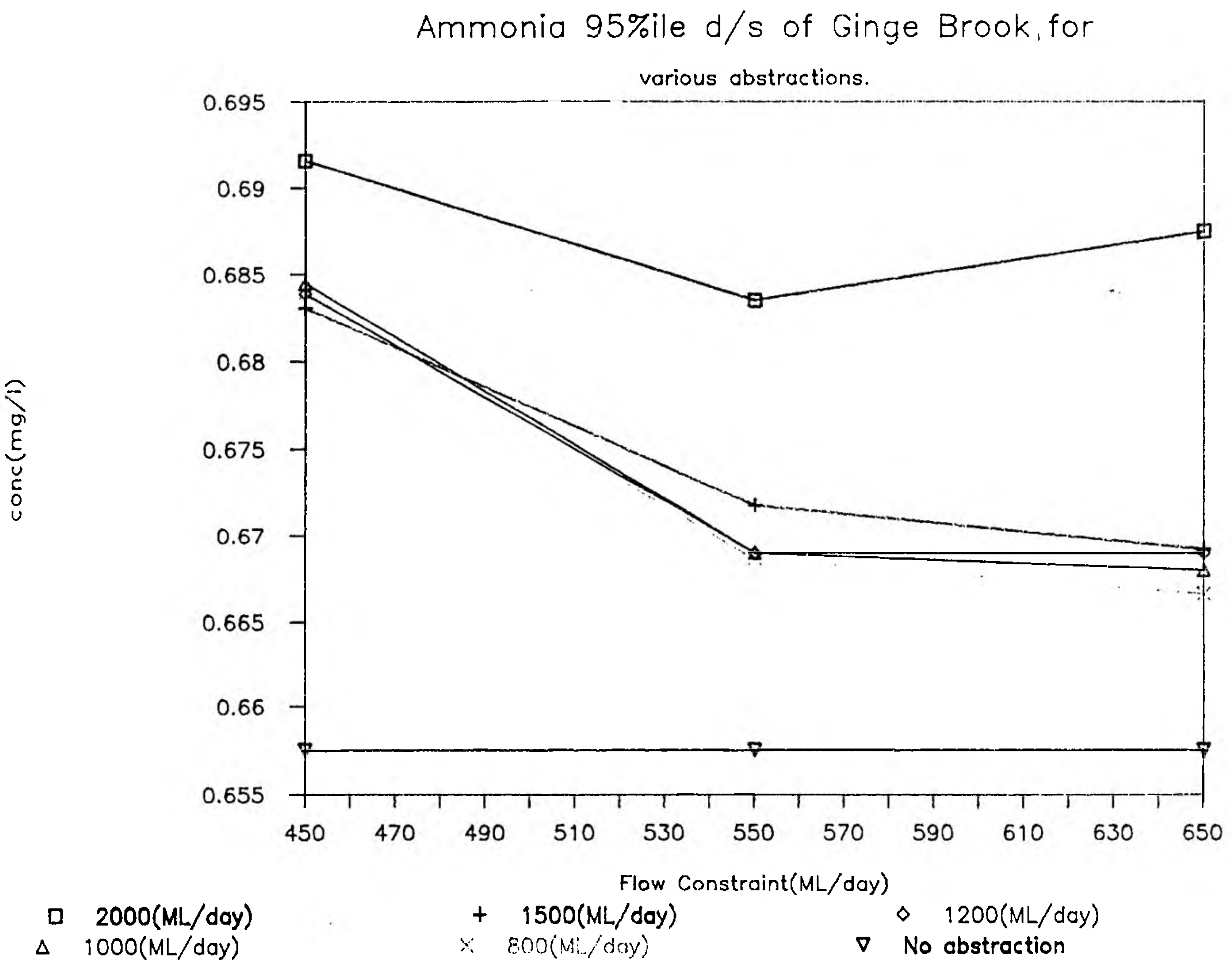
2.26

Fig 3


Mean ammonia d/s of Ginge Brook for
various abstractions.
Conc(mg/l)
0.282
0.28
0.278
0.276
0.274
0.272
0.27
0.268
0.266
0.264
0.262
0.26
0.258
0.256
0.254
0.252
450
470
490
510
530
550
570
590
610
630
650
Flow Constraint(ML/day)
2000(ML/day)
1500(ML/day)
1200(ML/day)
1000(ML/day)
800(ML/day)
No abstraction

2.27

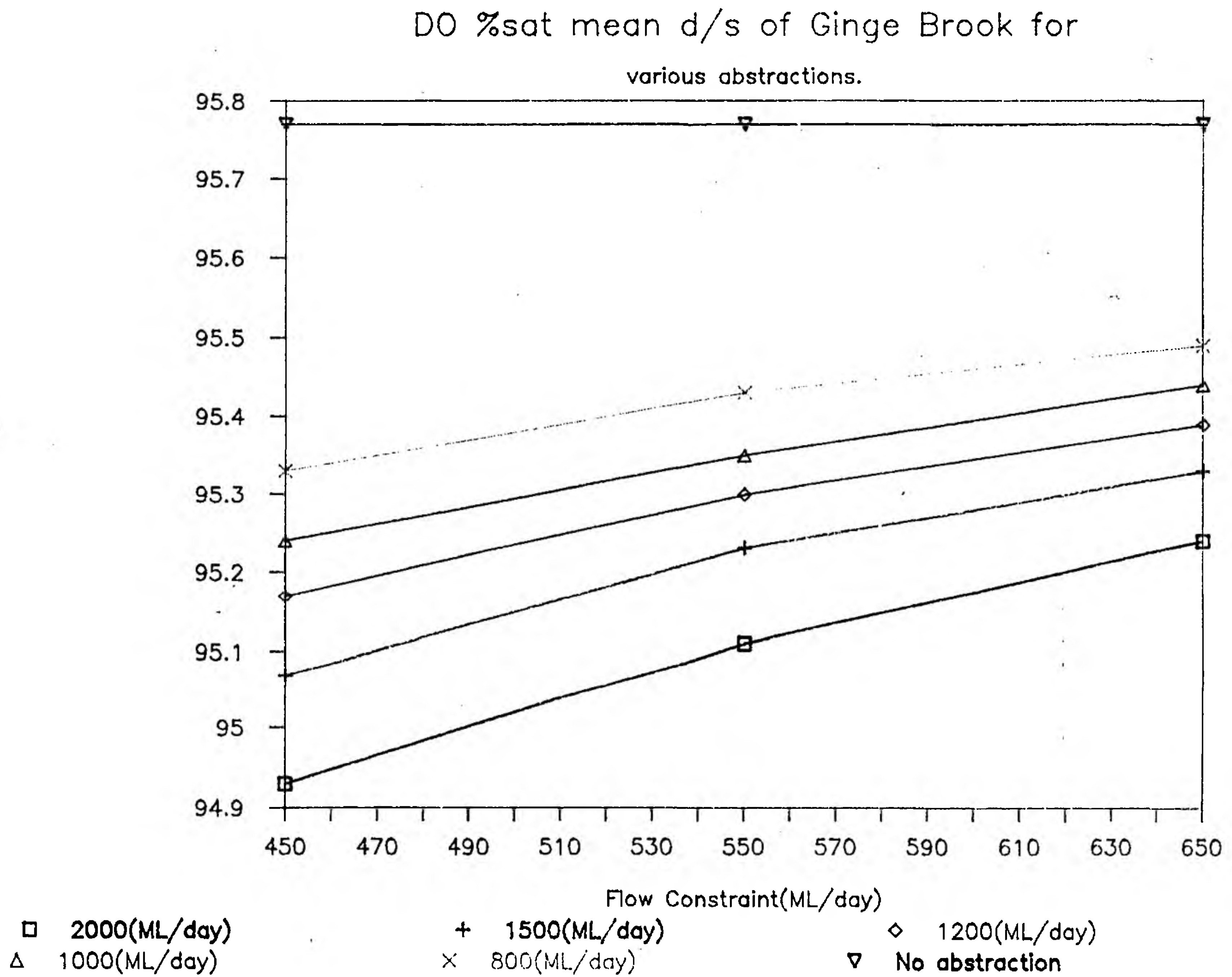
Fig 4



Ammonia 95%ile d/s of Ginge Brook, for
various abstractions.
0.695
0.69
0.685
0.68
0.675
0.67
0.665
0.66
0.655
conc(mg/l)
450
470
490
510
530
550
570
590
610
630
650
Flow Constraint(ML/day)
2000(ML/day)
1500(ML/day)
1200(ML/day)
1000(ML/day)
800(ML/day)
No abstraction

82.2

Fig 5


DO %sat mean d/s of Ginge Brook for
various abstractions.
%sat
95.8
95.7
95.6
95.5
95.4
95.3
95.2
95.1
95
94.9
450
470
490
510
530
550
570
590
610
630
650
Flow Constraint(ML/day)
2000(ML/day)
1500(ML/day)
1200(ML/day)
1000(ML/day)
800(ML/day)
No abstraction

62.9

Fig 6

DO%sat 95%ile d/s of Ginge Brook for

various abstractions.

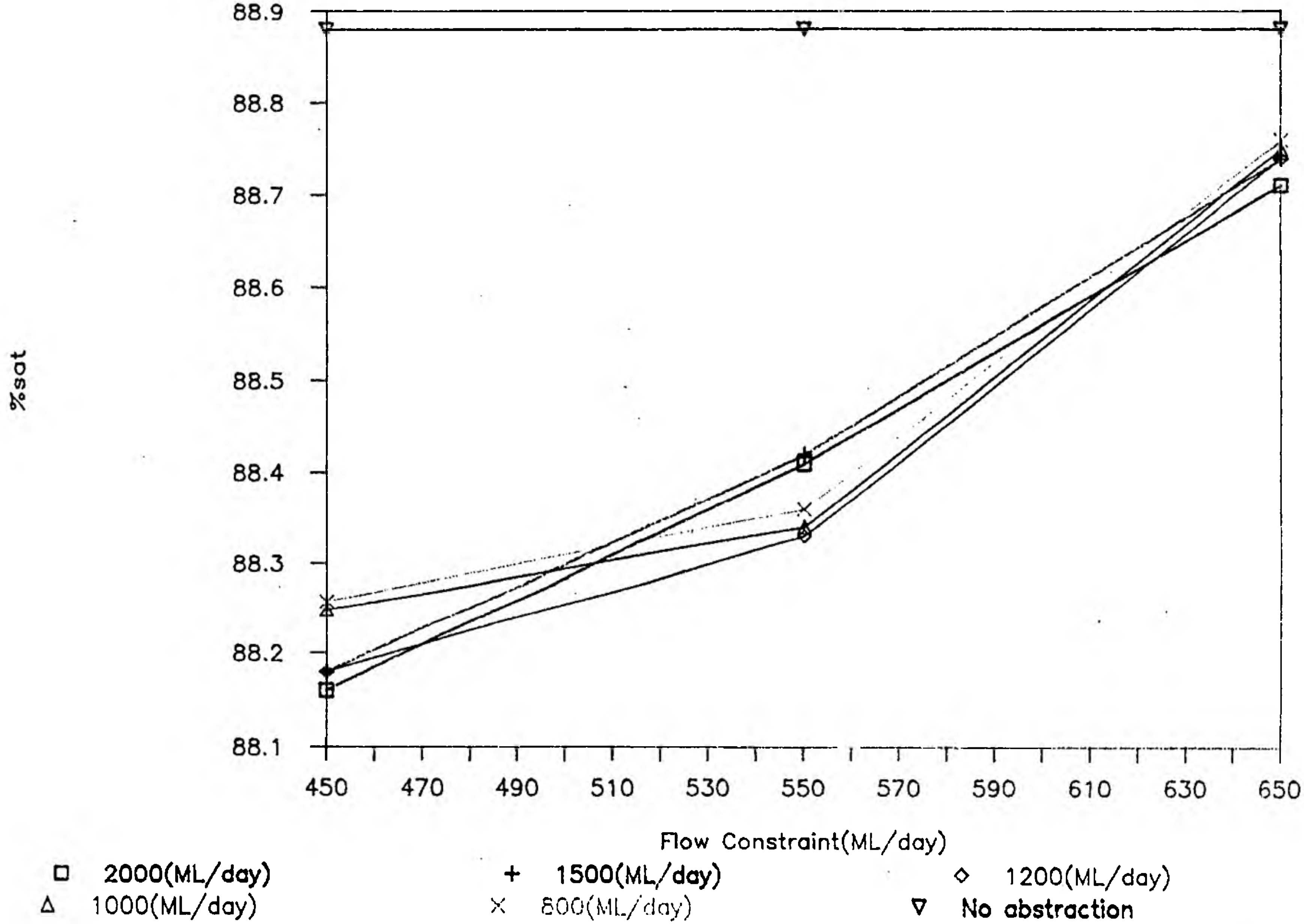
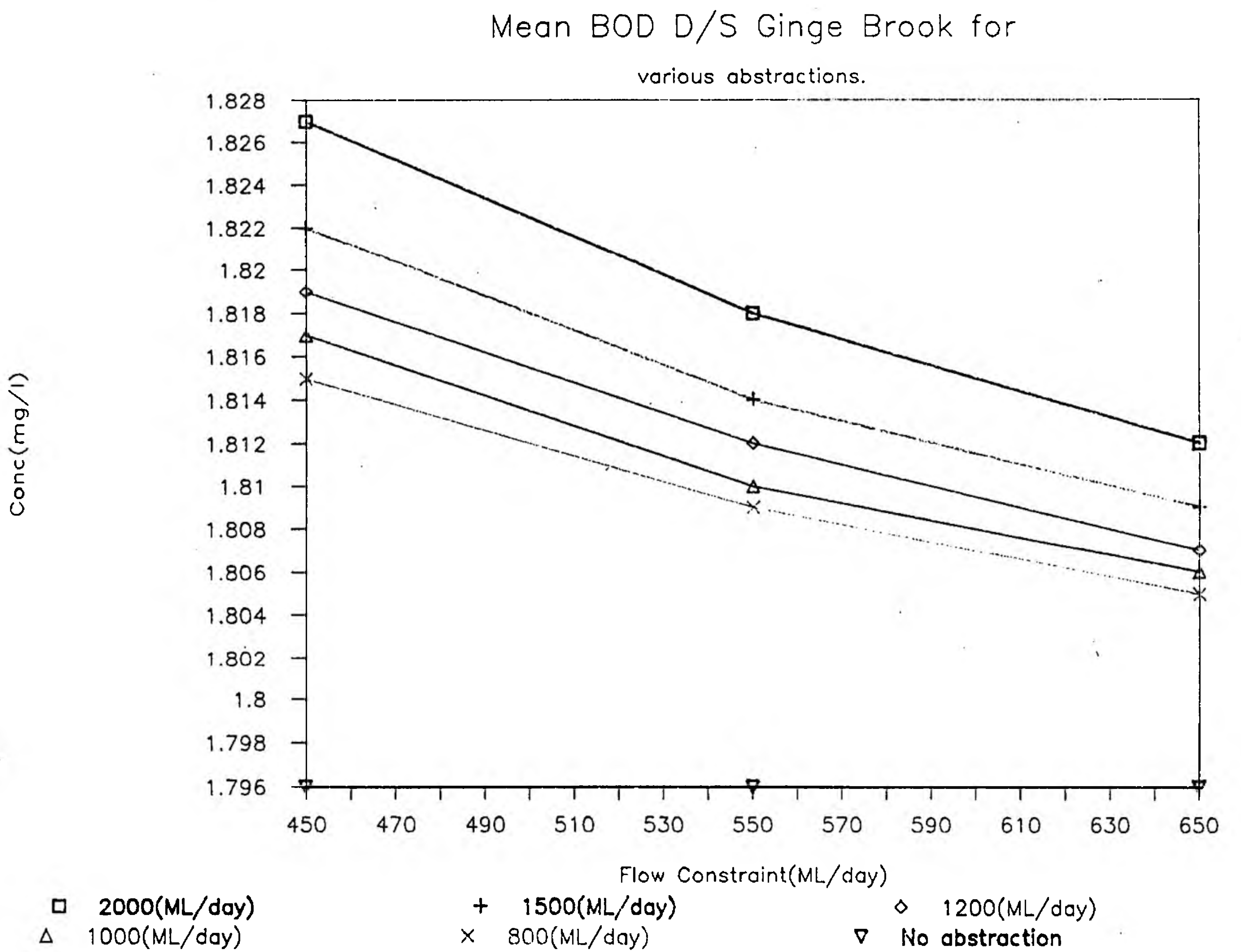
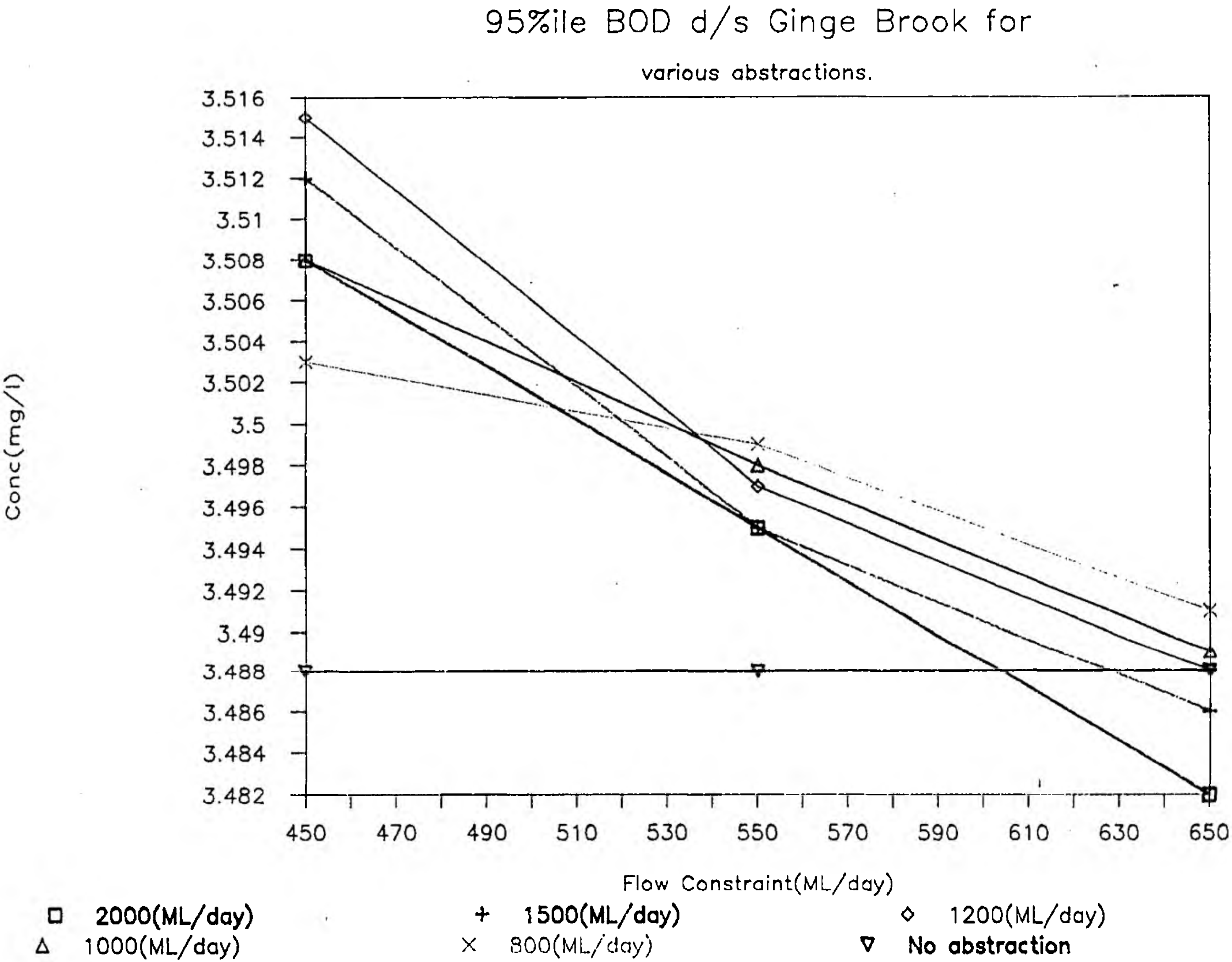


Fig 7.


Mean BOD D/S Ginge Brook for
various abstractions.
Conc(mg/l)
1.828
1.826
1.824
1.822
1.82
1.818
1.816
1.814
1.812
1.81
1.808
1.806
1.804
1.802
1.8
1.798
1.796
450
470
490
510
530
550
570
590
610
630
650
Flow Constraint(ML/day)
2000(ML/day)
1500(ML/day)
1200(ML/day)
1000(ML/day)
800(ML/day)
No abstraction

12.31

Fig 8


95%ile BOD d/s Ginge Brook for
various abstractions.
Conc(mg/l)
3.516
3.514
3.512
3.51
3.508
3.506
3.504
3.502
3.5
3.498
3.496
3.494
3.492
3.49
3.488
3.486
3.484
3.482
450
470
490
510
530
550
570
590
610
630
650
Flow Constraint(ML/day)
2000(ML/day)
1500(ML/day)
1200(ML/day)
1000(ML/day)
800(ML/day)
No abstraction

2.32

Fig 9.

Mean ammonia d/s of Ginge Brook for

various abstractions.

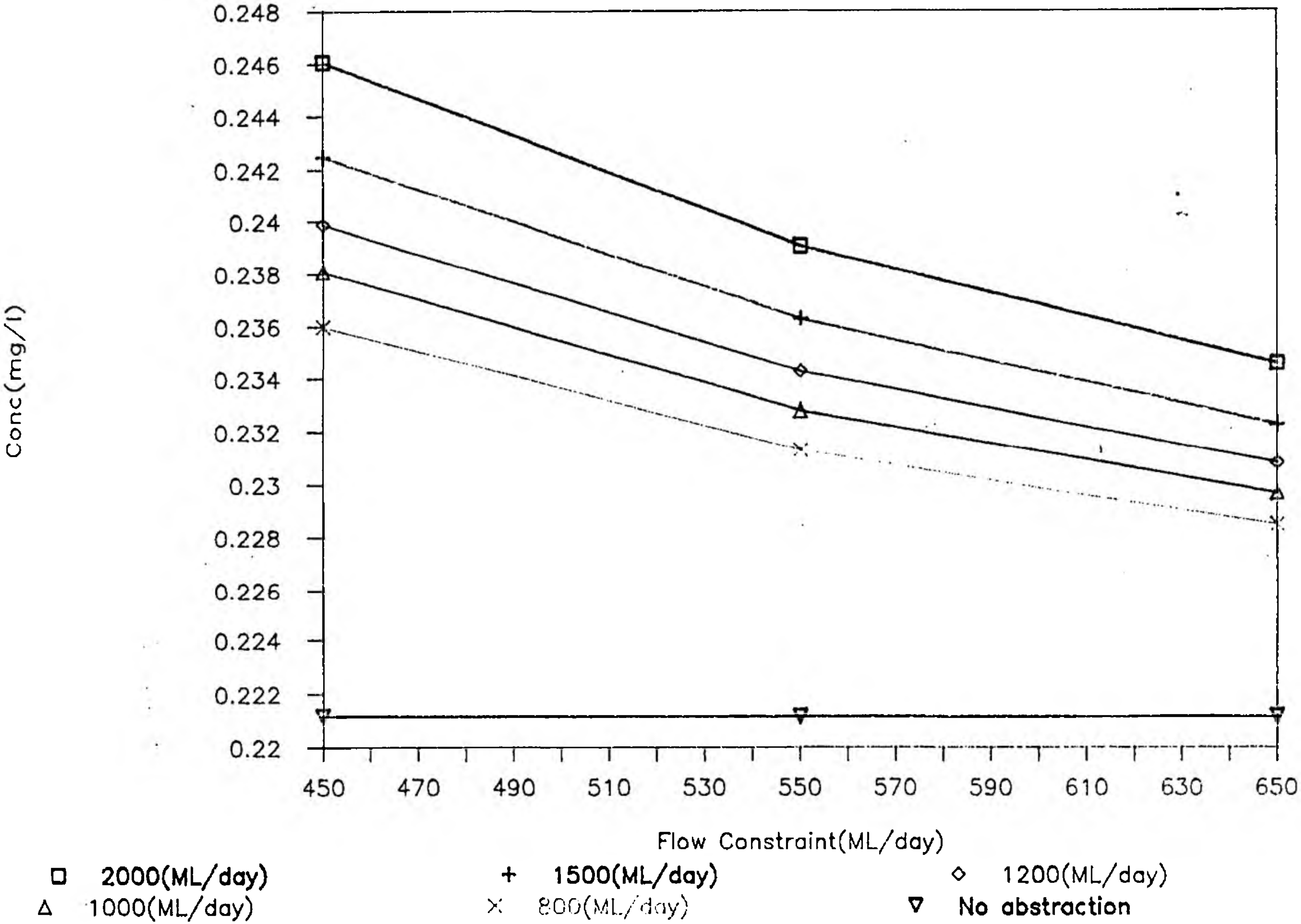
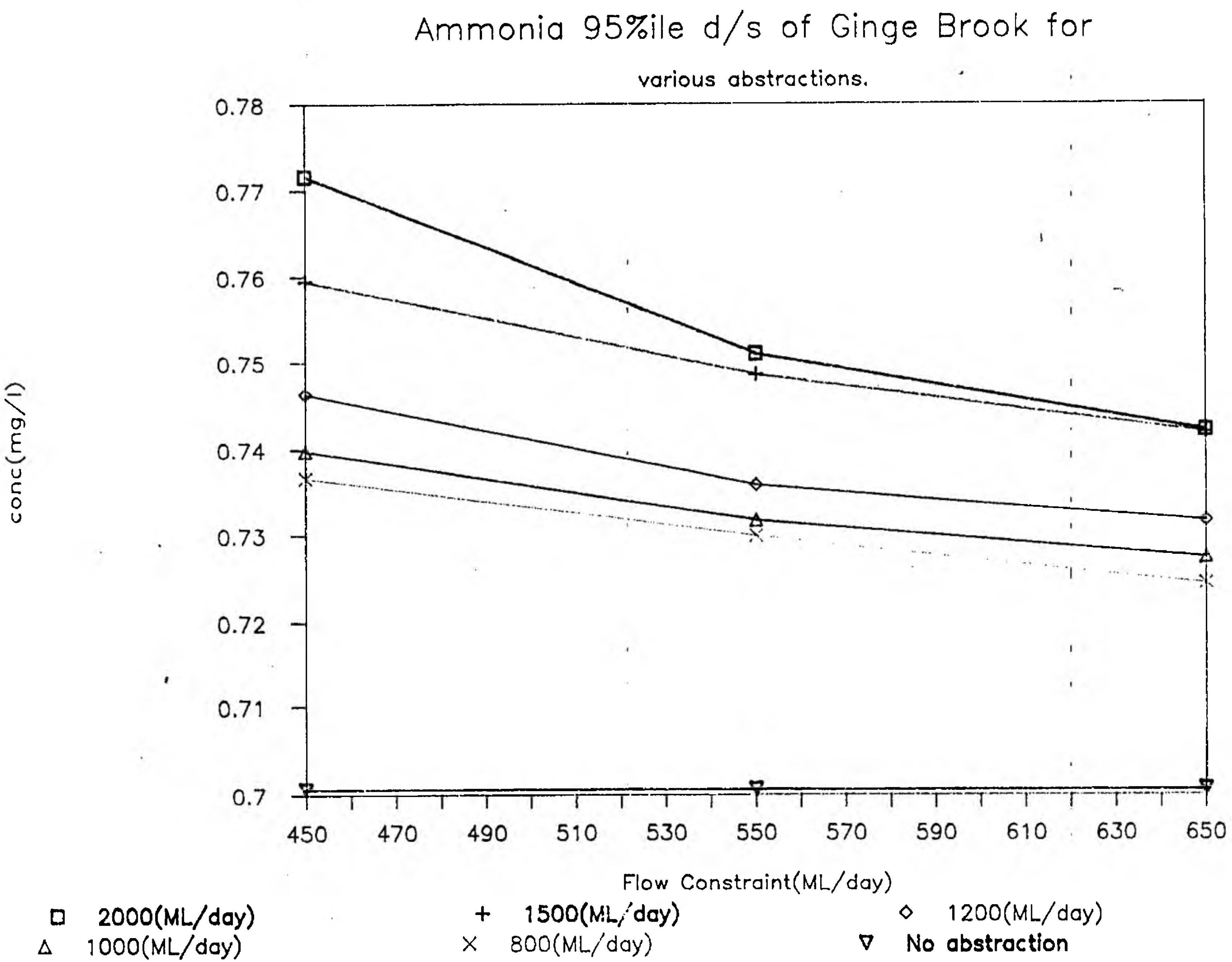
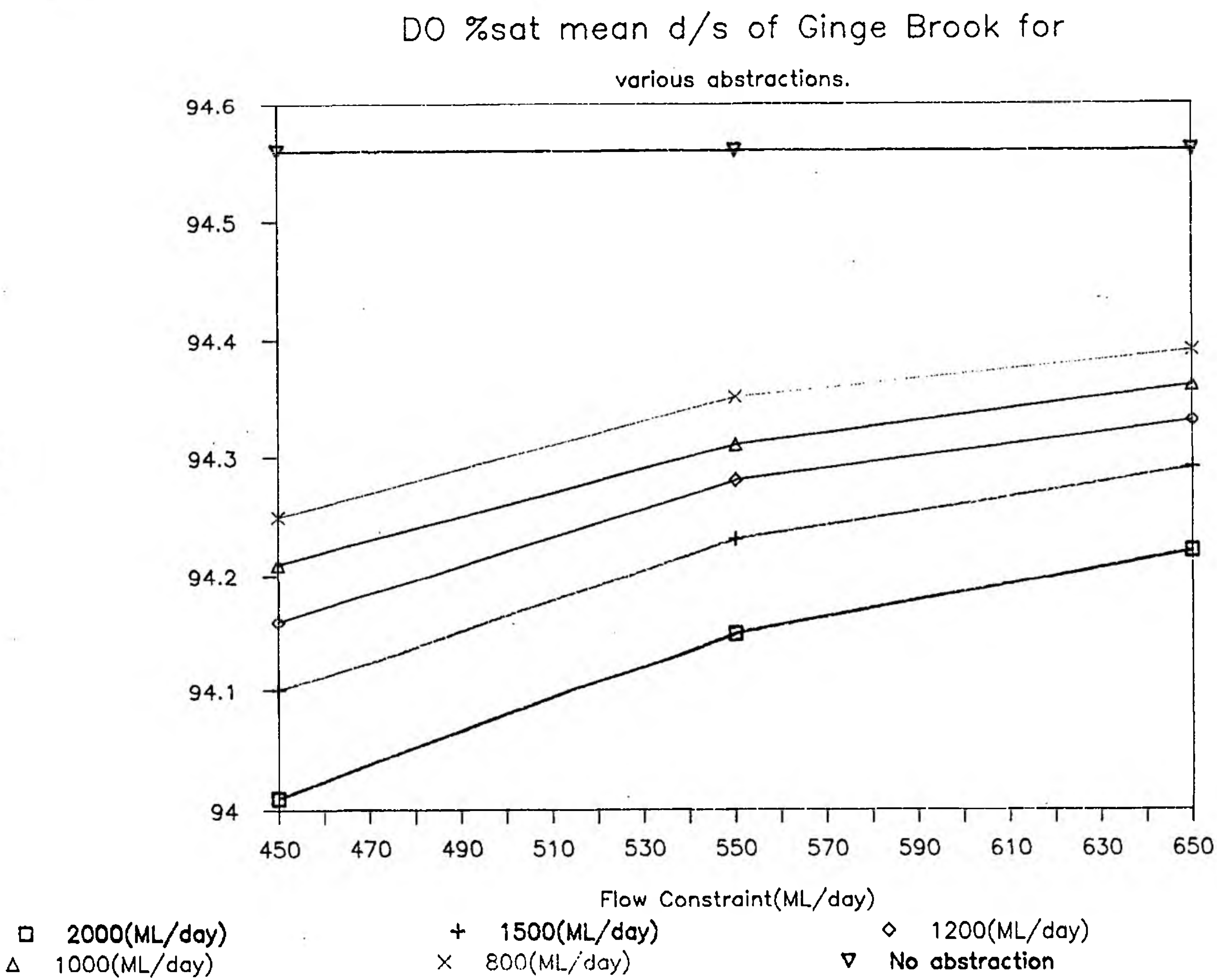


Fig 10.


Ammonia 95%ile d/s of Ginge Brook for
various abstractions.
conc(mg/l)
0.78
0.77
0.76
0.75
0.74
0.73
0.72
0.71
0.7
450
470
490
510
530
550
570
590
610
630
650
Flow Constraint(ML/day)
2000(ML/day)
1500(ML/day)
1200(ML/day)
1000(ML/day)
800(ML/day)
No abstraction

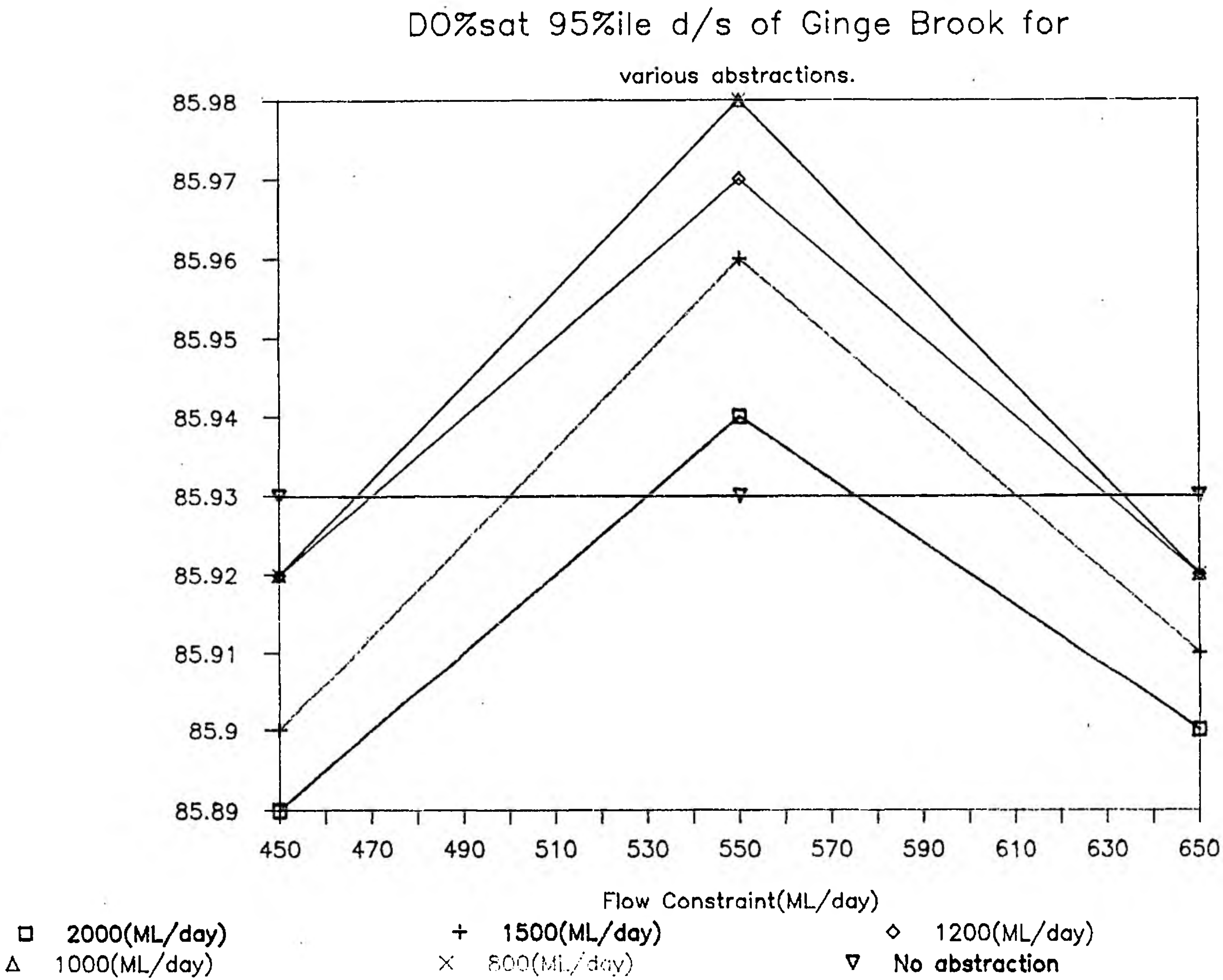
2.34

Fig 11.


DO %sat mean d/s of Ginge Brook for
various abstractions.
%sat
94.6
94.5
94.4
94.3
94.2
94.1
94
450
470
490
510
530
550
570
590
610
630
650
Flow Constraint(ML/day)
2000(ML/day)
1500(ML/day)
1200(ML/day)
1000(ML/day)
800(ML/day)
No abstraction

2-35

Fig 12.


DO%sat 95%ile d/s of Ginge Brook for
various abstractions.
%sat
85.98
85.97
85.96
85.95
85.94
85.93
85.92
85.91
85.9
85.89
450
470
490
510
530
550
570
590
610
630
650
Flow Constraint(ML/day)
2000(ML/day)
1500(ML/day)
1200(ML/day)
1000(ML/day)
800(ML/day)
No abstraction

2.36