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GOGWS

L. OUSE / THET CONTROL RULES

D HEARN JULY 1990

National Rivers Authority
Anglian Region

GROUNDWATER DEVELOPMENT SCHEME

LITTLE OUSE AND THET CATCHMENT

CONTROL RULES

1. Introduction

There are 27 abstraction wells available for the support of river flows in the basin.

A full investigation and precise formulation of a set of control rules could become the subject of a long and complex study.

In practice, in 1989, believed to be the only year in which the wells have been used to alleviate the efects of low flows, quite simple rules were applied with apparent success.

2. Order of Priority

The wells have been listed in an order of priority based on a subjective evaluation of several criteria.

These criteria are listed in Table 1.

At several sites, the criteria are in conflict. In such cases, a reasonable balance has been sought.

The resulting order of priority is given in Table 2.

The Wells fall into 3 lists, named A, B and C.

Wells higher in each list should be switched on before wells lower down, and List A should take priority over List B.

List A = Wells in R. Thet basin which have good yields and few derogation problems.

It should be noted that there were complaints in 1989 that pumping at Wk. No. 65 (=5A) was causing a local pond to dry up. If this is accepted, this well should be moved down the list, possibly into List C.

There was a complaint about the iron content in water from Wk. No. 58 (=9A) causing deposition problems in the Roudham Brook. This needs further investigation.

List B = Wells in upper Lt Ouse basin which only make a compact group when wells to the north in List A are already pumping.
On their own, they would probably merely transfer base flow from the Thet to the Lt. Ouse.

List C = Wells not far from Wetland sites, where abstraction may cause derogation.

3. Further Criteria

Other considerations could have been brought in, especially differences in net gain, electricity costs and chemical quality, but data may not be easily available . There is scope for these to be given further study.

Experience in the Rhee basin suggests that it is difficult to quantify net gains from individual wells and that net gains which appear high at a monitoring site close to the recharge point can be severely depleted by losses occurring farther downstream.

On the other hand, costs of a unit volume of water calculated from power consumption and electricity tariffs are known to vary widely and these should be further investigated and given due weight in the priority listing.

The quality of water produced at each site should also be reviewed to find out whether this should form a further parameter to be considered in the order of precedence.

4. Mode of Operation

There are at present two possible modes of operation which can be named according to their main objective as the 'Constant River Flow' mode and the 'Constant Net Gain' mode.

The first was applied during the testing of the Pilot Area well field in 1971, and in the Rhee in 1986. The second was applied in the Lt. Ouse during the drought of 1989.

Obviously the two objectives can be combined in various ways, especially in a large basin such as the Lt. Ouse. For example, there could be a requirement to maintain a flow of not less than 300 l/s at Bridgham AND a net gain at Abbey Heath of 200 l/s.

4.1 Constant River Flow

This places a priority on local needs in the river. It is assumed that if flow can be maintained above a certain level, its quality and environmental features can be preserved.

Although a constant flow is the ideal objective, in order to give a reasonable time in which to respond to varying conditions, an upper and a lower limit should be set.

Even so, this method of operation requires telemetry and remote control of pumps if it is to be reasonably successful.

4.2 Constant Net Gain

This places priority on needs at the downstream end of the system.

For example, in 1989 it was decided that more water was needed in the Lt. Ouse at Hockwold for diversion into the Cut Off Channel to support the abstraction at Blackdyke which feeds rivers in Essex.

The amount required was known and the appropriate number of pumps were selected to give this gain. Only when more water was required at Hockwold were more pumps prepared for switch-on.

This method of operation relies far less on telemetry and remote control.

Nevertheless, regular monitoring of flows is required as the drought proceeds, and the information must be plotted on some form of control chart to make sure that net gain is being maintained.

For this purpose, a Control Area is usually designated which is close enough to the pumped area to have similar conditions of rainfall, geology etc, but is nevertheless unaffected by the support activity.

Hydrological observations in the Control Area are used to predict undisturbed flow in the maintained river. This flow is often called "Natural Flow" for short, but it reflects longstanding abstractions and returns and is not the same as "Naturalised Flow".

The difference between the actual flow measured in the river and the natural flow is defined as "Net Gain".

In 1989, pumping took place only in the R. Thet basin and not in the Lt. Ouse basin upstream of Knettishall.

Prior investigation had shown that the record at Knettishall gauging station could be used to predict natural flow at Melford and Abbey Heath. Control charts were constructed and Figs. 1-3 give an example of their use.

As soon as the well field upstream of Knettishall is brought into use during the course of any future drought, these charts cannot be used as a control, and other unaffected sites must be found.

5. Target Flows

In a report in 1990, it was recommended that a Cessation Flow should be included as a condition in the new licences being granted for Public Supply abstractions close to the river, and upper and lower limits to the flow were proposed at Melford and Abbey Heath.

It was later decided not to use these values as a condition to be imposed on the licensee, but to accept them as targets to be aimed for by the NRA.

Criteria used in setting the targets were return periods of low flows and the shape of the flow duration curve at each monitoring point.

Since then a criterion based on one-fifth of the mean flow (1/5 QM) has been suggested. Because of differing rates of recession, the 1/5 QM value does not occur simultaneously at the various control points and its use could result in some unbalanced pumping of part of the aquifer.

Values are given in Table 3.

Bridgham has been included because it is a sensitive control point.

6. Monitoring of Groundwater Levels

In past use of the well field, because of innate difficulties in understanding groundwater behaviour, detailed measurements have been made in all surrounding observation boreholes.

For example in 1989, it was proposed to use 15 abstraction wells in the Thet basin. The number of observation bores required to monitor the effects of this was 37, and accordingly, the reading frequency was increased at these sites from about once per month to about twice per month.

Although this would still be counted as good practice, staff resources are not currently available to carry out an analysis of the extra data. The increased frequency can therefore are regarded as non-essential.

On the other hand, where it is known that there are very sensitive locations or complaints may be expected, more frequent monitoring should be attempted e.g. pond at Waterways Farm, East Harling (TL 990 867) and the Breckland Meres.

For the purpose of reference, a schedule of all observation bores in the vicinity of each abstraction well is included as Table 4.

7. Past History of Scheme

The Groundwater Development Scheme was promoted under a Parliamentary Order in 1977 for which printed maps were prepared and are still available.

For the record, all sites have been listed in Tables 5 and 6 to give the current status of each site and the basin in which each operates.

8. Recommendations

Pumping should take place using wells based on the given order of priority.

Before the onset of a drought condition, a decision should be made on whether to operate to a Constant River Flow criterion or a Constant Net Gain criterion.

As the drought proceeds, the choice between these two methods should be kept under review.

If a Constant River Flow is chosen, the values listed in Table 3 should be used.

If a Constant Net Gain is required, monitoring should take place according to control correlations which should be prepared from flows occurring in previous years and up-dated from data collected in the 3-4 months prior to the onset of pumping. Examples are given in Figs. 1-3.

Background monitoring of groundwater levels should continue at monthly intervals. At sensitive locations monitoring should be more frequent.

Control sites should be established for all parts of the well field. The area upstream of Knettishall is in particular need of attention.

The quality of groundwater produced at each site, especially the iron content, should be reviewed.

In any future operation of the scheme, careful records should be kept of electricity consumption and resultant charges.

D HESLAM

4 July 1990

DHREPGROU/MS

TABLE 1

CRITERIA FOR DECIDING ORDER OF PRIORITY FOR SWITCHING ON ABSTRACTION WELLS

HIGHER PRIORITY	LOWER PRIORITY
Well has high yield	Well has low yield
Pipeline outfall close to lower reach of river i.e. close to Thetford	Pipeline outfall far upstream i.e. remote from Thetford. (More chances of obstruction to flow and channel losses)
Well sited far from stream whereby base-flow interception will be delayed and net gain high	Well sited close to stream where loss of base-flow may be expected, and net gain will be low
Well discharges to Main River	Well discharges to I.D.B. or other small drain (More field checking required to ensure channel is not obstructed)
Abstraction not known to cause derogation	Abstraction likely to cause some effect on neighbourhood
Well is remote from wetland S.S.S.I's, especially the Meres	Well is closer to the Meres. N.B. It was agreed that the 5 wells closest to the Meres would be pumped last.
Part of well field in use at any time forms a compact unit with a linked area of drawdown, drawing on stored groundwater	Wells in use are scattered over area, leading to groundwater transfer across boundaries

LIST A

RIVER SUPPORT WELLS IN THE TEST CATCHMENT.

In Order Of Priority For Switch - On.

G.D.S WORKS NO.	G.W.P.S. NO.	STATION NO.	N.G.R	AVERAGE OUTPUT TCMD	L/S	CHANNEL IDB	CHANNEL RIPARIAN	REMARKS
1	-	TL 88/48	TL 889 828	12.000	138.9	-	-	-
3	-	TL 98/136	TL 961 837	8.040	93.1	-	-	-
59	7A	TL 98/134	TL 969 855	4.104	47.5	-	-	-
69	1A	TM 08/78	TM 011 859	2.246	26.0	-	-	-
64	8A	TL 98/103	TL 988 894	3.767	43.6	-	-	-
65	5A	TL 98/131	TL 988 867	3.024	35.0	-	-	-
61	10A	TL 98/105	TL 974 883	5.443	63.0	YES	-	-
58	9A	TL 98/104	TL 964 872	4.061	47.0	YES	-	-
66	11A	TL 99/89	TL 994 912	4.622	53.5	-	-	-
62	12A	TL 99/90	TL 981 918	6.221	72.0	YES	-	-
60	13A	TL 99/91	TL 971 905	4.234	49.0	YES	-	-
10	-	TM 03/91	TM 051 871	7.776	90.0	YES	-	-
11	-	TM 08/90	TM 071 856	4.152	48.1	YES	-	-
8	-	TM 09/119	TM 021 917	6.048	70.0	YES	-	-
12	-	TM 09/120	TM 084 910	9.600	111.1	YES	YES	-
TOTAL				85.338	983.7			

LIST B

RIVER SUPPORT WELLS IN LITTLE OUSE CATCHMENT

In Order Of Priority Of Switch On.

G.D.S WORKS NO.	G.W.P.S. NO.	STATION NO.	N.G.R	AVERAGE OUTPUT TCMD	L/S	CHANNEL IDB	CHANNEL RIPARIAN	REMARKS
4	$	TL 98/112	TL 972 830	1.918	22.2	-	-	-
5	$	TL 98/111	TL 985 818	2.998	34.7	-	YES	-
6	$	TM 08/117	TM 001 820	7.992	92.5	-	YES	-
9	$	TM 08/85	TM 025 836	4.320	50.0	-	YES	-
TOTAL				17.228	199.4			

N.B $ = NOT IN G.W.P.S.

LIST C

RIVER SUPPORT WELLS IN TEST CATCHMENT

SENSITIVE - WELLS COULD AFFECT WETLAND SITES.

In Order Of Priority For Switch On.

G.D.S WORKS NO.	G.W.P.S. NO.	STATION NO.	N.G.R	AVERAGE OUTPUT TCMD	L/S	CHANNEL IDB	CHANNEL RIPARIAN	REMARKS
68	2A	TM 08/79	TM 002 854	3.629	42.0	-	-	1.1 In from N. Harling Fen
63	3A	TM 98/100	TL 986 842	3.715	43.0	-	-	0.6 In from N. Harling Fen
67	6A	TM 08/81	TM 002 884	4.346	50.3	YES	-	0.5 In from E. Harling Fen
57	16A	TL 99/93	TL 963 921	4.838	56.0	YES	-	6.7 In from Ringmere $$$
55	17A	TL 99/94	TL 951 915	4.926	57.0	YES	-	5.4 In from Ringmere $$$
56	15A	TL 99/92	TL 951 901	2.989	34.6	YES	-	4.6 In from Ringmere $$$
54	14A	TL 98/106	TL 949 885	1.728	20.0	YES	-	4.0 In from Ringmere $$$
53	18A	TL 99/95	TL 939 906	4.622	53.5	YES	-	4.0 In from Ringmere $$$
TOTAL				30.793	356.4			

N.B. $$$ = Order of Switch - On Agreed With Nature Conservancy Council.

TABLE 2

TABLE 3

LT. OUSE AND THET - TARGET FLOWS IN L/S

	CONTROL GAUGING STATION			
	Abbey Heath	Melford	County Bridge	Bridgham
Upper limit	1200	470	125	380
Lower limit	1035	374	56	300
Single target based on 1/5 QM	800	405	100	320

OBSERVATION SCHEDULE

RIVER SUPPORT WELLS IN THET - (LIST A)

ABSTRACTION WELL			OBSERVATION BORE			REMARKS
GWDS No.	GWPS No.	STATION No.	GWDS No.	GWPS No.	STATION No.	
1	–	TL88/48	71		TL88/66	Adjacent
					TL88/6	
					TL88/13	
			70		TL88/65	
3	–	TL98/136			TL98/154	Adjacent
				147	TL98/1	
				4D	TL98/11	
				145	TL98/27	
			73		TL98/145	
59	7A	TL98/134		107	TL98/31	Adjacent
				5D	TL98/12	
				146	TL98/35	
69	1A	TM08/78		101	TM08/7	Adjacent
				24B	TM08/6	
				138	TM08/15	
64	8A	TL98/103		108	TL98/21	Adjacent
				7S	TL98/13	
				131	TL98/24	
65	5A	TL98/131		105	TL98/20	Adjacent
61	10A	TL98/105		110	TL98/5	Adjacent
				48	TL98/3	
				8B	TL98/14	

TABLE 4

OBSERVATION SCHEDULE

RIVER SUPPORT WELLS IN THET - (LIST A contd.)

ABSTRACTION WELL			OBSERVATION BORE			REMARKS.
GWDS No.	G.W.P.S. No.	STATION No.	GWDS No.	GWPS No	STATION No.	
58	9A	TL98/104		109	TL98/22	Adjacent Recorder
				9S	TL98/15	
66	11A	TL99/89		111	TL99/19	Adjacent
				6B	TM09/9A	
				"	TM09/98	
62	12A	TL99/90		112	TL99/20	Adjacent
60	13A	TL99/91		113	TL99/21	Adjacent
10	-	TM08/91	83		TM08/104	Adjacent
				133	TM08/11	
				134	TM08/12	
11	-	TM08/90	86		TM08/103	Adjacent
8		TM09/119	81		TM09/138	Adjacent
				130	TM09/2	
12		TM09/120	87		TM09/139	Adjacent
					TM09/1	

TABLE 4

OBSERVATION SCHEDULE
RIVER SUPPORT WELLS IN LT. OUSE (LIST B.)

ABSTRACTION WELL			OBSERVATION BORE			
GWDS No.	GWPS No	STATION No.	GWDS No.	GWPS No.	STATION No	REMARKS.
4	-	TL98/112	75		TL98/147	Adjacent
				142	TL98/6	
				144	TL98/26	
			74		TL98/148	
5		TL98/111	76		TL98/150	Adjacent.
				143	TL98/25	
6		TM08/117	77		TM08/112	Adjacent
				141	TM08/17	
9		TM08/85	82		TM08/108	Adjacent
				139	TM08/3	
			80		TM08/109	

TABLE 1.

OBSERVATION SCHEDULE

RIVER SUPPORT WELLS IN THET (LIST C - Could affect wetland sites)

ABSTRACTION WELL			OBSERVATION BORE			
GWDS No.	GWPS No	STATION No.	GWDS No	GWPS No	STATION No	REMARKS
G8	2A	TM08/79		102	TM08/8	Adjacent
G3	3A	TL98/100		103	TL98/19	Adjacent
				1B	TL98/9	
				2B	TL98/10	
G7	6A	TM08/81		106	TL98/30	Adjacent
				136	TL98/34	
					TL98/164	Gauge Board E22
					TL98/165	Gauge Board E23
				135	TM08/13	

TABLE 4

OBSERVATION SCHEDULE

RIVER SUPPORT WELLS IN THET (LIST C - Could affect Mercs. Wells must be pumped in given sequence)

ABSTRACTION WELL			OBSERVATION BORE			
GWDS No.	GWPS No.	STATION No.	GWDS No	GWPS No	STATION No.	REMARKS
57	16 A	TL99/93		116	TL99/22	Adjacent
				119	TL98/23	
				157	TL98/29	Recorder
				120	TL98/33	
				152	TL98/36	
				158	TL98/37	
				125	TL99/13A	
				"	TL99/13B	
				128	TL99/25	
55	17 A	TL99/94				All the above bores, plus:-
				117	TL99/23	Adjacent
				161	TL88/8	
				160	TL88/10	
				123	TL99/6	
				24	TL99/10	
				16 B	TL99/15	
				17 B	TL99/16A	
				17 B	TL99/16B	
56	15 A	TL99/92				All the above bores, plus:-
				115	TL99/28	Adjacent

TABLE 1

OBSERVATION SCHEDULE

RIVER SUPPORT IN THET (LIST C - Contd.)

ABSTRACTION WELL			OBSERVATION BORE			
GWDS No.	GWPS No.	STATION No	GWDS No	GWPS No	STATION No	REMARKS
54	14A	TL98/10G				All bores on previous sheet, plus:-
				11A	TL98/32	Adjacent
				10S	TL98/16	
53	18A	TL99/95				All the above bores, plus:-
				11B	TL99/29	
				25B	TL99/18	
				12I	TL99/30	

TABLE 4

GDS WELLS U.S. OF THETFORD (Not incl in Pilot Area)

G.D.S. No.	PILOT SCH No	REF No.	DATE OF DRILLING	STATUS IN 1989	THET U.S. MELFORD	LT OUSE U.S. SAPISTON COUNTY BR. U.S. RECTORY
1	-	TL 88/48	May 82	Available for R.S.	✓	
2		TL 98/137	Jul 82	Offered to C.W.C.	✓	
3		TL 98/136	Aug 82	Available for R.S.	✓	
4		TL 98/112	Jul 82	"		✓
5		TL 98/111	Aug 83	"		✓
6		TM 08/117	Nov 83	"		✓
7		-	-	Not drilled		✓
8		TM 09/119	Oct 81	Available for R.S.	✓	
9		TM 08/85	Mar 85	"		✓
10		TM 08/91	Oct 82	"	✓	
11		TM 08/90	Dec 81	"	✓	
12		TM 09/120	Dec 82	"	✓	
13		TL 97/137	May 83	Offered to C.W.C.		✓
14		-	-	Not drilled		✓
15		TL 98/110	Jul 83	Offered to CWC		✓
16		-	-	Not drilled		✓
17				"		✓
18				"		✓
19				"		✓
20				"		✓
21				"		✓
22				"		✓
23				"		✓
24-32				"		✓

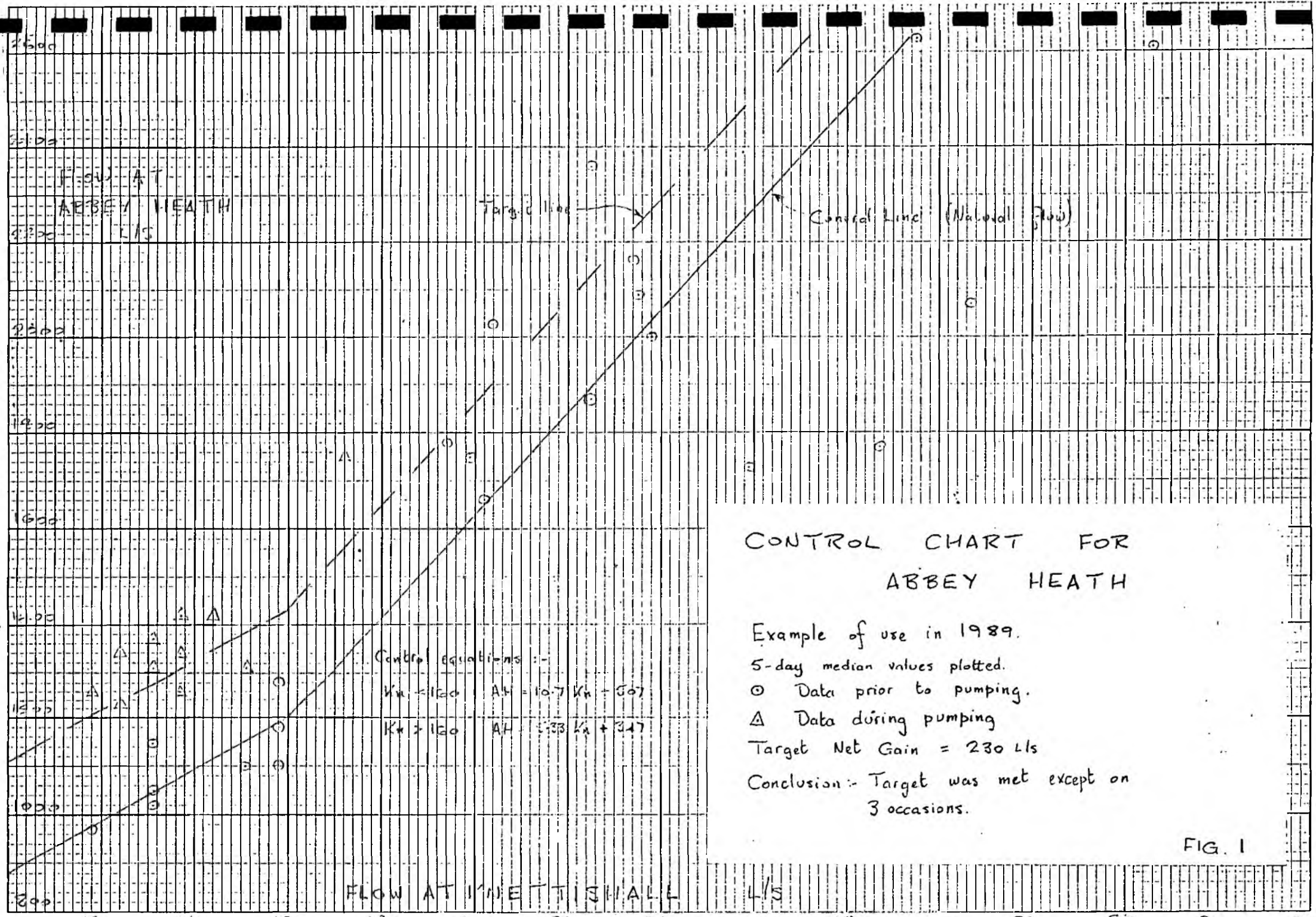
TABLE 5

G.D.S WELLS U.S. OF THETFORD (Incl. in Pilot Area)

G.D.S. No	PILOT SCH. No.	REF No.	DATE OF DRILLING	STATUS IN 1989
53	18 A	TL99/95	Aug 68	Available for River Support
54	14 A	TL98/106	Jun 68	"
55	17 A	TL99/94	Jul 68	"
56	15 A	TL99/92	Sep 68	"
57	16 A	TL99/93	Sep 68	"
58	9 A	TL98/104	May 68	"
59	7A	TL98/102	Jun 68	"
60	13 A	TL99/91	Aug 68	"
61	10 A	TL98/105	Jul 68	"
62	12 A	TL99/90	Jul 68	"
63	3A	TL98/100	Apr 68	"
64	8A	TL98/103	Jul 68	"
65	5A	TL98/101	Apr 68	"
66	11 A	TL99/89	Jun 68	"
67	6A	TM08/81	May 68	"
68	2A	TM08/79	Apr 68	"
69	1A	TM08/78	68	"
NB	4A	TM08/80	1968 – Handed over for P.W.S in 1973	

All wells U.S of Melford or Bridgham.

TABLE 6



CONTROL CHART FOR ABBEY HEATH

Example of use in 1989.

5-day median values plotted.

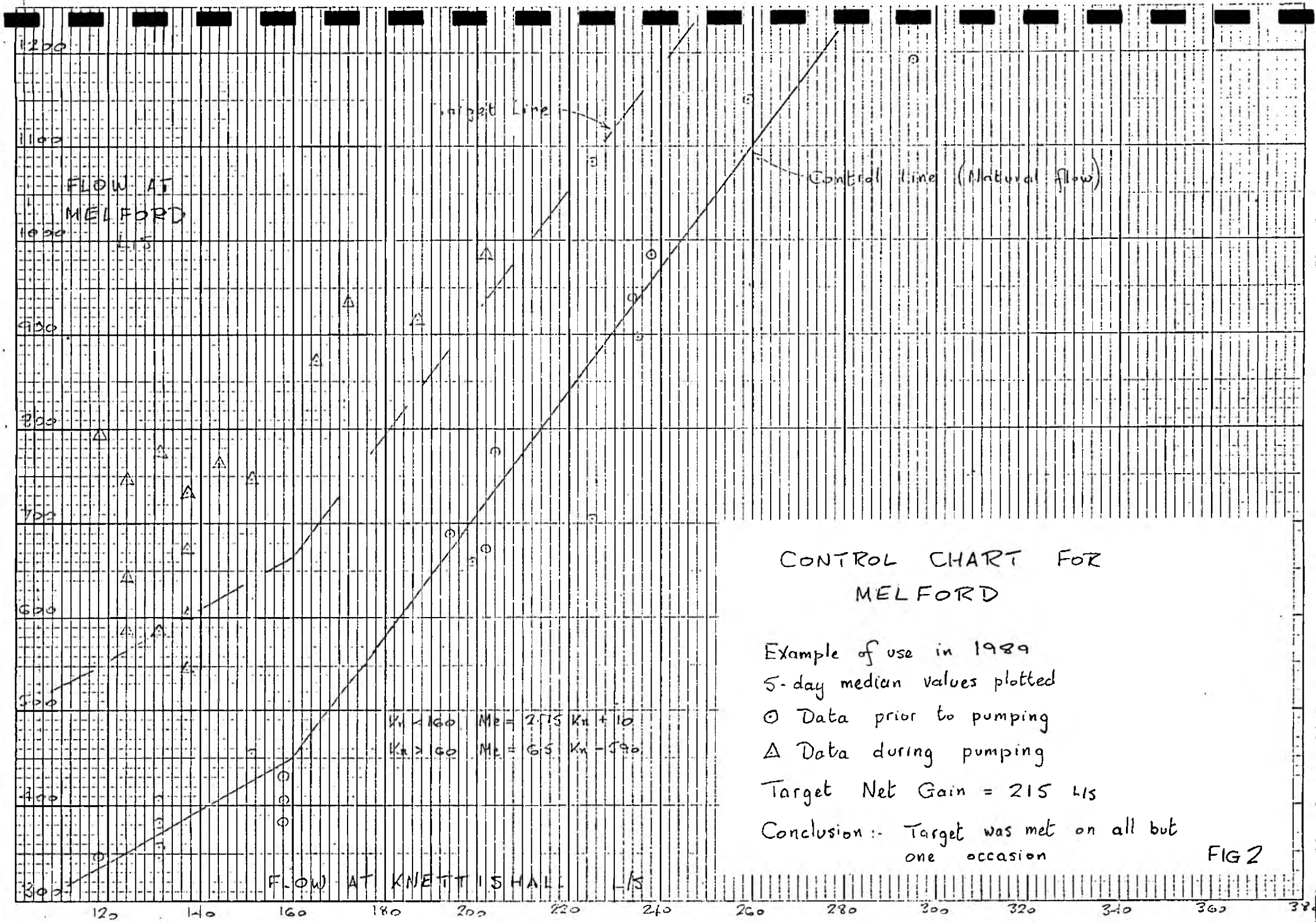
⊙ Data prior to pumping.

Δ Data during pumping

Target Net Gain = 230 L/s

Conclusion :- Target was met except on 3 occasions.

FIG. 1



CONTROL CHART FOR MELFORD

Example of use in 1989

5-day median values plotted

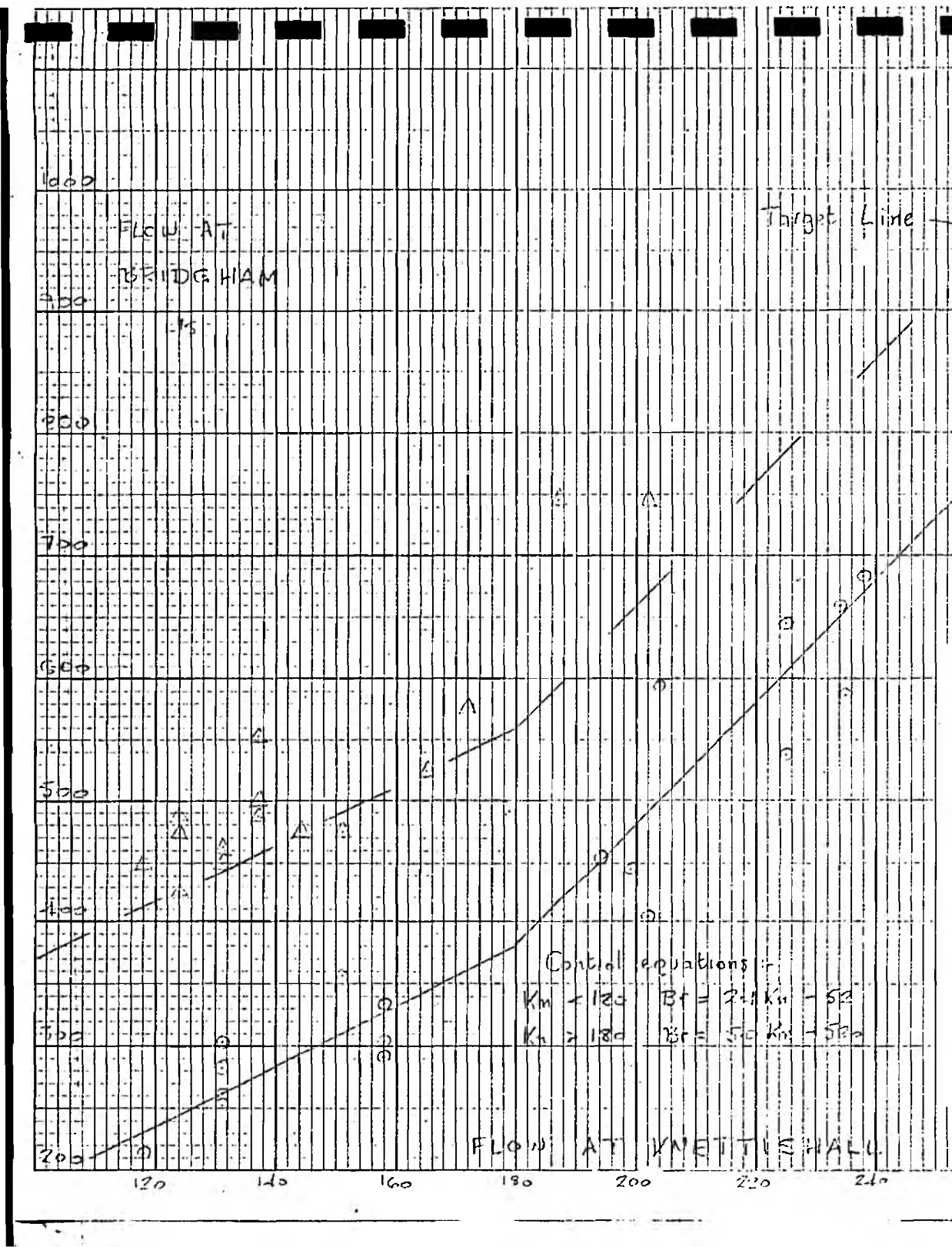
⊙ Data prior to pumping

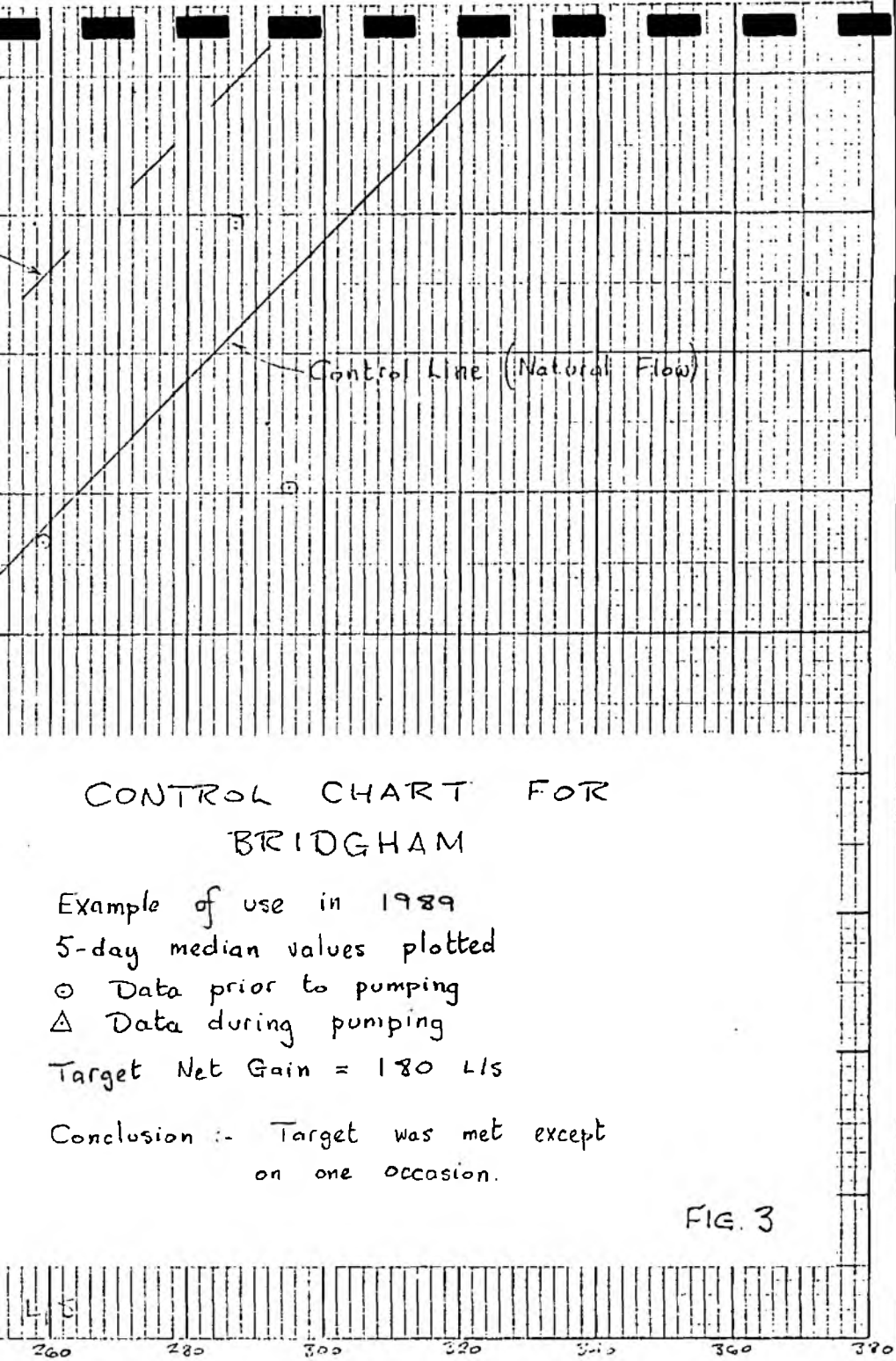
△ Data during pumping

Target Net Gain = 215 l/s

Conclusion :- Target was met on all but one occasion

FIG 2


FLOW AT BRIDGHAM
Target Line
Control equations :
$K_m < 120$ $B_f = 2.1 K_m - 52$
$K_m > 180$ $B_f = 5.0 K_m + 580$
FLOW AT WHETTLESHALL
1000
900
800
700
600
500
400
300
200
120
140
160
180
200
220
240



CONTROL CHART FOR BRIDGHAM

Example of use in 1989

5-day median values plotted

⊙ Data prior to pumping

△ Data during pumping

Target Net Gain = 180 L/s

Conclusion :- Target was met except on one occasion.

FIG. 3