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GEOLOGICAL SURVEY OF CANADA
OPEN FILE 2109

Analysis of 1988 In Situ TDR Data, Norman Wells Pipeline

D.E. Patterson

1989

Energy, Mines and Resources Canada
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Inside title Page

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Analysis of 1988 In Situ TDR Data, Norman Wells Pipeline

Final Report

for M. Burgess

Geological Survey of Canada
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1989

FOREWORD

This report documents work undertaken as part of the federal government's Permafrost and Terrain Research and Monitoring Program along the 868.6 km Norman Wells to Zama oil pipeline. The 324 mm diameter, shallow burial (1 m) pipeline, traverses the discontinuous permafrost zone of northwestern Canada and began operation in April 1985. A joint monitoring program with Interprovincial Pipe Lines (NW) Ltd. was established following the signing of an environmental agreement between the pipeline company and the Department of Indian and Northern Affairs (INAC) in 1983. INAC coordinates the government's monitoring program in which Energy, Mines and Resources' Geological Survey of Canada, the National Research Council's Institute for Research in Construction, and Agriculture Canada's Land Resource Research Institute participate.

A major component of this research and monitoring program involves the detailed quantification of changes in the ground thermal regime and geomorphic conditions at thirteen instrumented sites along the route. This project was developed in cooperation with the Permafrost Research Section of the Geological Survey in order to examine and quantify the effects of pipeline construction, operation and maintenance in thaw sensitive terrain. Many components of this research are contracted out.

The work undertaken in this contract report describes but one aspect of these site investigations. Interpretations contained herein are often limited to the specific data base under analysis and may thus not present an integrated or comprehensive analysis of all site observations. The opinions and views expressed by the authors are their own and do not necessarily reflect those of the Geological Survey of Canada or Indian and Northern Affairs.

Funding for the research and analyses reported herein was largely provided by INAC's Northern Affairs Program.

Margo Burgess
Scientific Authority
Permafrost Research Section
Geological Survey of Canada

Analysis of 1988 In Situ TDR Data, Norman Wells Pipeline

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1. Introduction

Information on the dielectric constant, K, obtained via Time-domain Reflectometry (TDR) has been collected at 13 monitoring sites along the 868 km long pipeline route from Norman Wells NWT to Zama Alta since 1984 (see Table 1). These data were analysed in a previous report (Patterson, 1988), to determine:

1. temporal variations in soil moisture regimes at each site;

2. lateral variations in the soil moisture regime at each site (specifically, the existence of differences in observations between the TDR installations beside the pipeline, on the pipeline right-of-way (ROW) and off the right-of-way);

3. the existence and depth of thaw at each TDR installation at each site.

Recommendations were made as to whether observations at a given site should be continued and, if so, at what frequency should they be made. These are summarized in Table 2.

At each monitoring site, there are 3 TDR installations each having up to 5 TDR probes. The TDR stations are coded as follows:

KB	off right-of-way
KC	on right-of-way
KP	beside pipeline

The TDR probes have nominal lengths of 1, 2, 3, 4.5 and 6 feet. Each probe extends from the ground surface down to the depth determined by the probe length, giving an estimate of the dielectric constant over the total length. Initially, two inches of each TDR probe stuck out of the ground to allow connection to the TDR unit, however, the probes are subject to heave and settlement so the depth over which the dielectric constant is being measured could change. Beginning in October 1986, a detailed record was made of the length of rod exposed above the ground surface.

The actual number of TDR probes and their coverage depths are summarized in tables for each site.

Table 1 Site Descriptions

Site	Station and distance along pipeline	Description (at time of Pipeline establishment)
84-1	Pump Station 1	
	0.1 km	Ice-rich silty clay in widespread permafrost
84-2	Canyon Creek	
	A 19.0 km	Level location, frozen till with low ice content in widespread permafrost
	B 19.3 km	East-facing slope in widespread permafrost with a 1 m insulating woodchip cover
	C 19.6 km	West-facing slope in widespread permafrost with erosion control berms
84-3	Great Bear River	(Joint IPL site)
	A 79.2 km	Statigraphically comples ice-rich alluvial terrace deposits in widespread permafrost; cliff base
	B 79.4 km	Cliff-top lacustrine deposits with veneer of aeolian deposits
85-7	Table Mountain	(Joint IPL site)
	A 271.2 km	Ice-rich lacustrine plain (old seismic line, 1960's)
	B 272.0 km	Helipad clearing at bend on top of north facing slope, ice-rich lacustrine plain
	C 272.3 km	New clearing on ice-rich lacustrine plain
84-4	Trail River	(pipeline previously traversed frozen ground)
	A 478.0 km	Unfrozen saturated sands and silts in dune hollow
	B 478.1 km	Dry sands and silts in dune crest
85-8	Manner's Creek	(rapidly changing permafrost conditions)
	A 557.8 km	Thin peat with thick (10 m) permafrost
	B 558.2 km	Thick (2.7 m) peat with thin (4 m) permafrost
	C 558.3 km	thin peat (1 m) with thin (1 m) permafrost
85-9	Pump Station 3	
	583.3 km	Frost free granular soils after long frozen section
85-10	Mackenzie Highway South	
	A 588.3 km	Transition from a helipad clearing in unfrozen terrain to
	B 588.7 km	Thin (3 m) permafrost with 2 m peat cover
85-11	Moraine South	
	597.4 km	Thin ($<$ 4 m) permafrost in helipad clearing

Table 1 continued

85-12 Jean Marie Creek		
A	608.6 km	Thin unfrozen peat plateau
B	608.7 km	Thick ice-rich peat plateau; 4 m permafrost
85-13 Redknife Hills		
A	682.2 km	Frozen (6 m) terrain surrounding large fen
B	682.4 km	Frozen (6 m) terrain at fen border
C	682.6 km	Unfrozen terrain in fen
84-5 Petitot River North		
A	783.0 km	Ice-rich peat (3.5 m); (15-18 m) permafrost
B	783.3 km	Very thick icy peat (7 m); 12 m permafrost
84-6 Petitot River South		
	819.5 km	Thick (5 m) ice-rich peat; 7 m permafrost

Table 2 Recommendations Previously Made Regarding Continuation of Readings at the Various Sites

	Recommendation	Reason
84-1	Yes	Off-ROW relatively stable, on-ROW may be exhibiting increased active layer thickness, beside pipe should be continued, however, the 4.5 and 6 foot probes seem to be picking up the pipe.
84-2A	No	Appears to a low water content material. Only features evident are the seasonal freeze/thaw boundaries.
84-2B	Yes	Woodchip site. Nothing major to note but it should be monitored.
84-2C	Yes	Off-ROW has remained generally frozen. On-ROW and near pipe experience significant thaw but remain relatively dry throughout the year.
84-3A	Yes	On-ROW and beside pipe may be showing increased active layer thickness. Off-ROW is similar and needs another year of observations before conclusions can be drawn.
84-3B	No	On-ROW and beside pipe just experience seasonal freeze-thaw. The material is dense sand.
84-4A	No	Unfrozen sands, little seasonal or site specific change
84-4B	No	Unfrozen sands, little seasonal or site specific change
84-5A	Yes	Material beside pipe is essentially thawed. On-ROW is gradually increasing in K.
84-5B	Yes	Similar to 5A
84-6	Yes	Maybe for another year. The site has been gradually increasing in K at all sites.
85-7A	No	This site is now just experiencing seasonal freeze/thaw.
85-7B	Yes	Should monitor to see if the wettness in KB and KP persists.

Table 2 continued

85-7C	Yes	Same reasons as for 7B
85-8A	No	On-ROW and near pipe experience complete freeze/thaw, off-ROW doesn't.
85-8B	Yes	On-ROW still seems to have frozen ground, pipe doesn't other than seasonal freezing
85-8C	Yes	On-ROW still seems to have frozen ground, pipe area appears to be thawing
85-9	No	Only experiences seasonal freeze-thaw. KP probes are suspect.
85-10A	No	Same as above.
85-10B	Yes	Frozen ground still evident on-ROW but not by pipe.
85-11	No	Lack of agreement between probes at all sites suggesting within site variations are great. Also the pipe probes have been buried.
85-12A	No	Only experiences seasonal freezing-thawing.
85-12B	Yes	Monitor to see if thaw at KP persists. KC and KB are relatively stable at present.
85-13	Yes	Continue for one season.

2. Analyses Undertaken

This contract continued the analysis of dielectric constant data collected by the Scientific Authority since September 1984. This included:

1. adding to the data base of the dielectric constant data
2. correcting any anomalous observations
3. estimating travel time to apparent frost or thaw fronts

The summaries for the sites from the previous report have been included and amended to include the data for July and October 1988.

A series of 3-D bar graphs have been included to permit the reader to readily observe trends in the K data. Data were not collected for all TDR probes at all sites, hence, graphs were only produced for the longer (4.5'and 6') probes. The absence of a bar for a particular time either means that a reading was not made for the particular probe or that a K measurement was not possible. This latter case tends to occur in clay-rich materials of high water content. To determine which case applies, the site summaries can be consulted while viewing the graph.

Tabulated values for K are given in Appendix I for all time periods for the sites examined in 1988.

3. General Observations

The off-ROW probes (KB) for most sites have seemed to remain relatively constant over time showing only slight increases for equivalent time periods. These changes in some instances can be attributed to increased active layer thickness (in the order of several cm) but they can also be due to moisture conditions present at the time of observation.

Just about all the sites have seen a dramatic change in K for sites located adjacent to the pipe (KP probes). In some instances the changes occured quite early during pipeline operation (eg. 1986) as is the case for site 10B, while other sites changed much more gradually (see site 8C).

The sites located on the ROW (KC) tend to have K values greater than those off-ROW but less than those located beside the pipe. These sites tend to exhibit the greatest seasonal fluctuations when compared to their KB and KP equivalents.

4. Recommendations for Subsequent Data Acquisition

The only changes to that need to be made to the initial recommendations carried out in 1988 would be that:

1. 85-7B and 85-7C KC and KP probes being subjected to annual freeze/thaw cycles only. These sites may be discontinued with the possible exception of the KB sites.

2. It may be preferable to only take readings at the end of the thaw period (October) to permit monitoring of increasing active layer thickness for the KC and KB sites.

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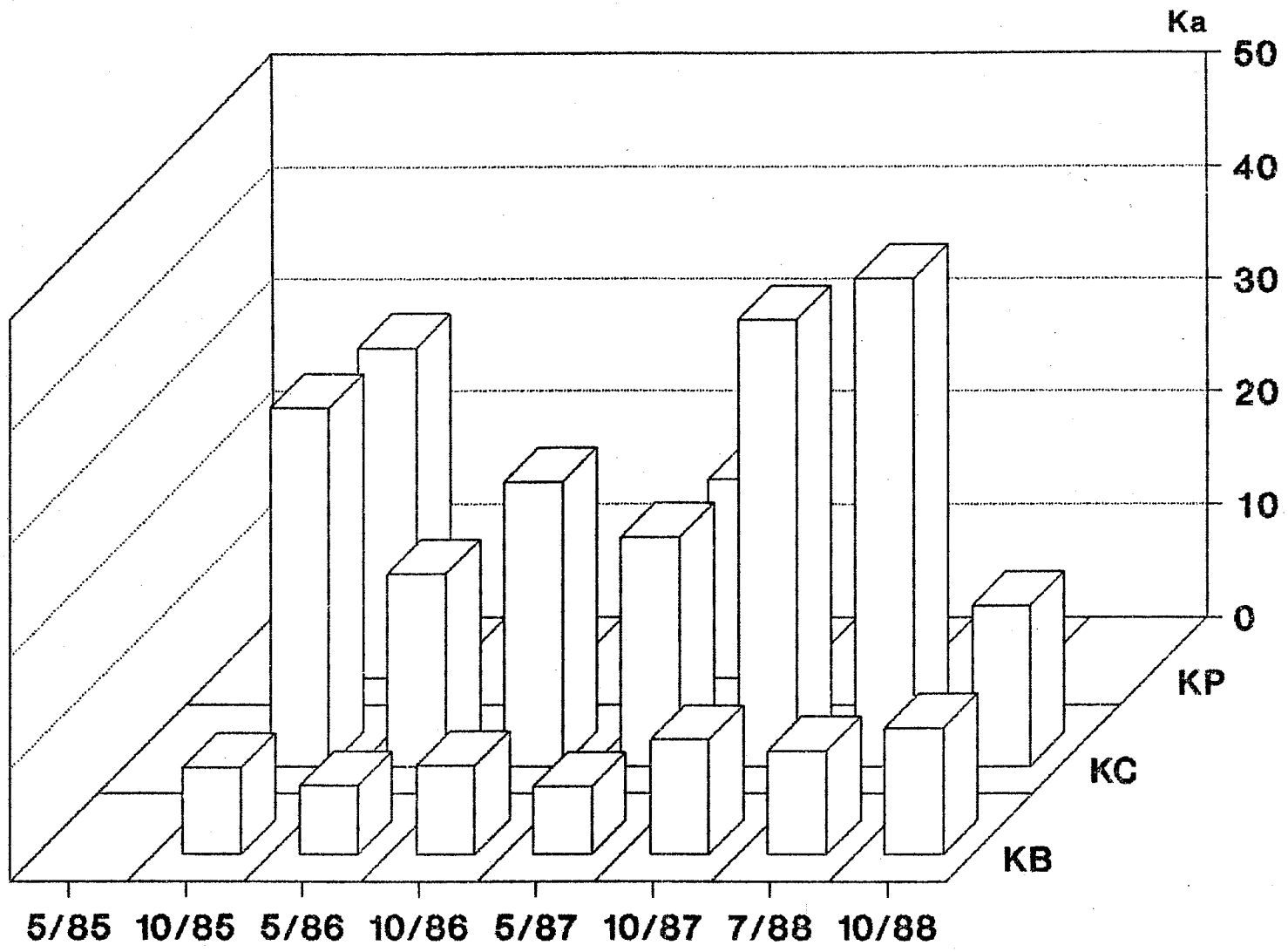

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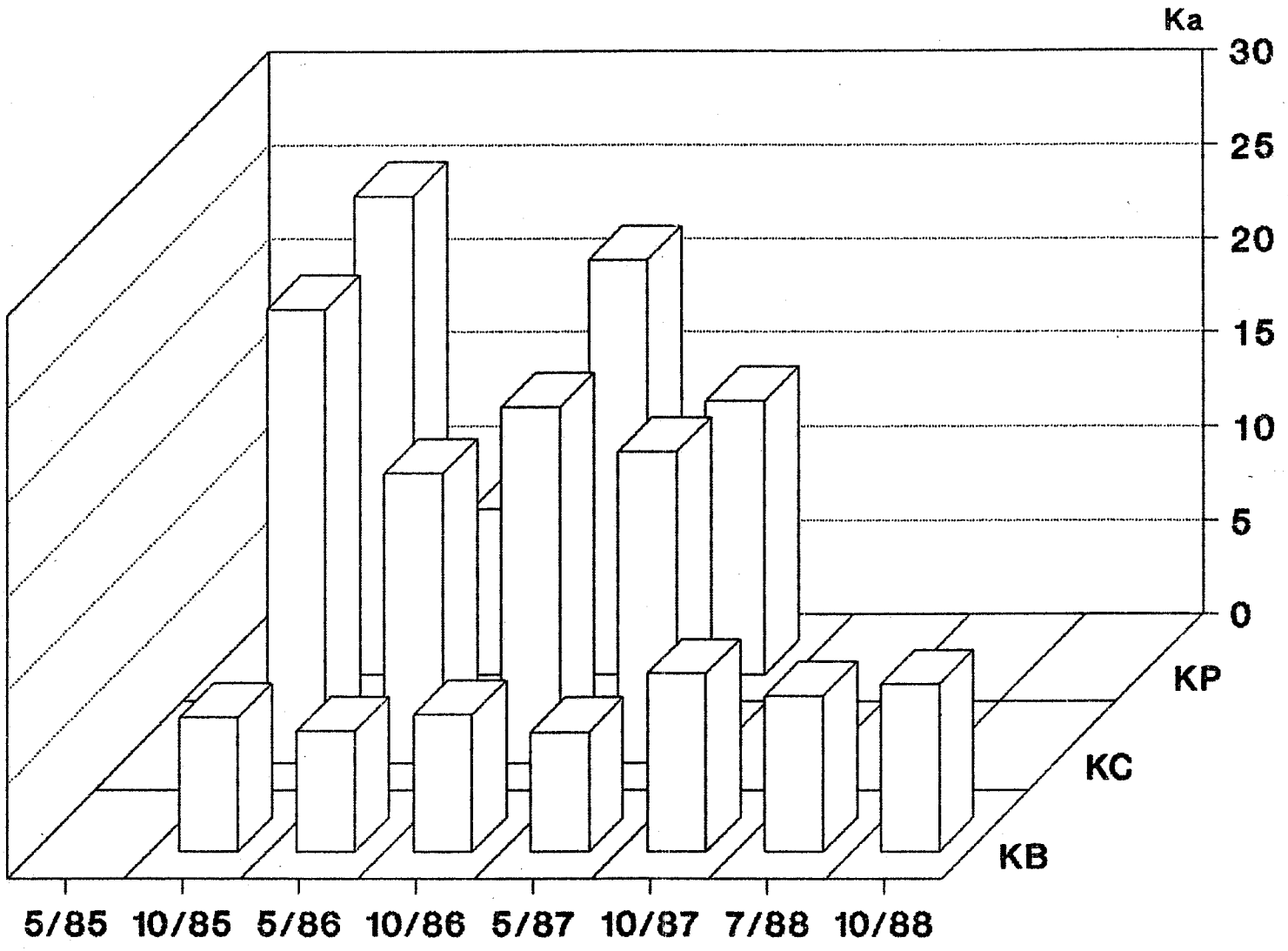

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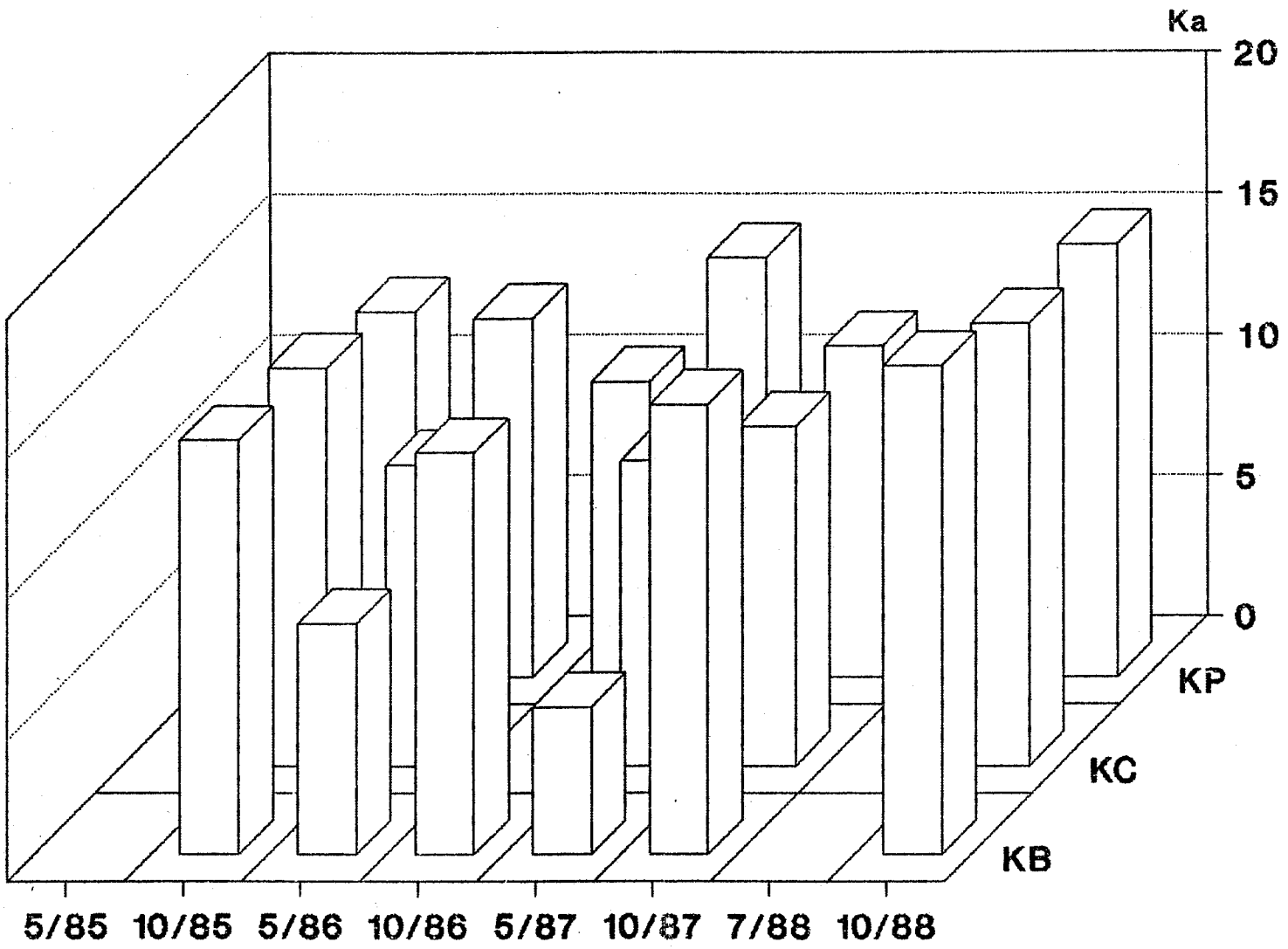

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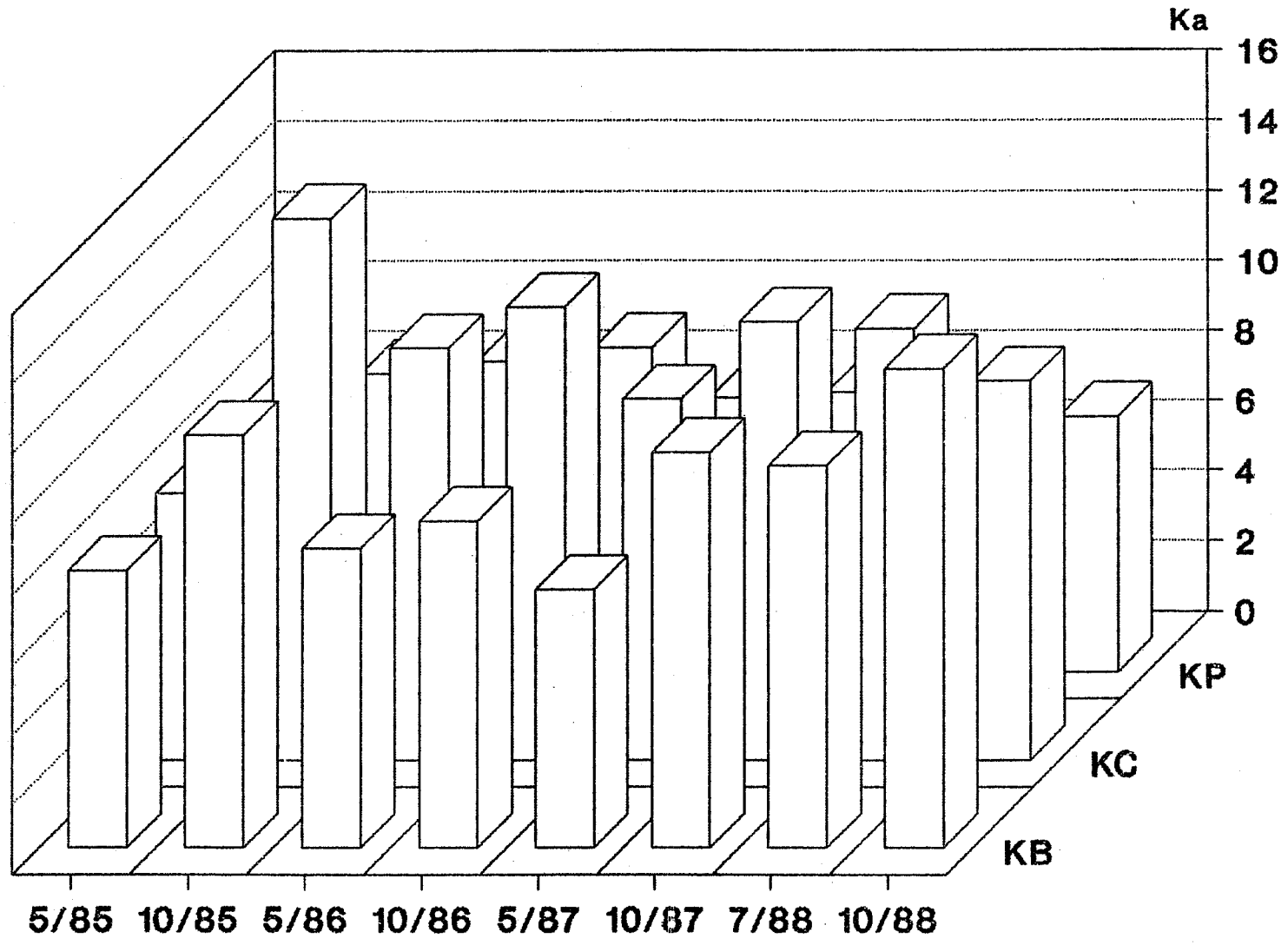

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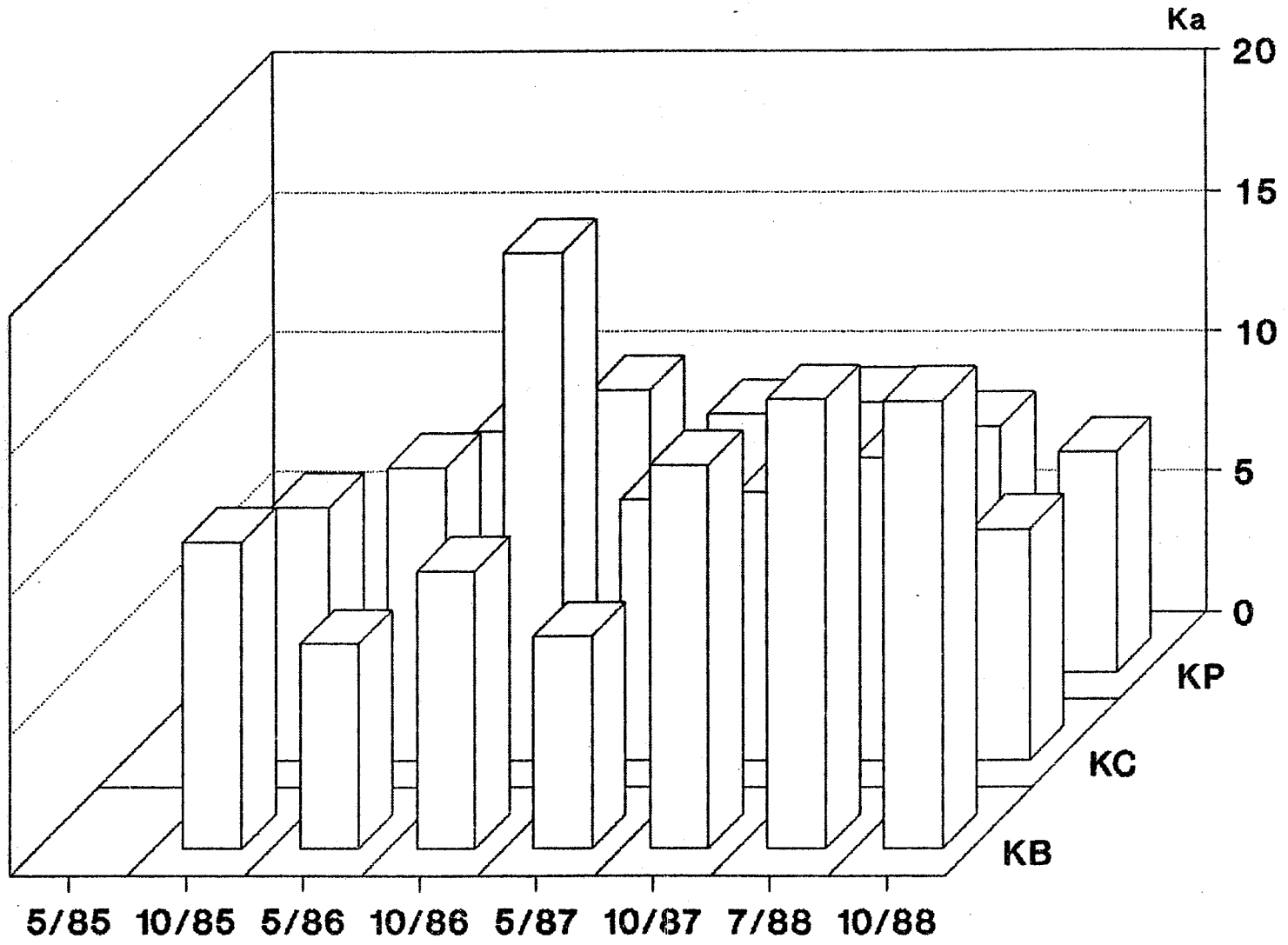

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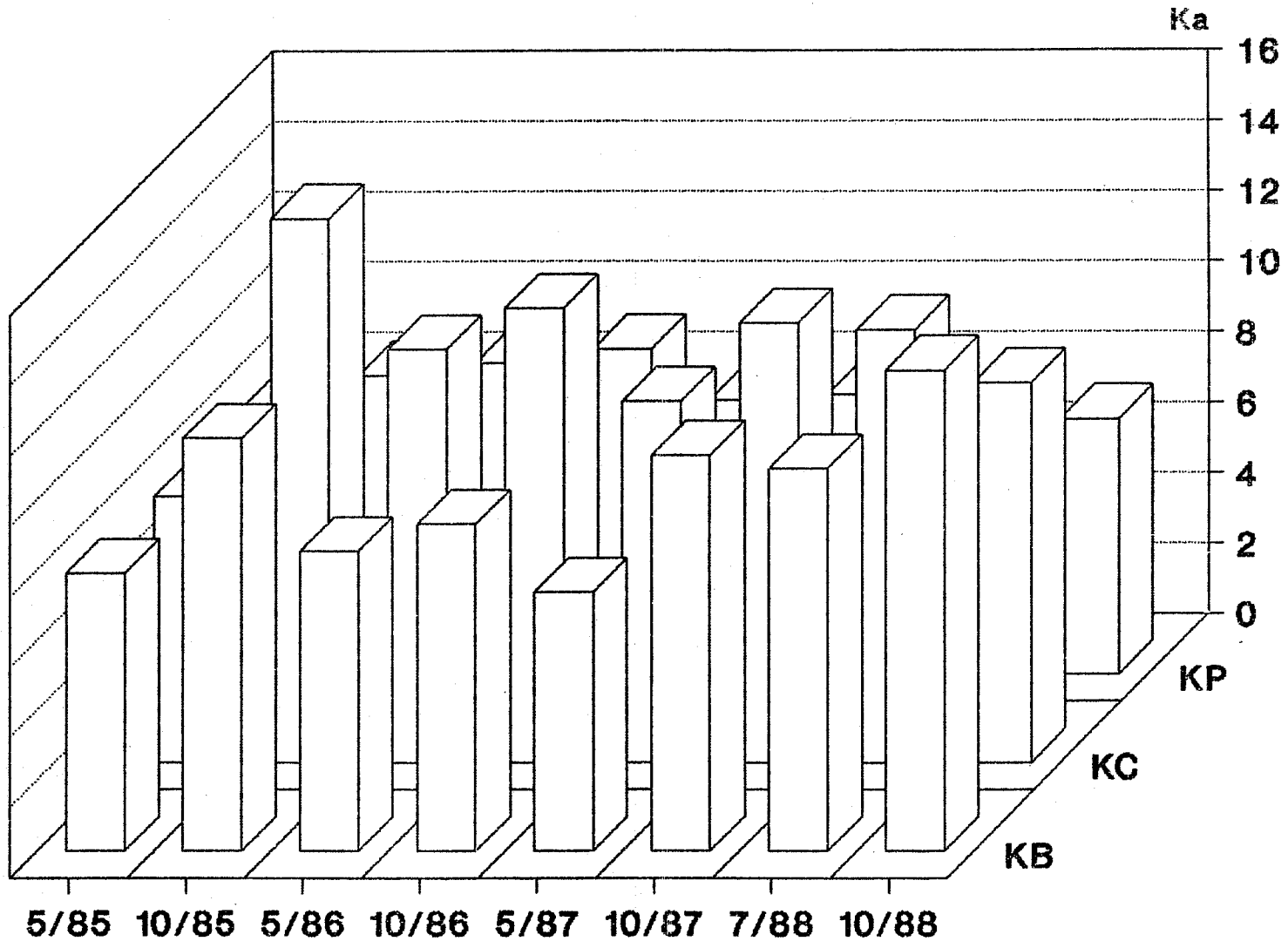

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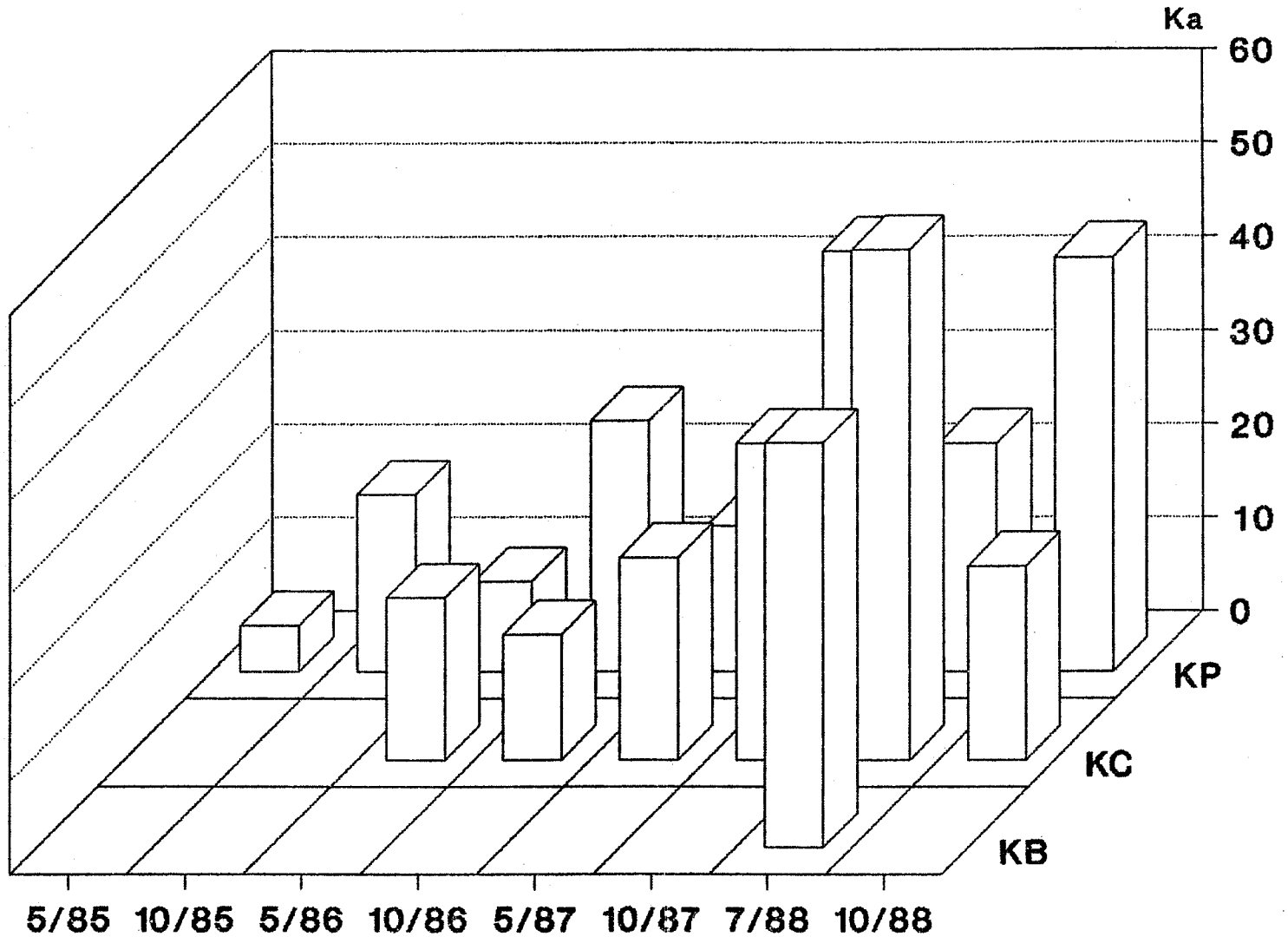

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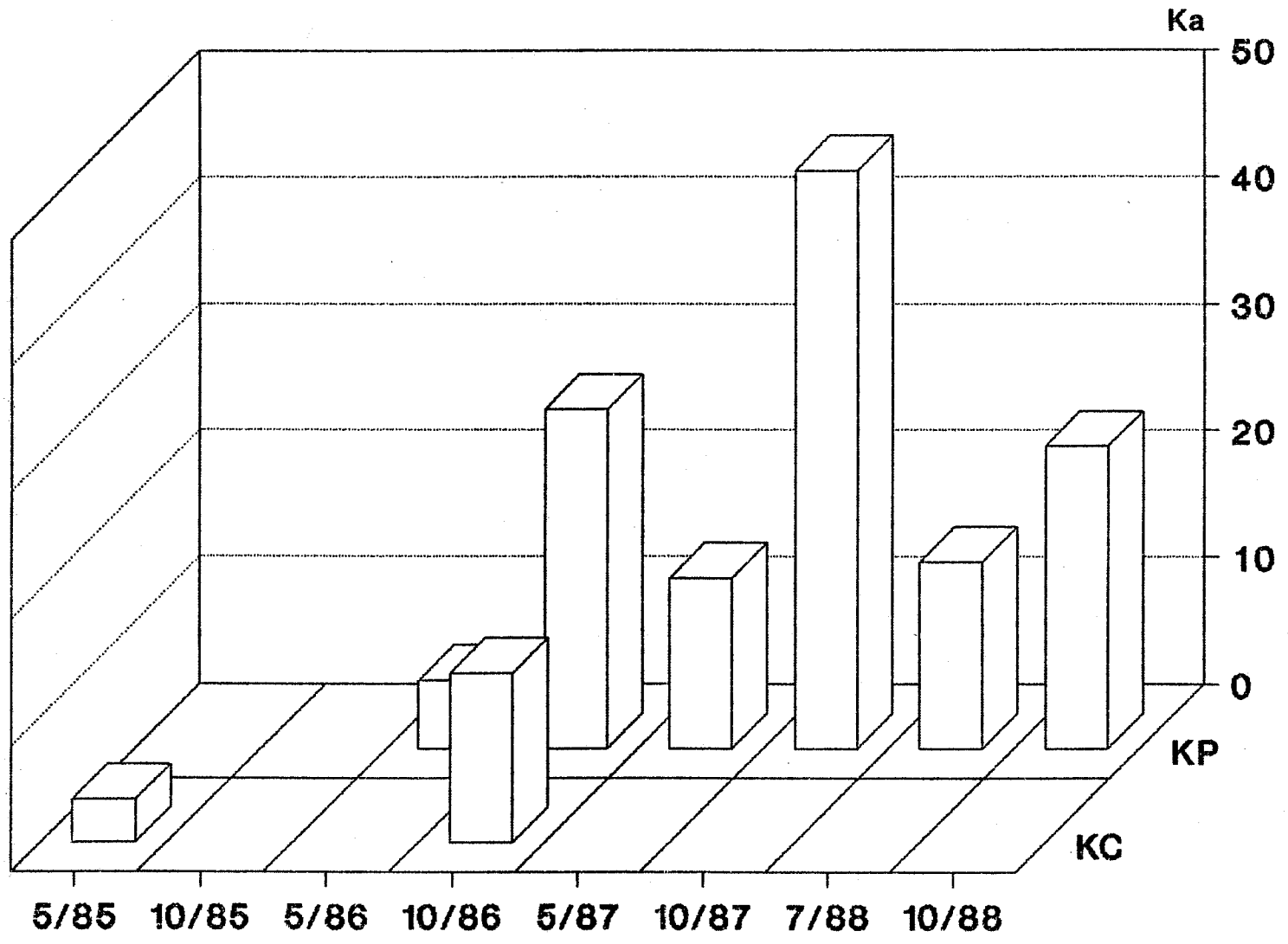

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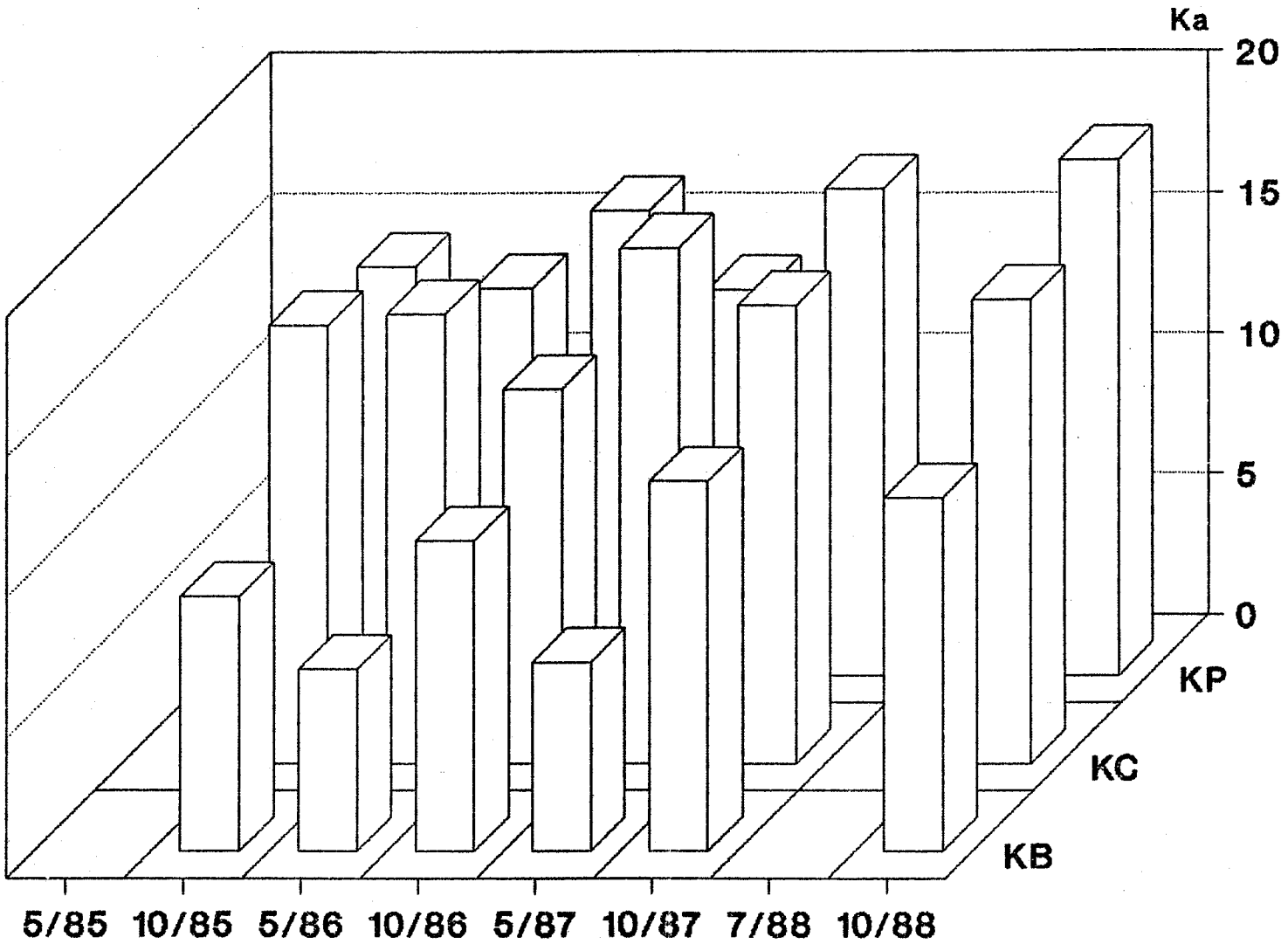

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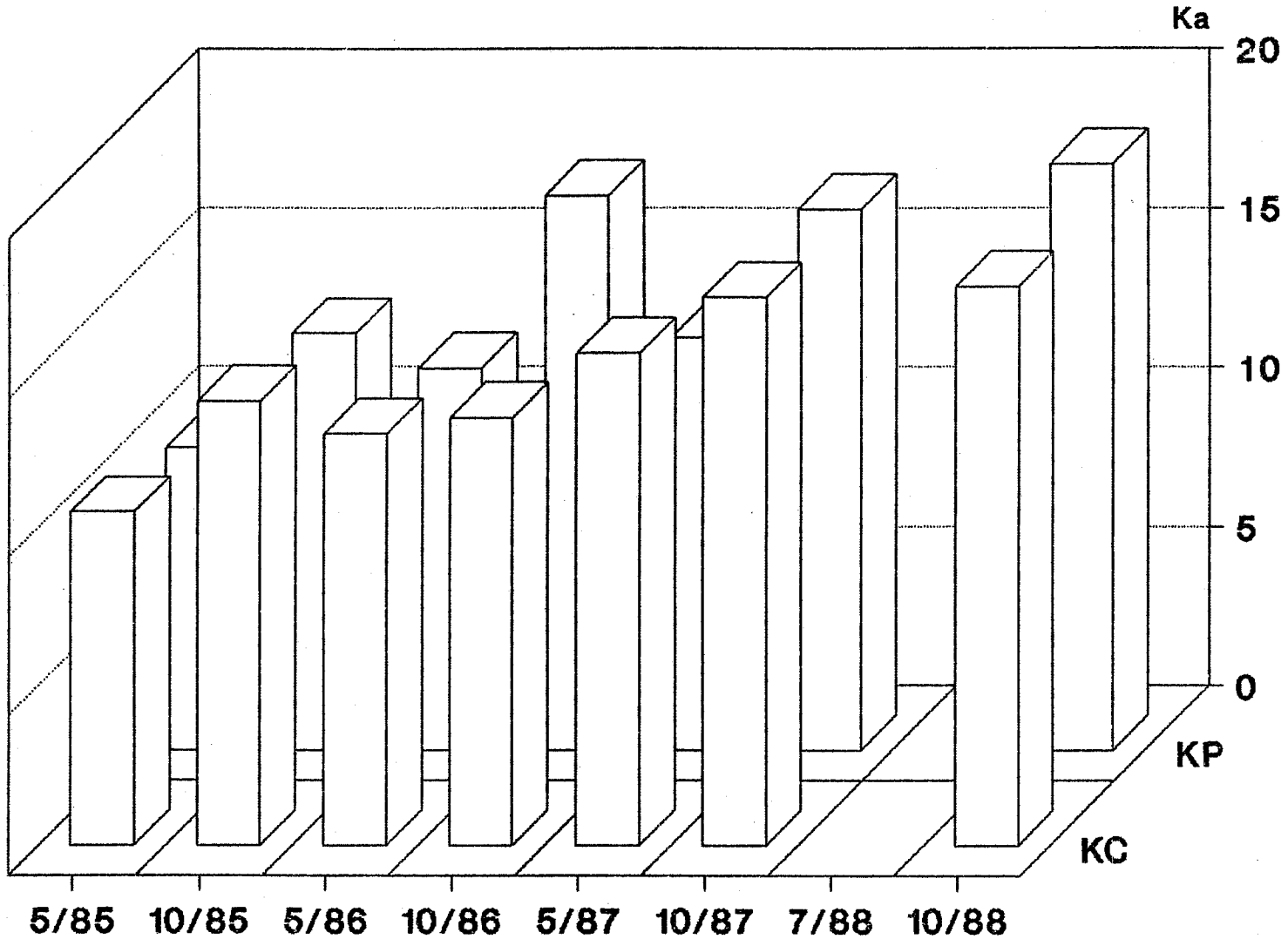

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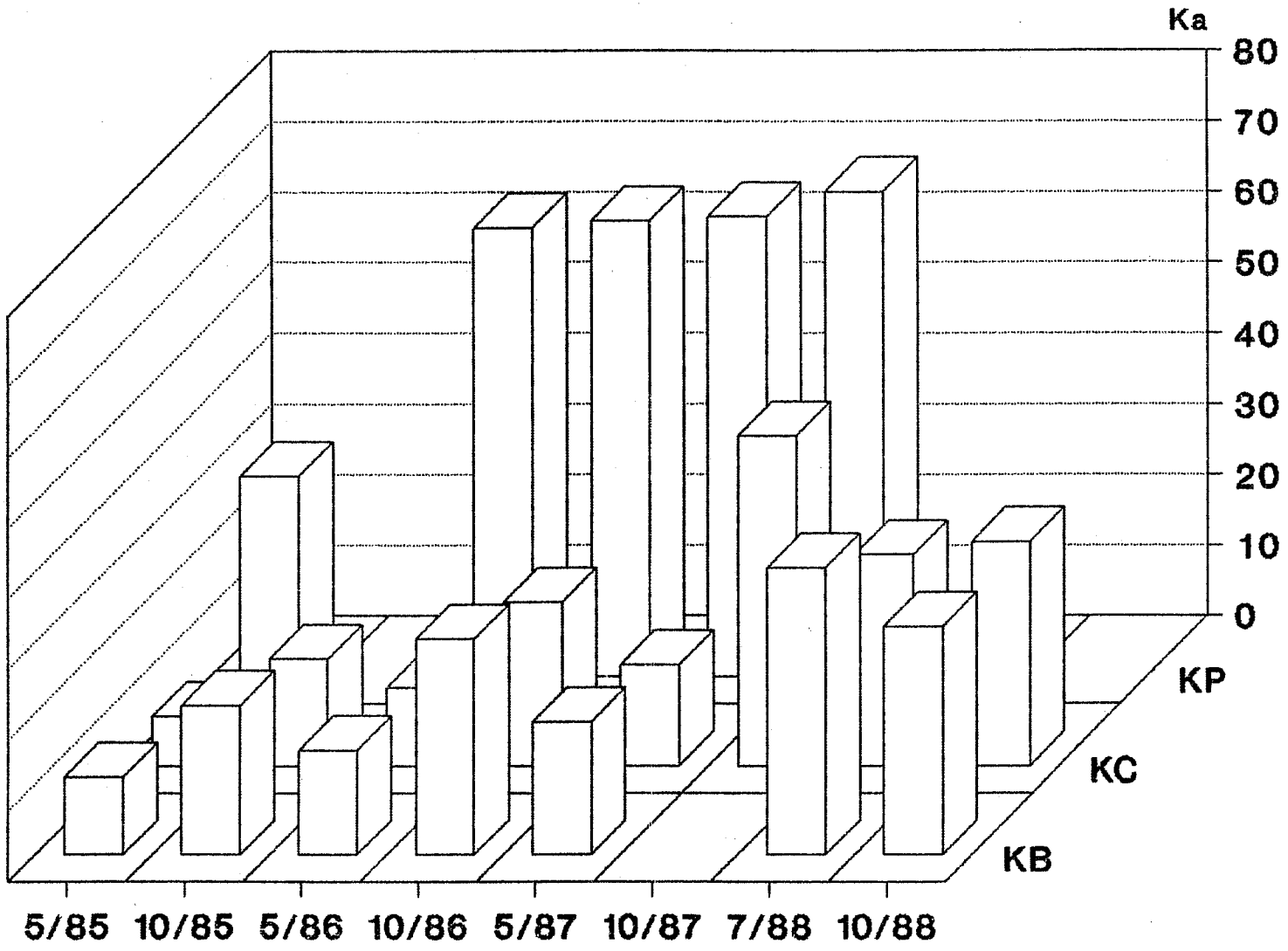
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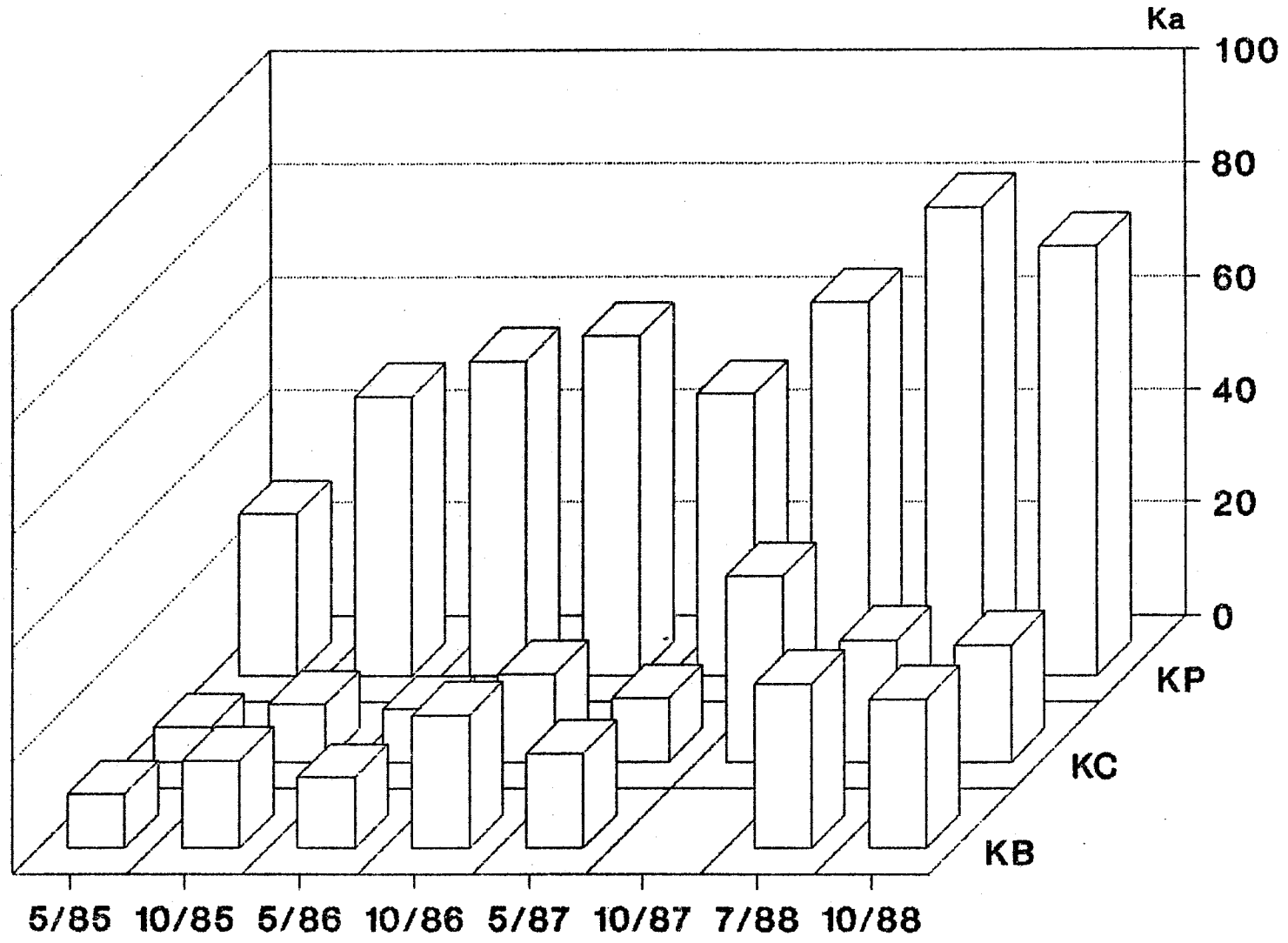

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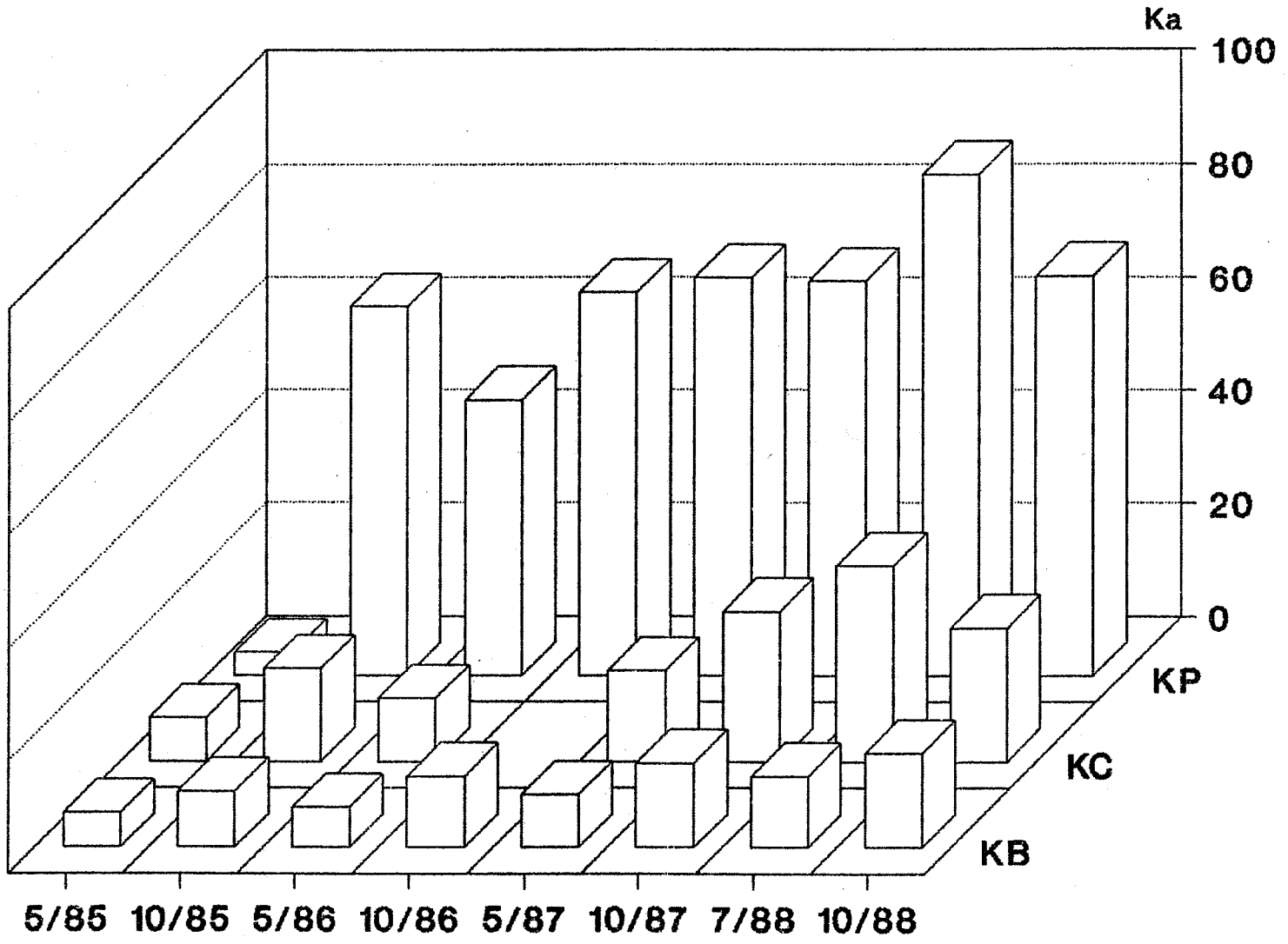

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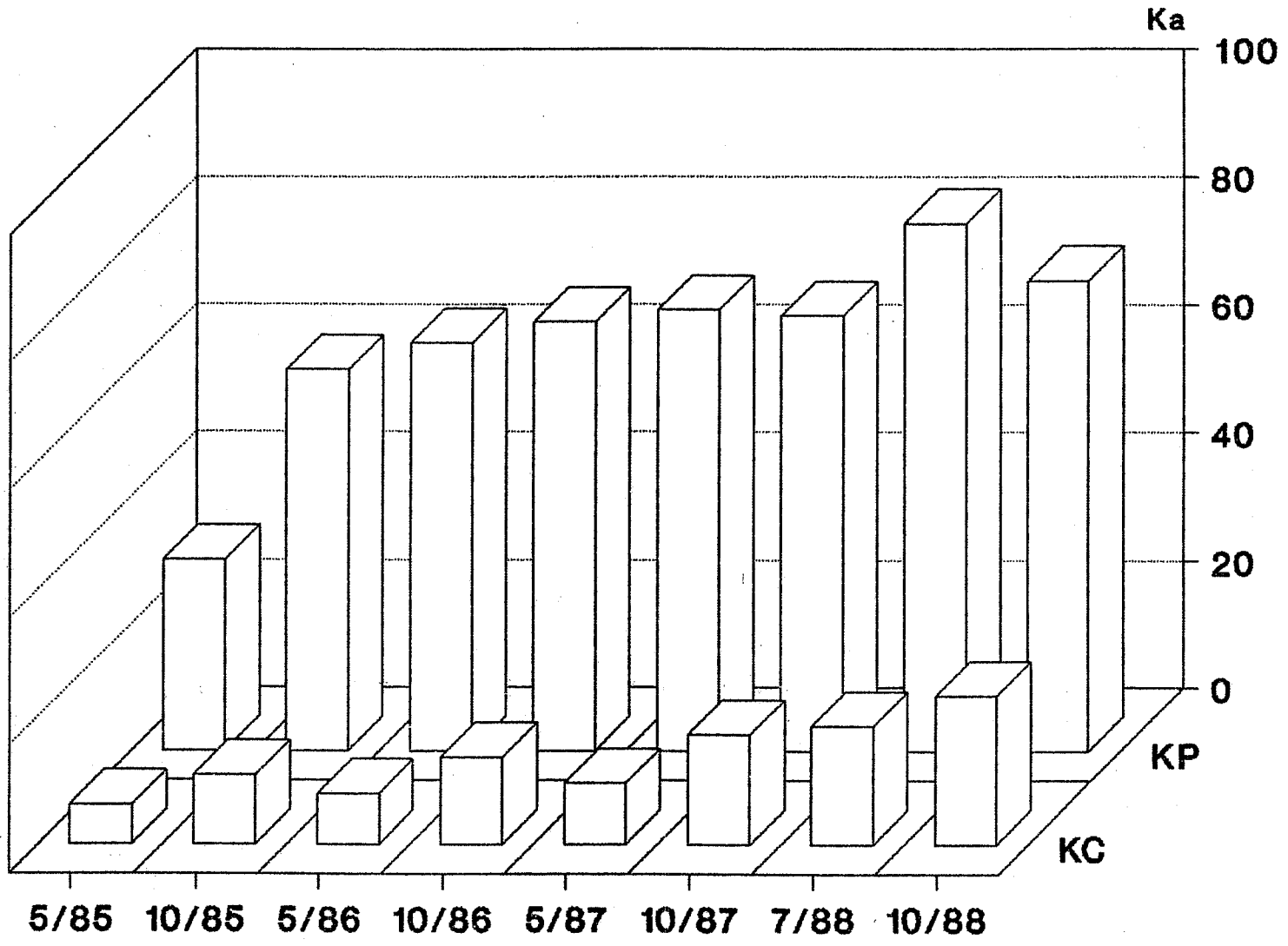

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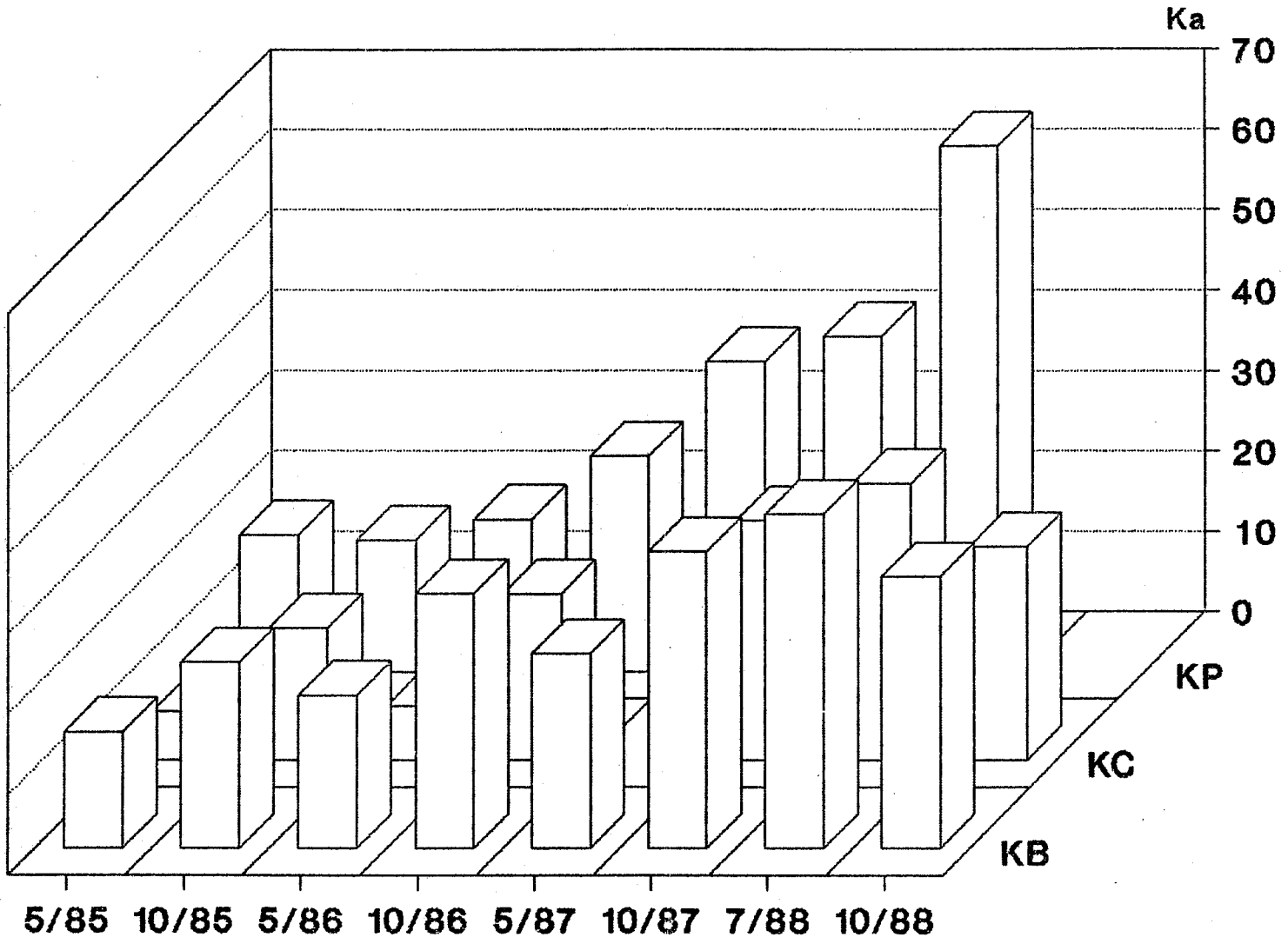
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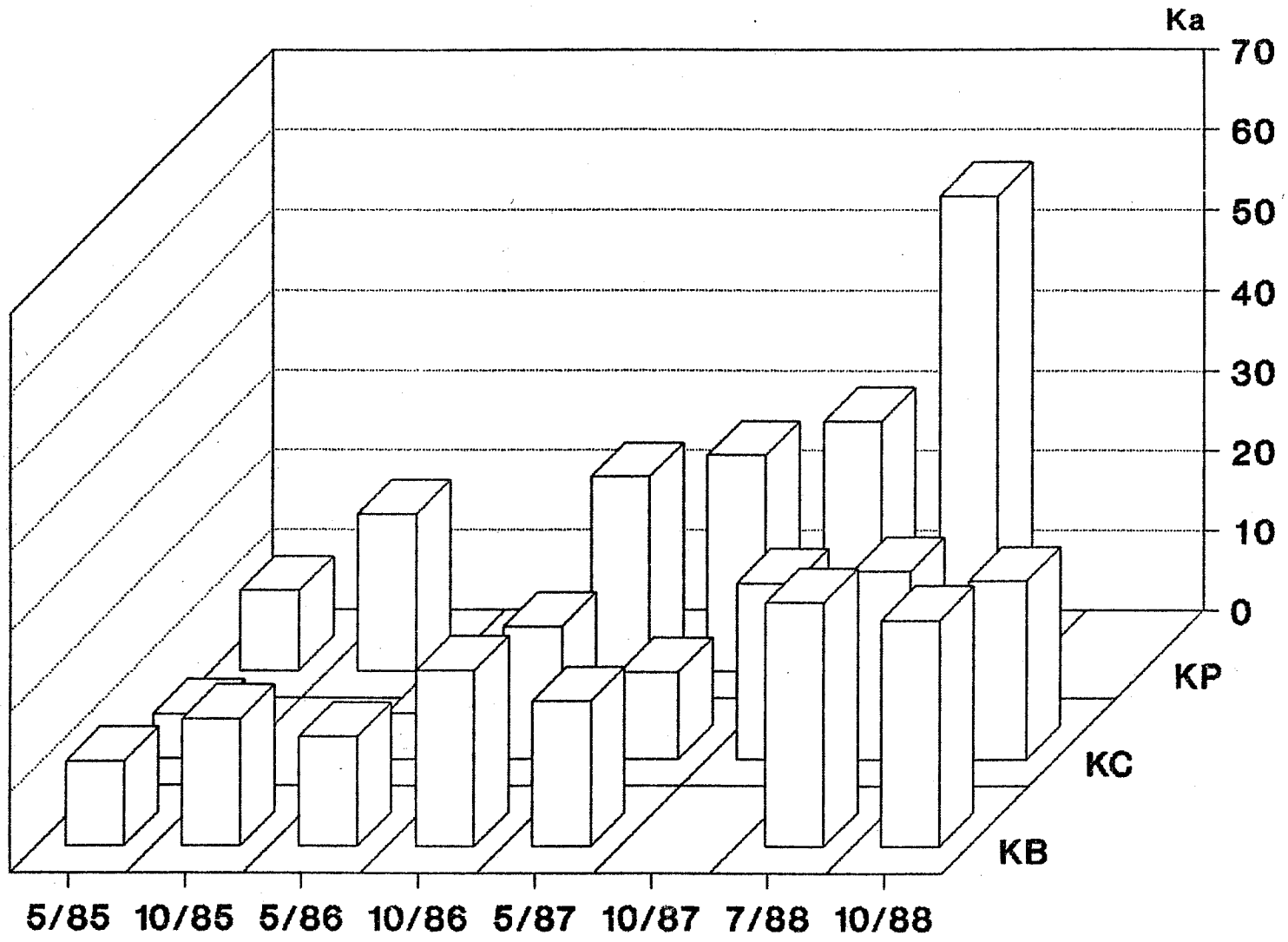
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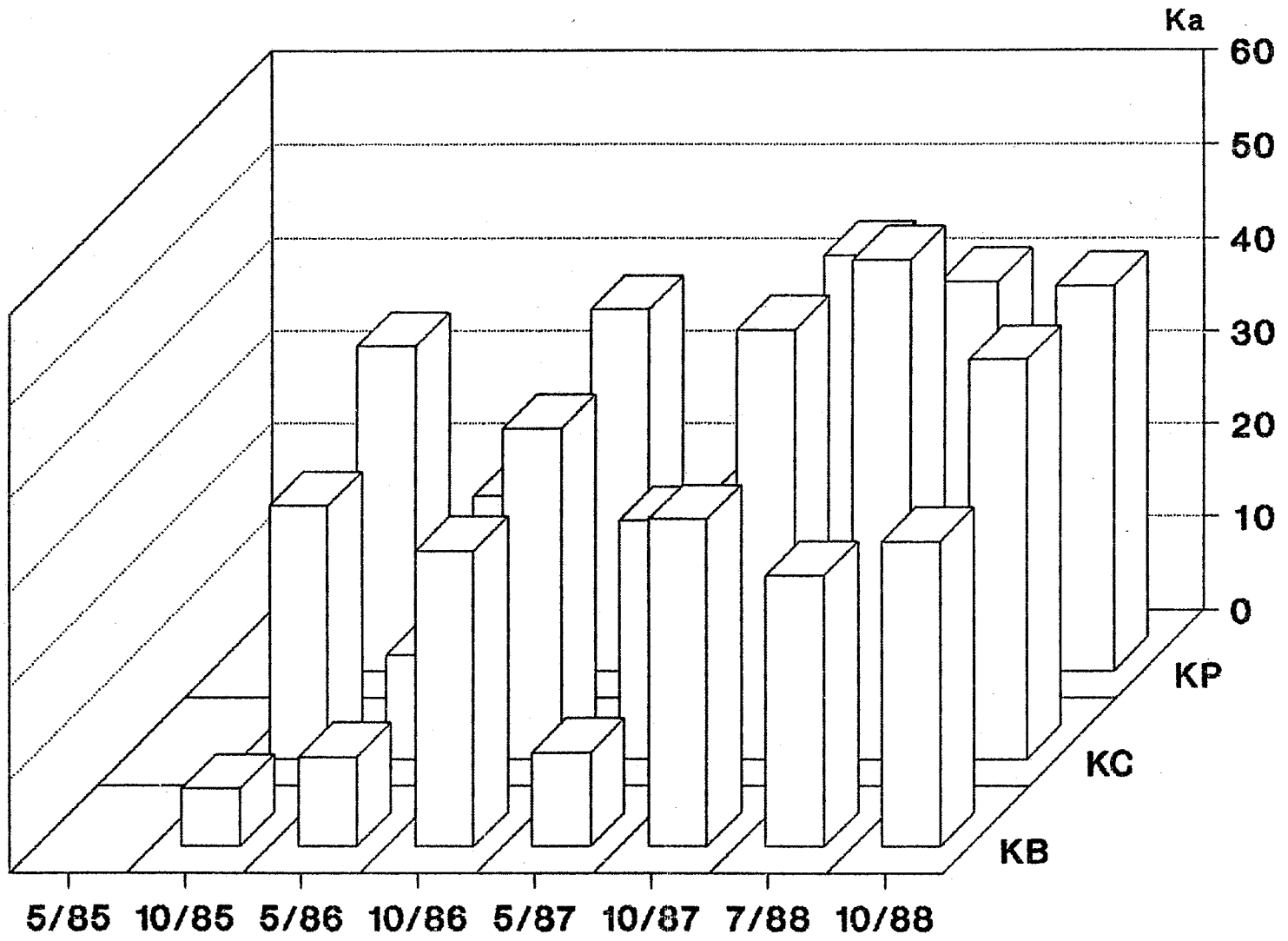
Site 7A 0-4.5'



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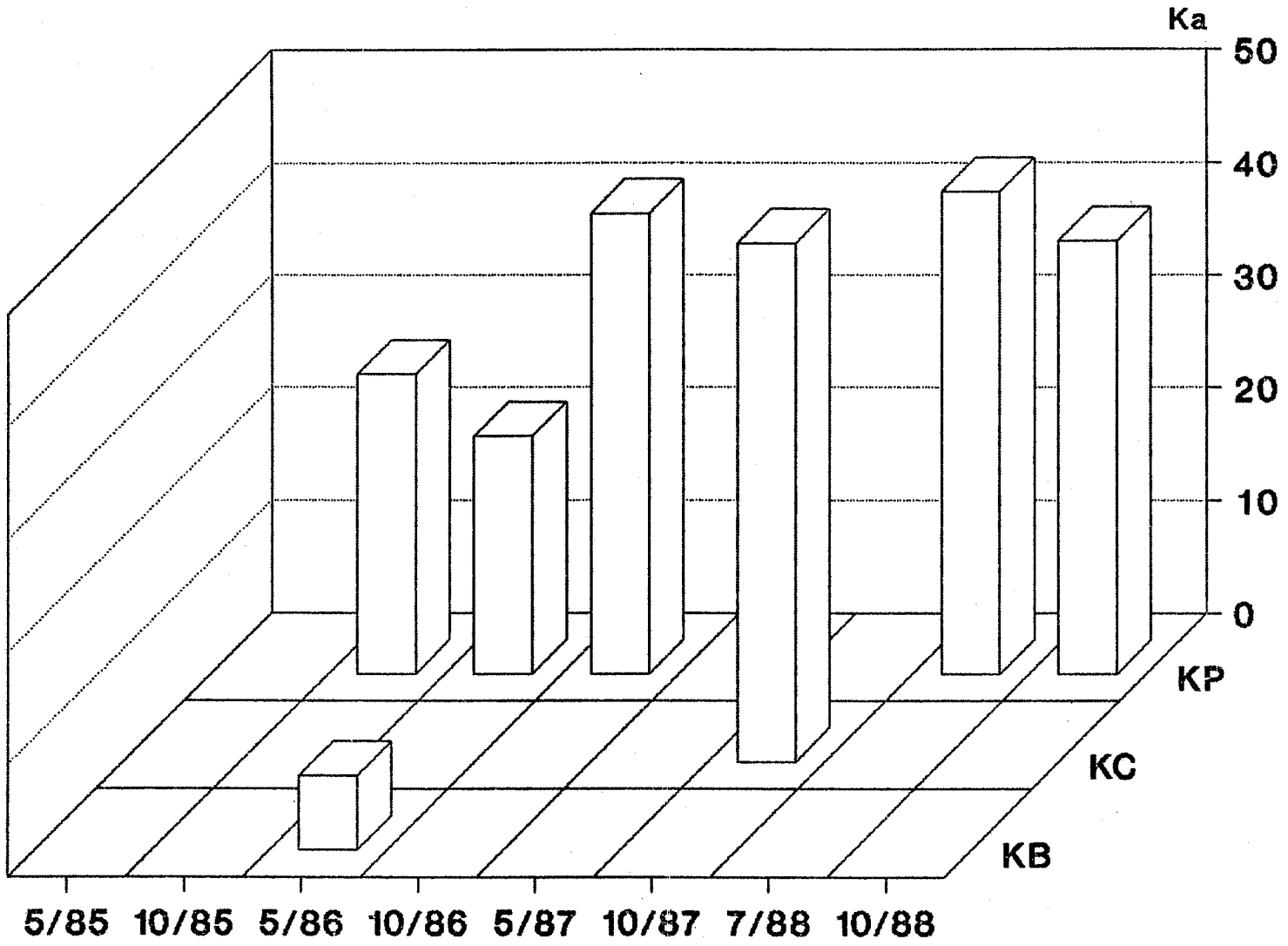

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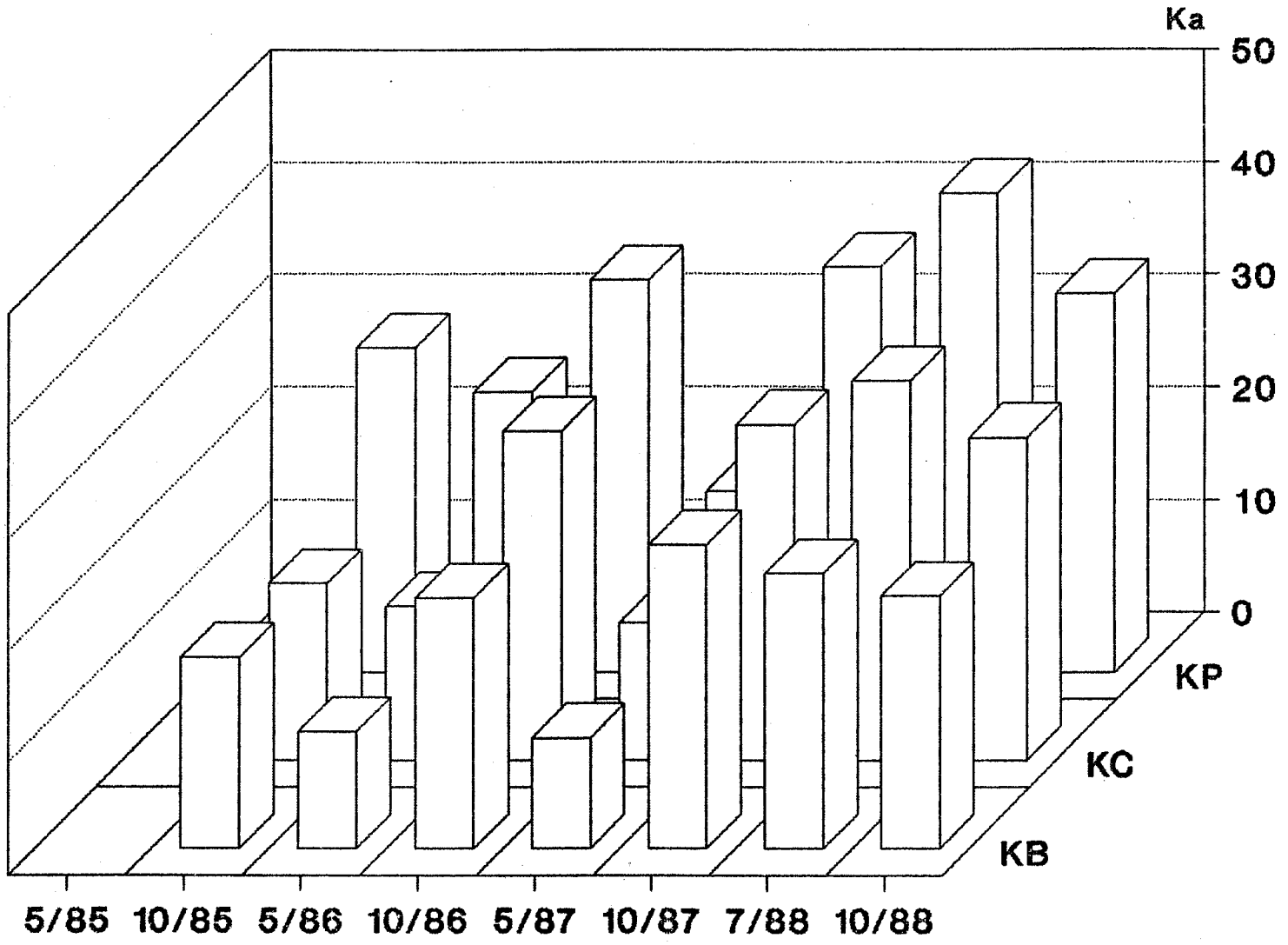

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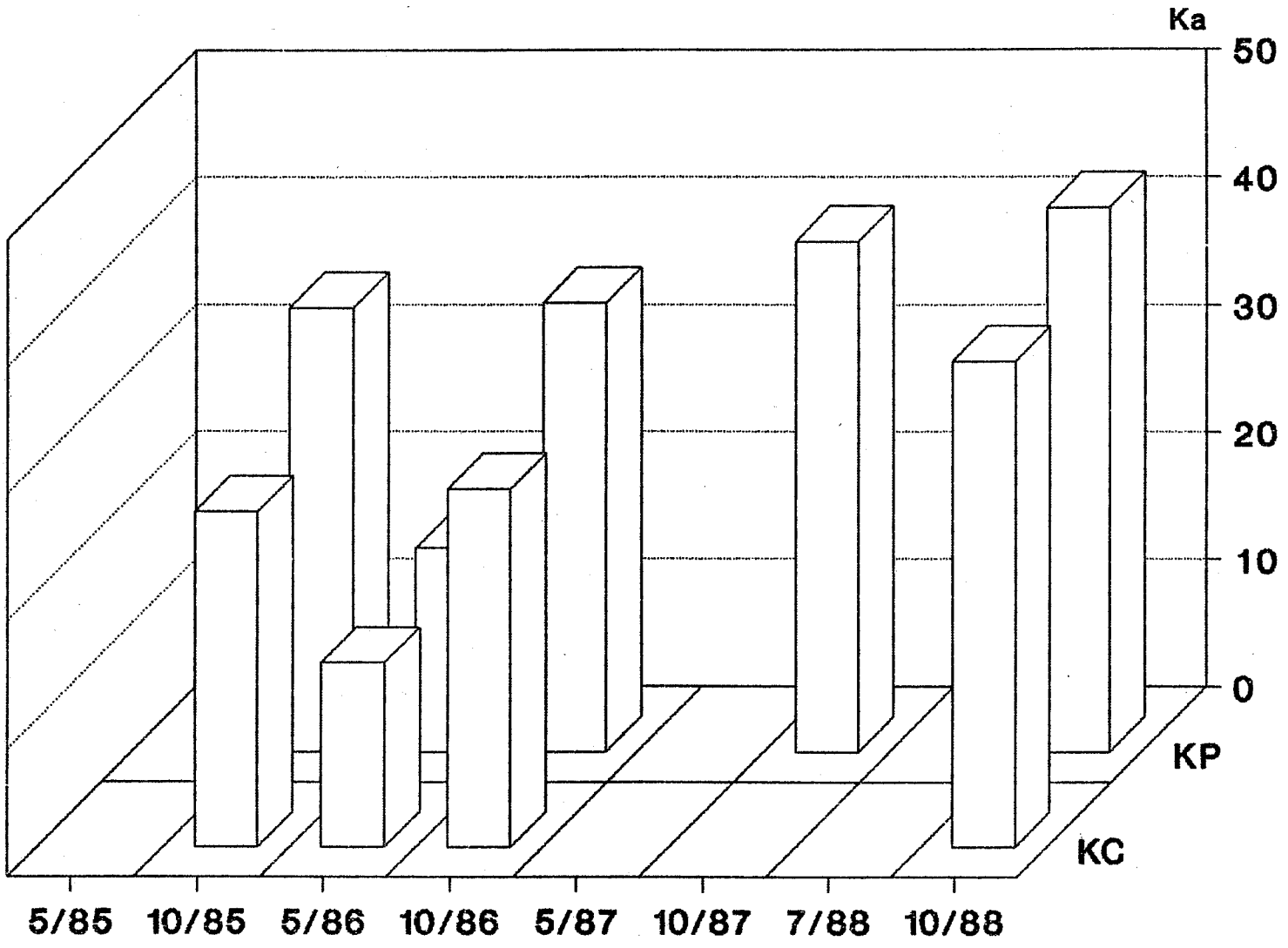

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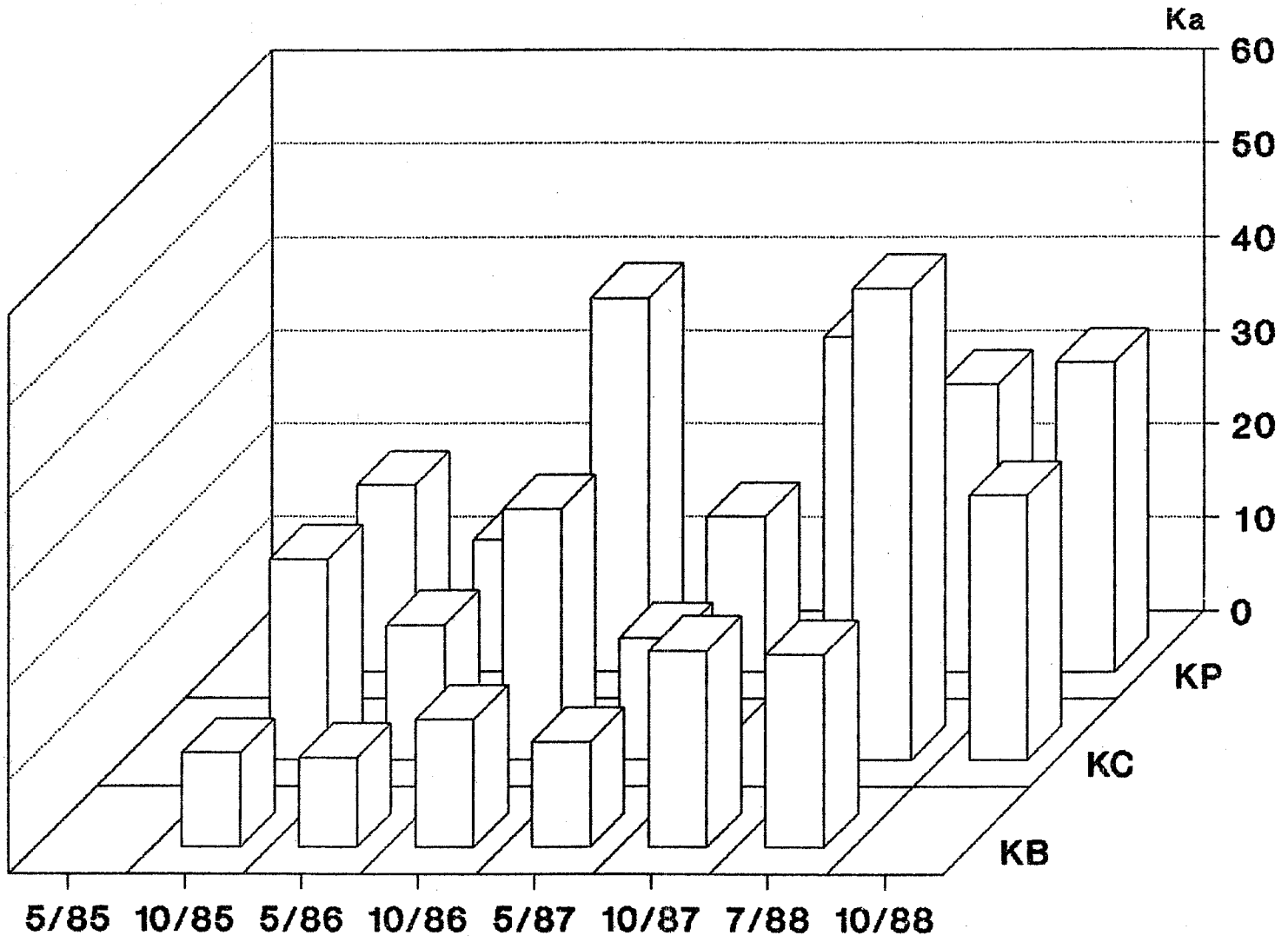

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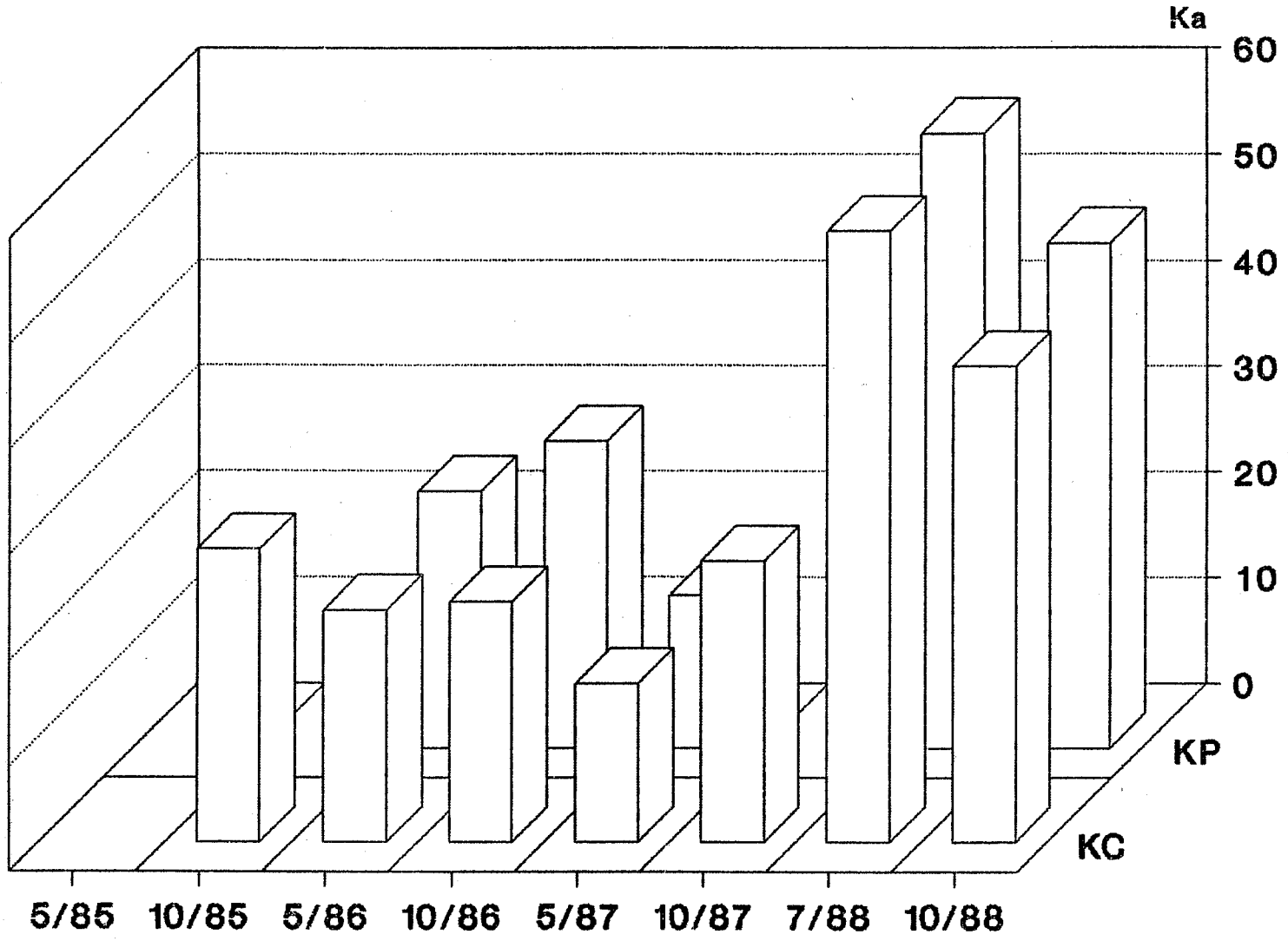

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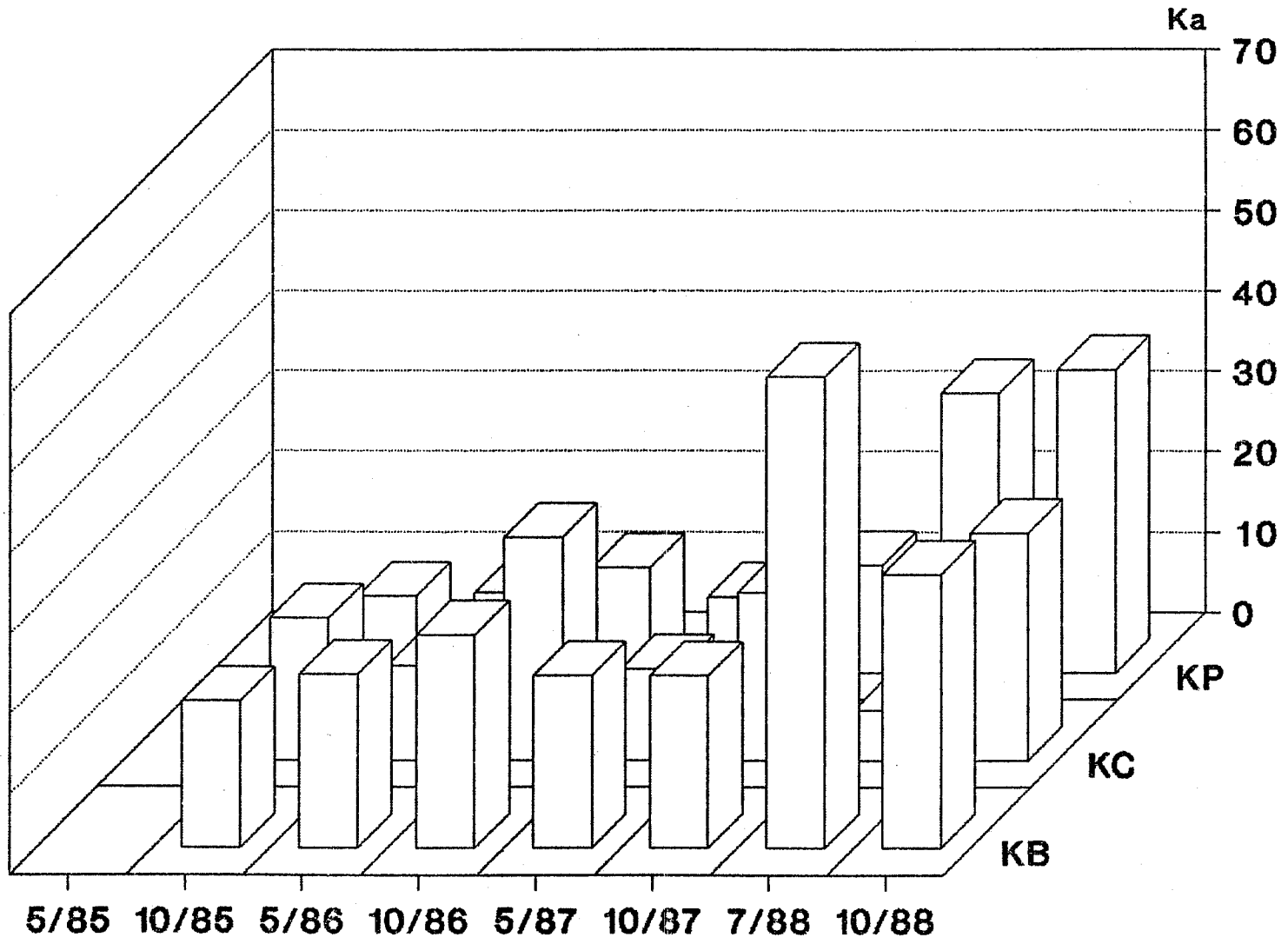
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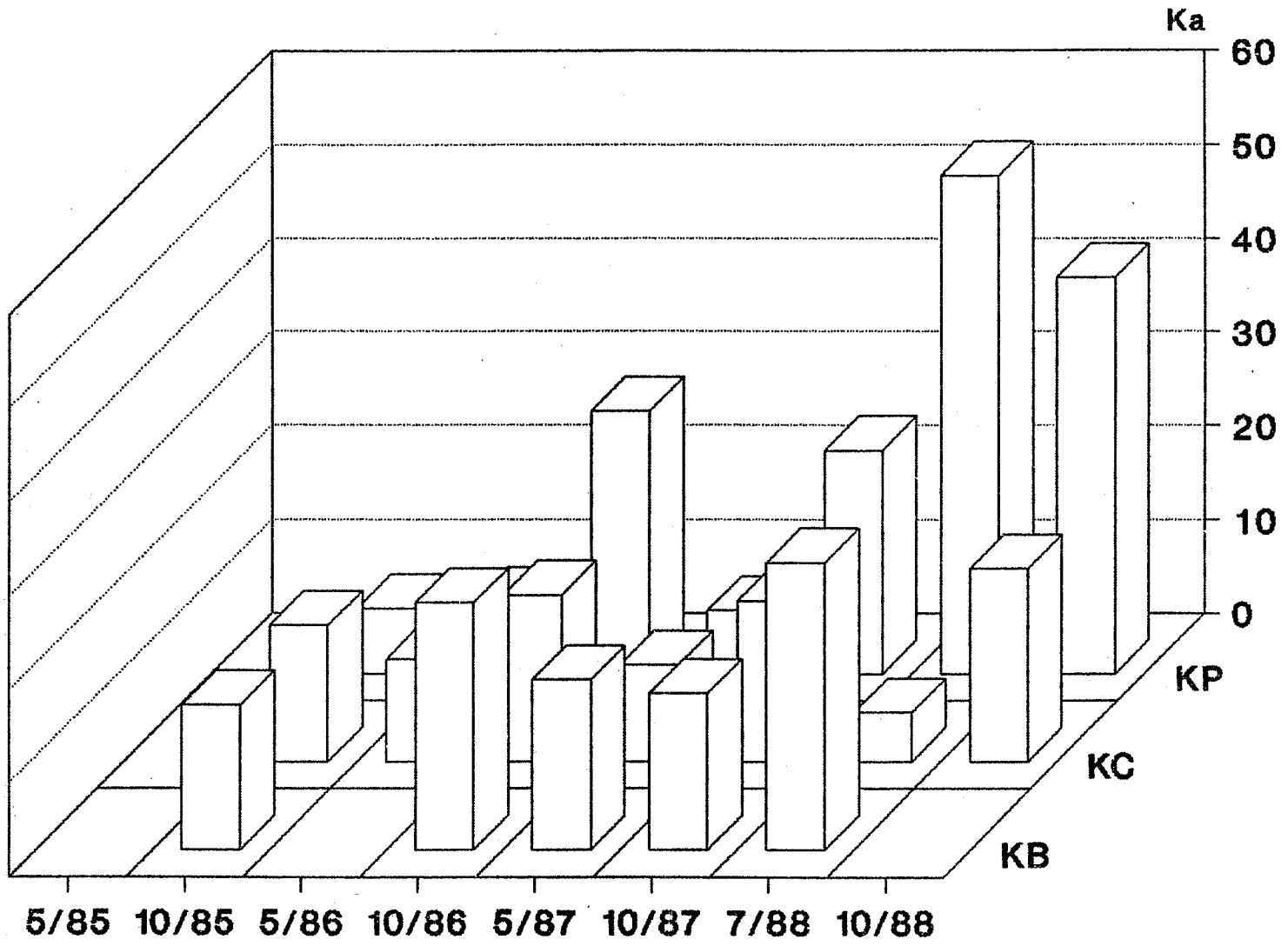

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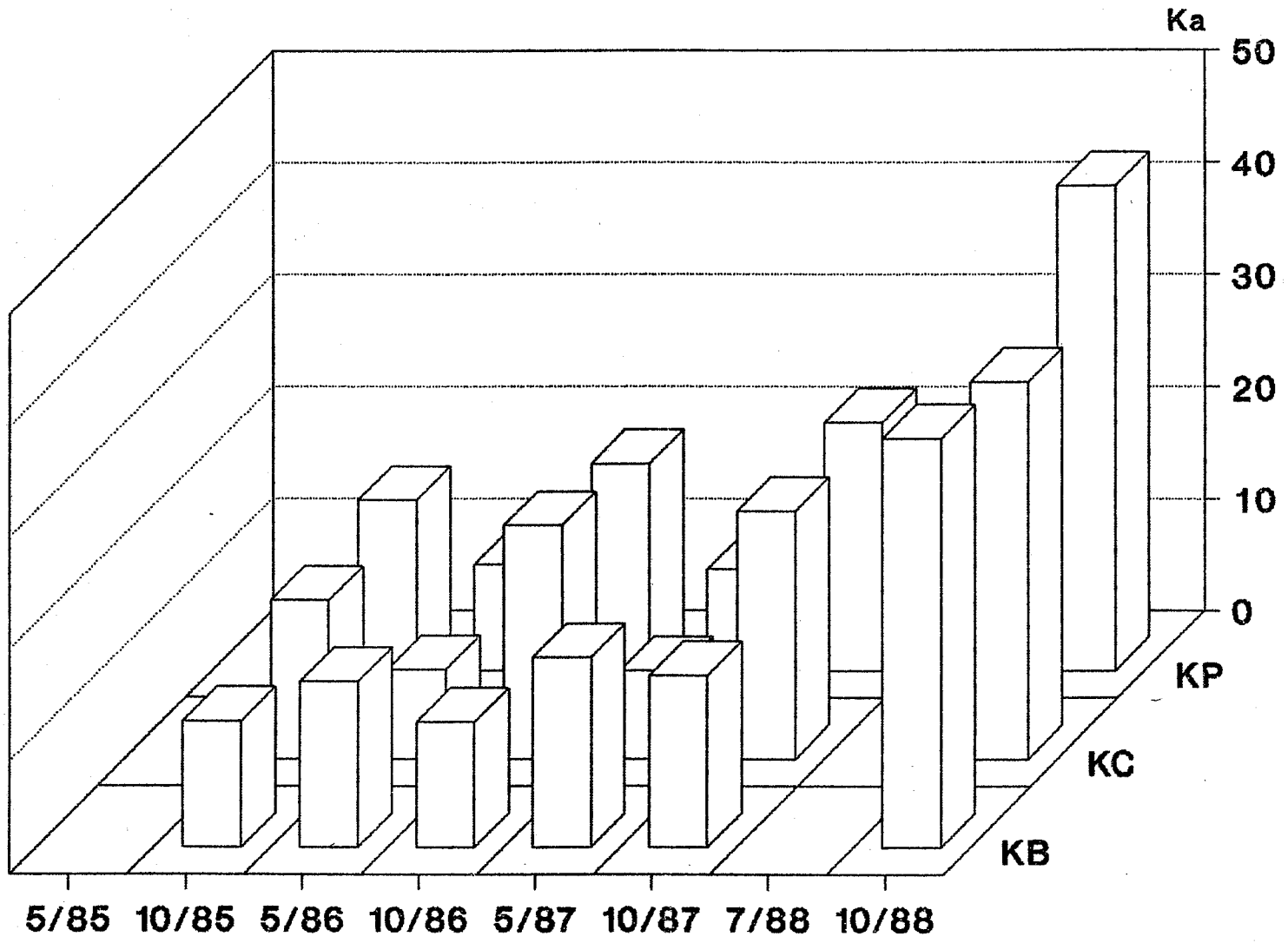

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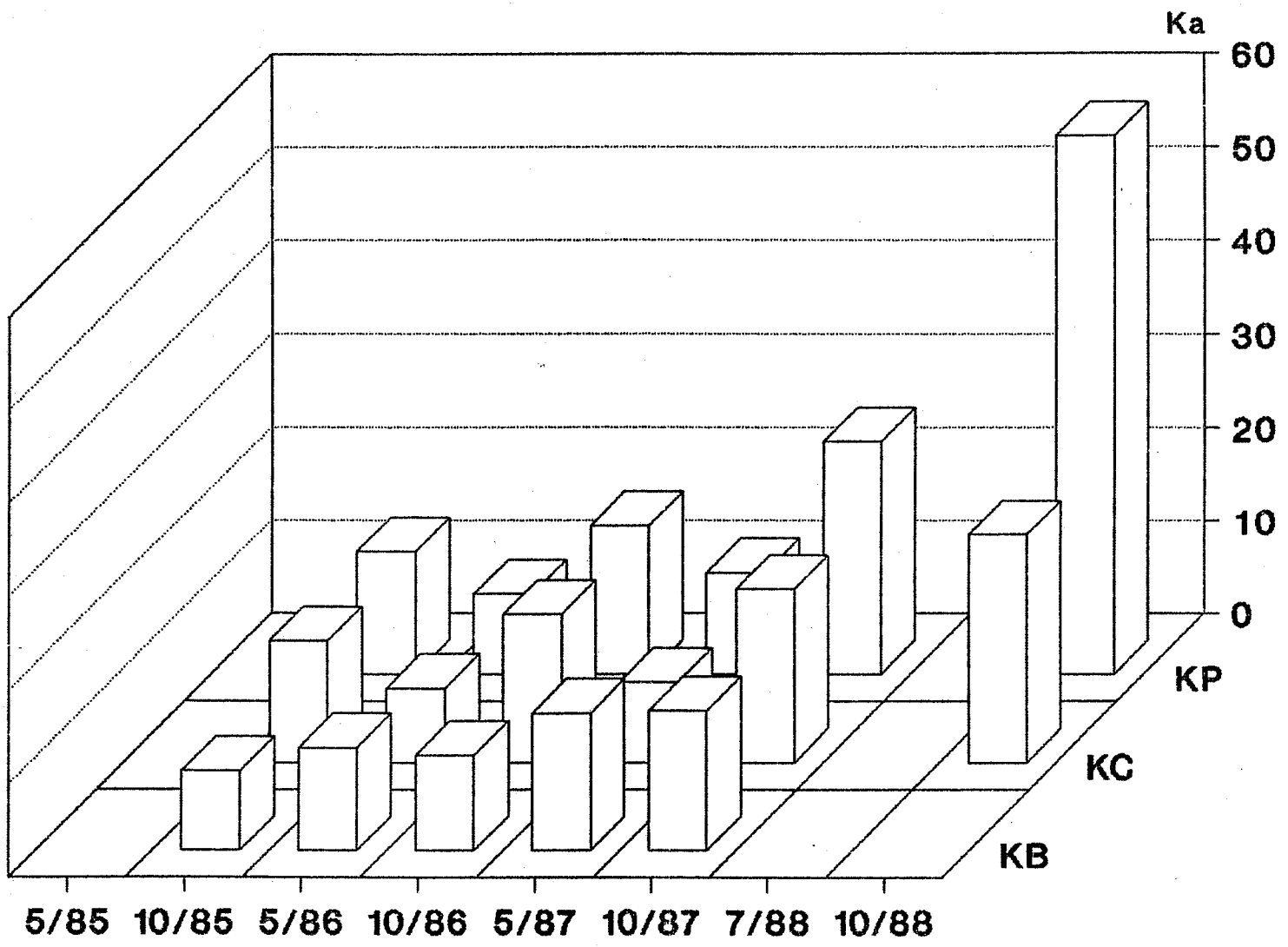

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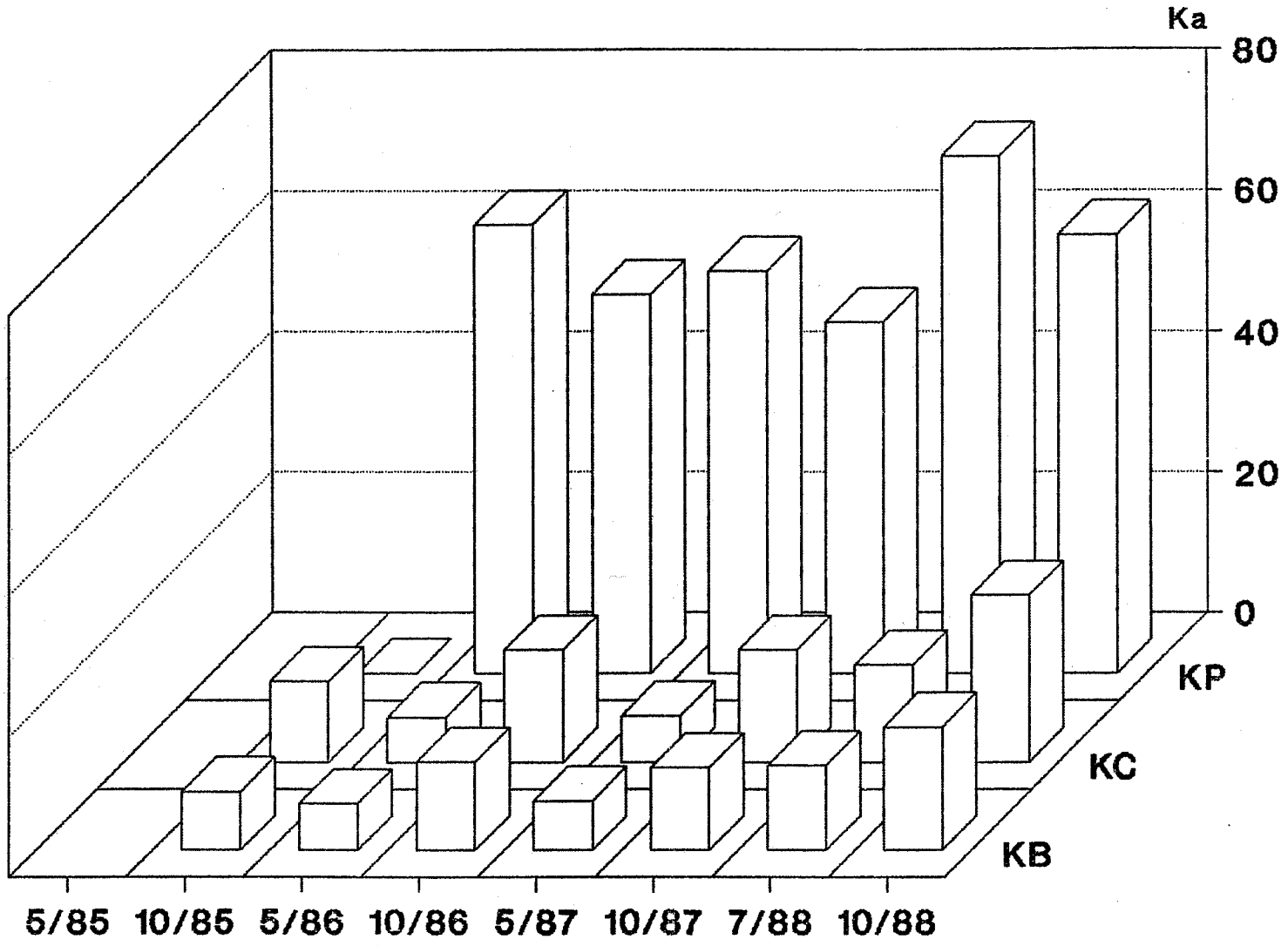

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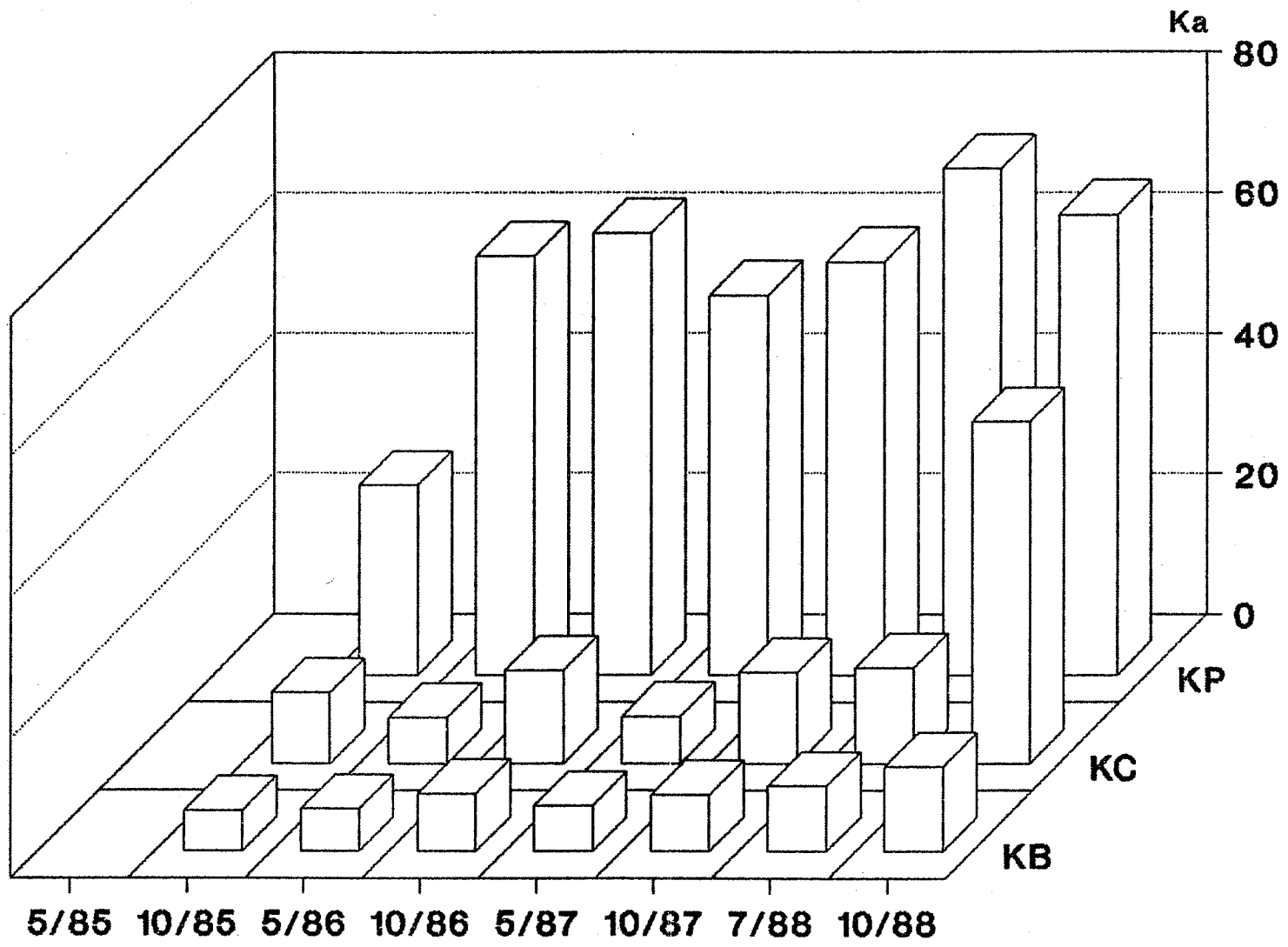

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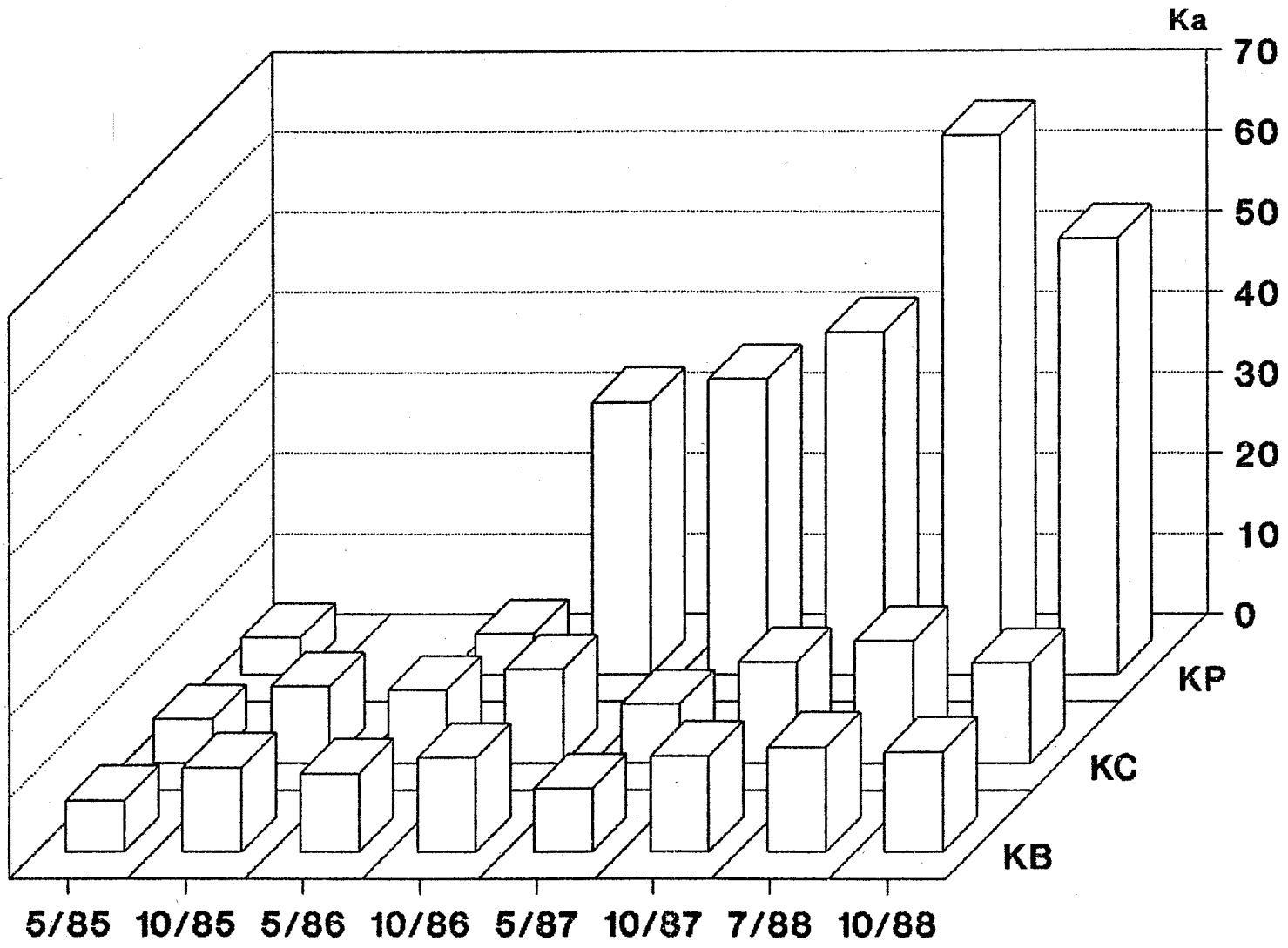
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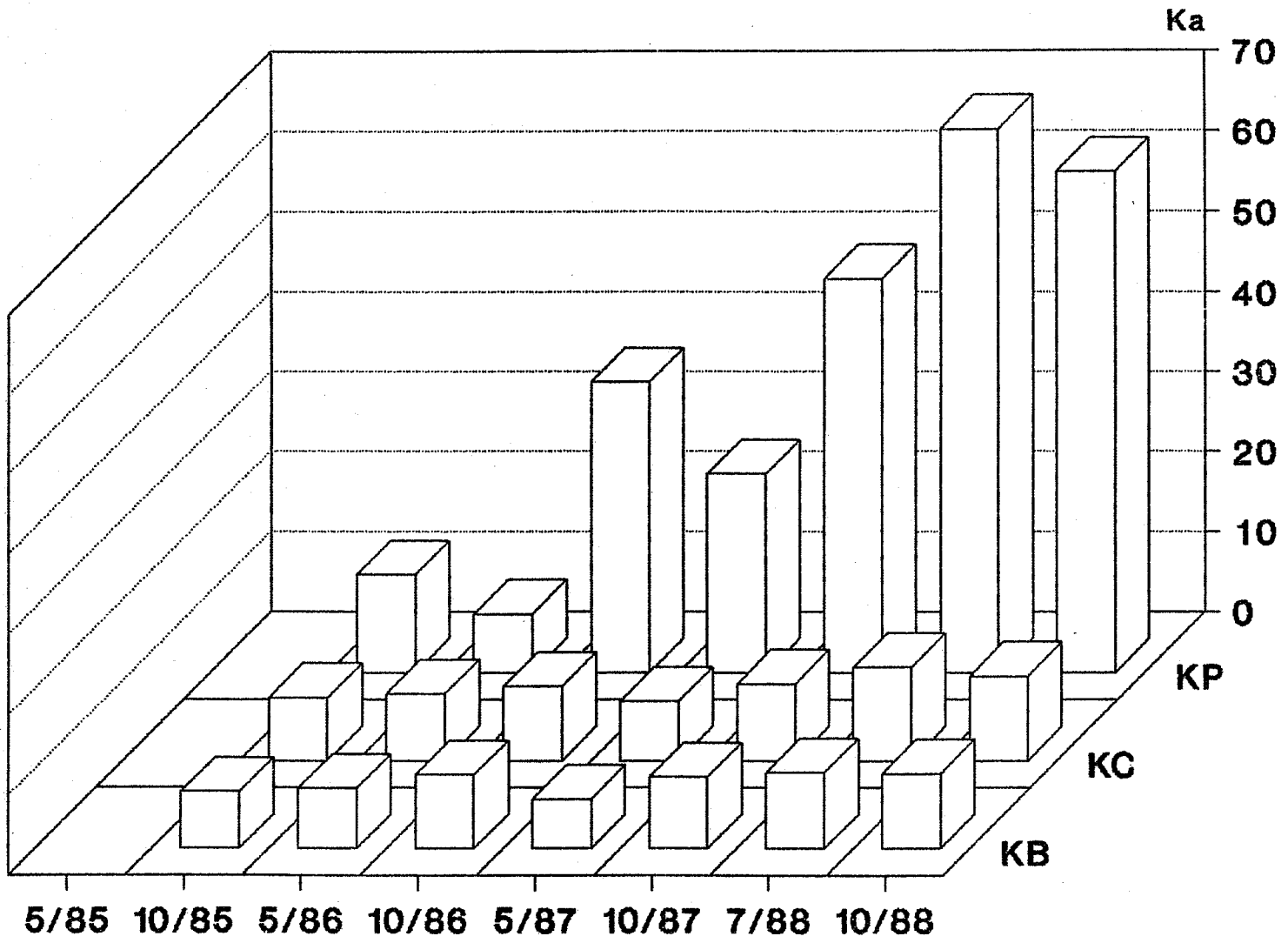
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Appendix I K Values for Norman Wells to Zama Pipeline Sites

Site	Probe	5/85	10/85	5/86	10/86	5/87	10/87	7/88	10/88
1-KB	1		6.8	10.3	4.3	6.0	5.0	8.8	
	2		17.4	6.9	14.0	6.0	23.0	21.2	23.5
	3		9.6	5.8	7.8	5.1	13.3	12.1	17.1
	4.5		7.7	6.1	7.9	6.0	10.2	9.2	11.3
	6		7.1	6.4	7.2	6.3	9.5	8.3	8.9
1-KC	1		41.5	64.1	8.2	66.2	20.0	63.7	
	2		46.7	27.7	28.0	31.0	40.7	67.2	
	3		42.2	24.4	28.7	25.4	34.7	56.2	
	4.5		31.8	17.1	25.2	20.3	39.6	43.3	14.3
	6		24.2	15.5	18.9	16.6			
1-KP	1		40.9	44.8	6.0	60.6	14.2	66.5	
	2		46.2	29.1	22.5	34.6	33.1	56.9	
	3		42.2	25.0	23.9	27.7	30.3	14.3	
	4.5		29.3			17.6			
	6		25.5	8.9	22.1	14.6			
2A-KB	1		7.8	9.9	6.7	8.6	8.6		
	2		9.7	6.9	9.6	12.3	11.7		11.3
	3		11.9	8.3	12.2	10.0	14.2		16.1
	4.5		14.7	8.2	14.3	5.2	16.0		17.3
	6		11.9	8.0	10.3	9.4	16.1		17.4
2A-KC	1	14.5	10.3	30.2	5.0	24.1	7.5		7.7
	2	13.5	10.2	15.6	7.9	6.2	9.9		15.5
	3	9.3	11.5	11.1	9.3	10.9	10.6		
	4.5		14.1	10.7		10.8	12.0		15.7
	6		14.4	9.5	11.7	9.9	13.5		16.2
2A-KP	1	1.4	12.3	29.2	4.9	23.0	9.6		12.9
	2	1.1	10.2	21.2	6.0	23.1	10.4		8.6
	3	1.1	12.7	16.2	8.9	20.7	13.8		17.5
	4.5		13.0	12.7	10.5	14.9	11.8		15.3
	6			14.2		15.4			
2B-KB	1	8.9	9.0	6.8	5.8	8.5	6.7	9.5	6.5
	2		8.1	6.5	7.7	7.8	10.4	13.0	11.0
	3	7.8	13.9	8.3	11.0	7.7	13.0	14.7	13.8
	4.5		10.9	7.3	9.9	7.6	13.7	16.0	16.0
	6	7.9	11.7	8.5	9.3	7.4	11.2	10.9	13.7
2B-KC	1								
	2		11.1	8.9	12.2	9.1	12.9	11.9	
	3	9.6	16.2	11.1	11.7	10.1	13.8	13.4	10.9
	4.5		9.0	10.4	18.1	9.3	9.6	10.8	8.2
	6	7.6	15.5	11.7	12.9	10.3	12.5	12.3	10.8
2B-KP	1								
	2		11.7	9.4	8.5	9.8	10.4	11.6	
	3	10.0	13.1	11.9	10.3	8.3	10.5	10.6	8.0
	4.5			8.6	10.1	9.2	9.7	8.8	7.8
	6	7.6	8.5	8.9	9.2	7.8	8.0	6.3	7.3

Site	Probe	5/85	10/85	5/86	10/86	5/87	10/87	7/88	10/88
3A-KB	1	11.5	17.9	14.3	12.6	23.2	14.6		
	2			7.6	8.0	15.6	15.8	32.0	15.5
	3	5.9	10.9	6.7	9.0	10.7	15.4	20.8	13.8
	4.5							43.3	
	6								
3A-KC	1		51.8	34.8		36.2	38.7	65.3	
	2			18.3	11.3	22.5	52.4	64.4	35.4
	3	3.5	7.3	19.0	11.9	18.3	38.1	42.9	24.7
	4.5			17.2	13.3	21.5	33.8	54.5	20.7
	6	3.5			13.4				
3A-KP	1	19.4	13.4	20.8	8.8	30.4	21.6	30.4	26.0
	2		23.3	10.0	22.1	15.6	32.9	44.9	38.8
	3	8.6	26.8	10.8					
	4.5	4.9	18.9	9.6	26.9	15.6	44.9	24.4	44.3
	6			5.4	26.8	13.4	45.6	14.7	23.8
3B-KB	1	9.0	8.4	11.4	6.3	7.5	5.5		5.5
	2		17.4	8.0	17.2	11.1	23.0		16.2
	3	6.4	13.2	7.3	15.9	6.8	19.2		18.0
	4.5		9.1	6.5	11.0	6.7	13.1		12.6
	6								
3B-KC	1	38.0	20.7	45.4		37.2	15.2		
	2		10.0	28.9	11.3	32.7	10.5		10.7
	3	14.4	11.9	25.0	11.9	27.1	12.6		12.6
	4.5		15.6	16.0	13.3	18.3	16.3		16.5
	6	10.5	14.0	12.9	13.4	15.5	17.2		17.6
3B-KP	1	41.4	16.0	44.4					
	2		12.9	23.3		24.6	14.1		
	3	14.8	11.8	18.6	10.9	19.1	11.7		12.9
	4.5		14.5	13.8	16.5	13.7	17.3		18.3
	6	9.5	13.1	12.0	17.4	13.0	17.0		18.4
5A-KB	1	12.9	20.0	20.3	16.1	16.4	18.0	32.0	
	2	20.8	34.0	33.5	39.2	18.6	38.1	51.7	
	3	15.7	33.0	22.7	42.1	25.9	60.8	55.4	
	4.5	10.9	21.0	14.7	30.4	18.7		40.6	32.1
	6	9.5	15.5	12.5	23.5	16.7		29.0	26.2
5A-KC	1	9.6	24.3	13.3	21.4	9.9	20.3	37.5	
	2	12.3	35.6	20.8	40.5	14.8	31.8	51.3	35.8
	3	8.3	24.7	3.9	41.0	20.1	44.6	51.6	42.5
	4.5	6.9	15.0	10.9	23.1	14.2	46.7	29.9	31.8
	6	6.1	10.2	9.4	15.5	11.2	32.7	21.5	20.6
5A-KP	1								
	2	8.9	31.0	14.8	33.8	21.4	36.4	66.7	
	3	9.1	46.0	36.4	52.4	38.9	50.1	58.7	
	4.5	28.5		63.6	64.5	65.1	68.7		
	6	28.5	49.3	55.6	60.1	49.8	66.1	82.7	45.8

Site	Probe	5/85	10/85	5/86	10/86	5/87	10/87	7/88	10/88
5B-KB	1	16.0	9.3	20.3	7.2	16.7	8.5	19.0	6.2
	2	12.0	20.8	17.7	21.1	19.5	21.8	37.0	
	3	7.9	16.6	11.1	21.7	16.3	24.2	21.8	29.8
	4.5	6.1	10.0	7.1	12.6	9.4	15.0	12.6	16.7
	6								
5B-KC	1	16.0	19.6	13.0	15.8	14.6	16.3	27.7	15.6
	2	10.1	35.6	10.5	38.1	11.6	28.7	39.6	32.8
	3	9.6	25.0	13.9	30.7	16.3	41.1	50.2	38.5
	4.5	7.7	16.5	11.2		16.1	26.6	34.6	23.7
	6	6.1	10.8	7.9	13.5	9.5	17.2	18.4	23.2
5B-KP	1								
	2	11.1	53.0	25.4	41.5	39.1	43.4	77.0	56.9
	3		62.8	44.4	60.3	55.7	59.7	76.6	60.6
	4.5	4.1	65.3	48.7	67.8	70.5	69.8	88.6	70.8
	6	30.0	59.7	63.9	67.2	69.1	68.2	82.6	73.8
6-KB	1	17.6	12.5	16.0	16.3	16.6	13.5	26.1	
	2	25.9	34.6	25.9	36.8	27.7	31.5	52.8	36.8
	3	17.1	29.8	23.9	42.1	30.8	45.3	58.7	
	4.5	14.4	23.1	19.0	31.7	24.2	36.9	41.6	33.9
	6	10.6	15.9	13.7	22.0	18.2		30.4	28.2
6-KC	1	10.9	18.8	7.8	16.1	12.2	13.2	27.8	
	2	9.4	37.7	10.1	41.5	17.0	41.3	44.8	
	3	8.6	20.1	8.9	28.8	20.9	45.6	52.7	
	4.5	6.0	16.5	6.7	20.7		29.9	34.5	26.6
	6	5.6		5.7	16.4	10.9	21.9	23.4	22.2
6-KP	1								
	2	13.5	19.2	19.2	16.1	28.4	25.0	62.6	
	3	16.6		21.7	25.1	36.5	35.6	67.7	
	4.5	17.1	16.5	19.0	26.9	38.8	41.8	65.5	
	6	9.9	19.5		24.2	26.9	31.2	59.3	
7A-KB	1		37.2	7.6	30.6	22.0	51.0	73.5	32.7
	2		35.4	7.8	41.5	15.0	54.8	58.5	40.6
	3		14.6	7.9	32.8	11.6	56.1	42.0	46.2
	4.5		6.3	9.6	31.6	10.1	34.9	28.9	32.5
	6			6.6					
7A-KC	1		45.5	68.4	24.1	66.6	45.4	67.8	32.0
	2		43.8	26.9	40.3	35.8	46.4	68.3	48.1
	3		39.1	17.9	42.0	22.3	51.0	60.3	51.6
	4.5		27.0	11.1	35.4	25.4	46.1	53.6	42.9
	6						46.1		
7A-KP	1		34.9	40.9	24.2	38.1	41.8	47.5	11.1
	2		41.5	25.1	35.9	21.3	46.1	58.5	36.9
	3		37.6	18.8	37.0	16.0	53.4	61.9	37.9
	4.5		34.9	18.6	38.8	18.3	44.7	41.8	41.4
	6		26.6	21.1	40.9			42.9	38.4

Site	Probe	5/85	10/85	5/86	10/86	5/87	10/87	7/88	10/88
7B-KB	1		10.9	6.6	5.1	5.0	12.2	20.3	
	2		17.5	7.4	16.9	6.7	19.4	25.5	
	3		21.2	10.1	20.4	9.0	30.7	34.5	11.6
	4.5		17.0	10.4	22.3	9.8	27.1	24.5	22.5
	6								
7B-KC	1		16.6	12.2	8.7	16.0	18.8	26.1	
	2		18.2	9.3	18.0	15.7	22.5	32.5	
	3		21.4	11.5	23.1	11.7	26.9	33.4	26.7
	4.5		15.8	13.8	29.3	12.2	29.9	33.8	28.8
	6		26.3	14.4	28.1				38.1
7B-KP	1		27.2	29.3	20.1	8.6	37.4	49.6	
	2		33.8	20.8	34.4	13.6	39.1	47.9	46.8
	3		33.5	17.9	36.4	13.9	46.3	51.0	44.4
	4.5		28.9	25.0	34.9	16.2	36.1	42.7	33.7
	6		34.9	16.0	35.2		40.0		42.7
7C-KB	1		9.3	10.6	8.2	10.2	15.8	26.0	
	2		15.1	9.5	13.5	10.5	21.5	25.0	
	3		14.2	8.7	13.6	10.3	22.3	21.7	
	4.5		10.1	9.6	13.7	11.3	21.0	20.6	
	6								
7C-KC	1		24.2	34.8	18.8	28.4	35.5	44.0	
	2		26.9	16.9	21.1	14.1	33.8	47.9	30.1
	3		29.6	16.9	26.3	12.3	36.1	53.5	30.8
	4.5		21.3	14.3	26.7	13.0		50.5	28.2
	6		27.7	21.9	22.7	15.0	26.6	57.9	45.1
7C-KP	1		21.4	36.0	17.1	31.2	44.4	72.5	
	2		27.9	26.9	23.8	22.0	40.1	44.4	13.4
	3		27.1	17.9	24.5	18.3	32.6	40.2	26.0
	4.5		19.9	14.0	40.0	16.5	35.9	30.8	33.2
	6			24.2	29.0	14.4		58.1	47.8
8B-KB	1		5.6	16.0	5.8	7.1	5.4		
	2			24.9	24.0	16.0	14.1	14.4	
	3		24.4	26.2	37.0	23.1	23.1	16.0	36.1
	4.5		18.3	21.7	26.6	21.6	21.5	58.8	34.2
	6		15.5		26.4	18.2	16.7	30.7	
8B-KC	1		17.5	30.2	27.3	48.2	24.5	20.3	
	2		28.6	20.0	35.9	20.6	28.3	17.5	
	3		25.0	17.1	36.3	16.5	31.3	11.7	45.4
	4.5		17.7	11.8	27.8	11.4	21.0	6.3	28.4
	6		14.6	11.0	17.8	10.4	17.2	5.3	20.7
8B-KP	1		6.2	10.9	7.2	12.9	10.0	24.0	
	2		9.9	12.3	9.5	9.2	9.1	35.1	14.3
	3		6.3	8.3	12.2	8.5	11.5	45.7	26.8
	4.5		9.5	10.0	13.1	9.5	13.4	34.8	37.7
	6		7.0	7.7	28.0	6.8	23.8	53.2	42.3

Site	Probe	5/85	10/85	5/86	10/86	5/87	10/87	7/88	10/88
8C-KB	1		2.2	5.1	2.6	4.8	2.7		3.0
	2		3.7	13.5	6.6	12.4	7.7		14.4
	3		10.4	16.6	13.0	16.3	12.5		32.9
	4.5		11.2	14.7	11.1	16.8	15.2		36.5
	6		8.5	11.0	10.2	14.6	14.9		
8C-KC	1		15.5	22.9	21.3	22.0	23.0		34.6
	2		29.7	12.9	40.9	13.7	36.5		47.9
	3		22.2	10.7	34.2	10.9	32.2		51.4
	4.5		14.1	8.0	20.9	7.8	22.1		33.7
	6		12.9	7.9	15.7	8.5	18.5		24.4
8C-KP	1		19.4	30.2	13.4	17.5	17.7		
	2		29.1	16.3	27.6	12.7	26.0		38.8
	3		26.8	12.7	29.8	13.4	41.1		51.8
	4.5		15.3	9.5	18.5	9.1	22.3		43.3
	6		13.1	8.5	15.9	10.9	25.0		57.6
10B-KB	1		12.9	25.0	15.4	9.0	11.8	23.9	
	2		10.2	7.6	25.7	8.4	24.0	19.8	
	3		11.1	7.6	17.6	7.9	17.3	22.1	33.8
	4.5		8.4	6.7	12.6	7.1	11.8	12.1	17.5
	6		5.8	6.1	8.3	6.5	8.1	9.4	12.1
10B-KC	1		14.0	16.0	14.0	13.9	18.0	23.9	
	2		17.0	8.4	29.5	7.8	26.0	26.2	
	3		16.9	7.6	22.5	8.2	18.5	29.1	35.8
	4.5		11.4	6.4	15.8	6.5	15.8	13.7	23.6
	6		10.1	6.5	13.2	6.7	12.9	13.6	48.6
10B-KP	1		25.0	59.4	33.7	56.3	27.1	81.4	
	2		42.7	41.6	51.2	37.6	36.9	73.5	
	3		52.4	47.5	58.3	42.7	47.2	68.2	57.1
	4.5			63.8	53.9	57.2	50.1	73.5	62.3
	6		27.0	59.7	62.9	54.1	58.9	72.0	65.5
12B-KB	1		6.8	6.2	6.7	9.4	7.0	8.1	
	2	9.4	15.6	15.6	17.6	10.5	16.1	4.1	
	3		10.6	9.6	12.9	6.2	13.1	11.7	11.0
	4.5	6.3	10.4	9.7	11.7	7.8	11.9	13.0	12.4
	6		7.1	7.6	9.2	6.2	9.0	9.5	9.4
12B-KC	1		15.2	22.9	14.7	18.4	15.3	14.2	
	2	6.7	17.4	19.2	17.2	14.1	16.1	24.1	
	3		12.1	13.5	10.2	9.8	14.6	18.5	14.0
	4.5	5.4	9.5	9.0	11.7	7.3	12.6	15.2	12.4
	6		7.9	8.4	9.2	7.4	9.5	11.6	10.5
12B-KP	1		17.6	16.0	10.5	12.0	13.4	19.2	
	2	4.8	8.1	11.0	23.7	24.0	29.0	59.8	
	3		17.4	8.9	28.8	13.1	28.5		47.4
	4.5	4.7		5.1	33.9	36.8	42.6	67.1	54.2
	6		12.2	7.3	36.3	24.7	49.2	67.8	62.5

Appendix II Site Summaries

Summary for 1 KB

Notes Lithologic record from the installation of thermistor cable T4 gives:

0 - 30 cm	organic silt	30 - 300 cm	clay till
300 - 650 cm	silty clay		

Temperature data shows that the material is continuously frozen at depths greater than 50 cm to at least 13.6 m depth with the warmest temperature at the 50 cm being 0.0 (from cable T4).

	Cable T4			
	50 cm	100 cm	150 cm	200 cm
May 1985	-1.2	-2.1	-2.5	-2.5
Oct 1985	-0.2	-0.8	-1.2	-1.4
May 1986	-1.1	-2.0	-2.3	-2.3
Oct 1986	-1.6	-1.1	-1.0	-1.3
May 1987	-1.0	-1.9	-2.3	-2.3
Oct 1987	0.0	-0.7	-1.1	-1.3
Jul 1988		-0.0		-0.9
Oct 1988		-1.4		-0.8

Oct 1985 Freeze-back of the active layer evident. K in frozen layer is 5.0. A feature (base of active layer) appears between the 25 cm (2.17 ns) and 57 cm (7.92 ns) depths between 5.33 and 6.5 ns (38 to 49 cm) and appears to reflect the base of the active layer.

May 1986 K 6.0 to 7.0 throughout profile (10.3 in top 25 cm). A feature appears between 1.8 and 2.1 ns (about 14 to 21 cm) and is evident on all probes, suggesting a thin thawed layer.

Oct 1986 Top 25 cm frozen (K is 4.3). Thaw evident down to about 50 cm (K 28 in the 25 to 53 cm layer). K is about 7.5 in frozen zone. No distinct features in the trace.

May 1987 Profile is essentially frozen; K is 6.0.

Oct 1987 Top 25 cm frozen back (K = 5.02). The 25 to 49 cm zone appears to be very wet (K = 54). K is about 7.5 below about 70 cm. A feature is evident between between the 49 cm (7.83 ns) and 71.4 cm (8.67 ns) probes between 6 to 6.7 ns (45 to 53 cm). This feature seems to correspond with the base of the active layer.

July 1988 Profile is essentially frozen (K is 6.0) with thawed layer on top. K is about 39 in the 24.5 to 48 cm zone.

Oct 1988 No 1 foot probe. Thaw discontinuity appears at about 6.9 ns on remaining probe.

Summary for 1 KC

Lithologic record from the installation of thermistor cable T2 gives:

0 - 250 cm clay till 250 - 520 cm silt

Temperature data shows that the base of the permafrost is greater than 5 m (end of thermistor cable). The readings for Oct 1987 suggest complete thaw to 100 cm at least, this is substantiated by the TDR record.

Cable T2

	50 cm	100 cm	150 cm	200 cm
Oct 1984	-0.3	-0.6	-1.0	-1.4
May 1985	-0.7	-1.1	-1.5	-1.8
Oct 1985	0.2	-0.1	-0.4	-0.7
May 1986	-0.2	-0.4	-0.7	-0.8
Oct 1986	-0.1	-0.0	-0.2	-0.4
May 1987	-0.1	-0.4	-0.7	-0.7
Oct 1987	2.2	1.2	-0.0	-0.3
Jul 1988	5.8	-0.2	-0.4	-0.5
Oct 1988	-0.2	0.2	0.1	-0.1

Oct 1985 Surface very wet (K about 42). Feature detected on the 133 cm (25 ns) and 178 cm (29.2 ns) probes at 21.2 ns and 19.2 ns respectively. This feature is probably the base of the active layer (between 87 and 133 cm) yet the K profile doesn't show a distinct boundary.

May 1986 Top 25 cm very wet (K is 64). Some scatter in data. A feature was detected on the 57, 87 133 and 178 cm probes (10, 14.3, 18.3, 23.3 ns respectively) at about 7.83 ns. The average K in the frozen zone is about 11 putting the feature between 28 to 38 cm. It appears to be a thin thaw zone.

Oct 1986 Overlays of the Oct 1985 and Oct 1986 data show much the same thing.

May 1987 Essentially a duplicate of May 1986, however, there is no scatter in the data. Average K in frozen zone is about 14. Top 30 or so cm very wet, K of about 66.

Oct 1987 Top 25 cm or so freezing back. It was very wet to at least 111 cm. An estimate of K for the longest probe (146 cm) could not be made since the end point was missed. It is difficult to say whether the increased wetness at this site is due to seasonal conditions or represents a degradation of the permafrost.

July 1988 Very wet. No reading for 6 foot probe.

Oct 1988 No readings for 1,2,3 foot probe (6 foot cannot read).

Summary for 1 KP

Lithologic record from the installation of thermistor cable T1 gives:

0 - 250 cm clay till 250 - 520 cm silt

Temperature data shows that the base of the permafrost is greater than 5 m (end of thermistor cable). The readings for Oct 1987 suggest complete thaw to 100 cm at least, this is substantiated by the TDR record.

Cable T1

	50 cm	100 cm	150 cm	200 cm
Oct 1984	-0.0	-0.3	-0.8	-1.3
May 1985	-0.3	-0.8	-1.2	-1.6
Oct 1985	0.9	0.5	-0.1	-0.5
May 1986	0.1	-0.1	-0.4	-0.7
Oct 1986	-1.3	-0.1	-0.1	-0.3
May 1987	2.3	-0.2	-0.6	-0.8
Oct 1987	4.0	1.4	0.4	-0.2
Jul 1988		4.0	-0.3	-0.5
Oct 1988	-2.8	-0.0	-0.1	-0.2

Oct 1985 The profile is generally wet down to about 80 or so cm (K is 42 in the 0-87 cm zone). The 133 and 178 cm probes produced strange crt traces, suggesting either the probes are shorted, crossed or are encountering a "feature" along their length.

May 1986 The surface layer has begun to thaw (K = 44.8) but appears to have frozen completely through during winter. The 133 and 178 cm probes still exhibit the "feature" along their length. The thaw front can be detected on the 57 cm (10.25 ns) and the 87 cm (14.5 ns) probes at 7.75 and 8.42 ns respectively. K in the frozen portion is about 19, suggesting the thaw front is at about 39 to 45 cm from the surface.

Oct 1986 The surface is experiencing freeze-back. The 127 and 170.2 cm probes still exhibit the strange feature. K in the frozen zone is about 22.

May 1987 Surface zone very wet (K about 60). K decreases from aobut 20 in the 21.5 to 51 cm layer to about 8 in the 119.2 to 164.9 cm layer. A feature was detected on the 21.5 cm (5.58 ns) 51 cm (10 ns), 76.4 cm (13.41 ns), and 164.9 cm (26 ns) probes. Since the K profile is highly graded, it can only be estimated that the thaw layer is within the top 21.5 cm of the profile.

Oct 1987 The top layer of the profile is experiencing freeze-back (K is 14.2 in the top 30.5 cm). The 111.2 and 152.9 cm probes exhibit strange crt displays and should

not be considered reliable.

July 1988 Very wet. Can't read 4.5 and 6 foot probe.

Oct 1988 Impossible to read traces.

Summary for 2A KB

Lithologic record from the installation of thermistor cable T4 gives:

0 - 40 cm organic silt 40 - 440 cm clayey silt

	Cable T4 100 cm	200 cm
Oct 1984	-0.3	-0.4
May 1985	-1.3	-1.6
Oct 1985	-0.1	-0.4
May 1986	-1.1	-1.3
Oct 1986	-0.7	-0.3
May 1987	-1.0	-1.3
Oct 1987	0.3	-0.3
Jul 1988	-	-
Oct 1988	-	-

Oct 1985 Appears to be well frozen throughout profile. K varies from 7.8 in the top 25 cm to about 20 in the 133-152 cm zone.

May 1986 Frozen throughout with K of about 8.5. Feature noted on all probes between 0.9 and 1.7 ns (about 10 cm) suggesting the start of a thaw zone.

Oct 1986 Similar to Oct 1985

May 1987 Similar to May 1986. Feature noted at 1.83 to 3 ns on all probes (about 23 cm) perhaps showing the lower K in surface zone. There is some lack of congruity between the probes.

Oct 1987 Similar to other Oct readings. Average K is about 18.5 below 60 cm.

July 1988 No readings

Oct 1988 Very similar to other Oct readings. Average K about 21 over the 48 to 167 cm range.

Summary for 2A KC

Lithologic record from the installation of thermistor cable T3 gives:

0 - 440 cm clayey silt

	Cable T3 100 cm	200 cm
Oct 1984	0.0	-0.3
May 1985	-1.8	-2.4
Oct 1985	0.4	-0.3
May 1986	-1.2	-1.6
Oct 1986	-0.0	-0.1
May 1987	-0.5	-0.8
Oct 1987	2.0	0.5
Jul 1988	5.1	-0.1
Oct 1988	2.0	1.6

May 1985 Surface zone slightly wetter than the rest of the profile. K is about 7.5 in lower portion of the profile. Feature noted between 2.83 and 3.17 ns on the 57 cm (6.99 ns) and 87 cm (8.83 ns) probes but not on the 25 cm (3.17 ns) probe suggesting the start of surface thaw/warming to about 25 cm.

Oct 1985 Generally low water content and thawed to at least 1 m with K increasing from about 10 in the 25-57 cm zone to 15 in the 133-178 cm zone.

May 1986 Surface thaw evident. Feature noted on all probes at between 3.6 to 4 ns. K in frozen portion is about 7 suggesting a thin thaw layer of 10 to 20 cm.

Oct 1986 Generally low water content. Average K is about 12.

May 1987 Surface thaw evident. Feature noted between 2.8 and 2.9 ns on the 25.5 cm (4.17 ns), 53 cm (4.41 ns) and 83.4 cm (9.17 ns) probes.

Oct 1987 Profile appears frozen through although the temperatures suggest otherwise. K increases from 7.5 in the 0-25 cm zone to about 18 in the 128-174 cm zone. The material is probably of low water content.

July 1988 No readings

Oct 1988 Low water content suggested in Oct 1987 seems to be correct. K averages 18 over profile.

Summary for 2A KP

Lithologic record from the installation of thermistor cable T1 gives:

0 - 440 cm clayey silt

	Cable T1			
	50 cm	100 cm	150 cm	200 cm
Oct 1984	0.3	0.3	0.2	0.0
May 1985	-0.5	-0.8	-1.1	-1.2
Oct 1985	0.5	0.6	0.4	0.1
May 1986	-0.3	-0.5	-0.6	-0.7
Oct 1986	-0.0	0.0	0.0	-0.0
May 1987	-0.1	-0.4	-0.4	-0.4
Oct 1987	2.8	2.2	1.8	1.1
Jul 1988	7.7	4.2	1.2	0.1
Oct 1988	1.9	1.9	1.6	1.4

Oct 1985 Profile is relatively uniform with an average K of 14 to 16. Temperatures suggest that it is unfrozen, so it is of low water content.

May 1986 Surface zone is wet (K = 29.2). A feature was detected on the 87 cm (11.67 ns) and the 133 cm (15.83 ns) probes between 8 and 8.7 ns. The position is between 48 and 62 cm and probably represents surface thaw.

Oct 1986 Surface zone appears drier than the rest of the profile (K = 4.9). Average at depth is about 15, similar to Oct 1985.

May 1987 Similar to May 1986. Feature noted between 8.33 and 8.83 ns which is near the end of the 53 cm (8.5 ns) probe.

Oct 1987 Similar to other Oct readings.

July 1988 No readings.

Oct 1988 Cannot read 6 foot probe. Similar to other Oct readings.

Note The crt display for the 6 foot probe on most dates suggests that it is picking up the pipe or the rods are nearly shorted. The results should be used with caution.

Summary for 2B KB

Lithologic record from the installation of thermistor cable T4 gives:

0 - 30 cm	organic silt	30 - 90 cm	clay (till)
90 - 175 cm	silty clay	175 >	shale

	Cable T4 100 cm	200 cm
May 1985	-2.6	-3.8
Oct 1985	-0.1	-0.9
May 1986	-2.7	-3.8
Oct 1986	-0.1	-0.9
May 1987	-2.4	-3.4
Oct 1987	-0.3	-1.0
Jul 1988	-0.7	-1.8
Oct 1988	-0.1	-0.7

May 1985 Frozen material. Feature detected at 8.33 ns on the 178 cm (16.67 ns) probe. Average K is about 8. The feature is at about 89 cm suggesting that it represents the lithologic change between clay and silty clay.

Oct 1985 Scatter exists in the layer analysis; the best estimate of K is about 14.

May 1986 Material is well frozen.

Oct 1986 Material seems to be wetter in the top 54 cm (K = 12) and drier (more frozen) in the lower zone (K = 8)

May 1987 Almost completely uniform with depth (K = 7.5). Definitely frozen.

Oct 1987 Very near surface is drier; average K with depth is about 16.

July 1988 Material frozen, K averaging about 10.

Oct 1988 Similar to Oct 1987, K averaging about 16.

Summary for 2B KC

Lithologic record from the installation of thermistor cable T3 gives:

0 - 90 cm	woodchips
90 - 150 cm	clay (till)
150 - 240 cm	silty clay
240 >	shale

	Cable T3 100 cm	200 cm
Oct 1984	-0.3	-1.3
May 1985	-0.4	-0.7
Oct 1985	-0.3	-0.6
May 1986	-0.3	-0.5
Oct 1986	-0.2	-0.4
May 1987	-0.5	-0.6
Oct 1987	-0.3	-0.5
Jul 1988	-0.4	-0.6
Oct 1988	-0.3	-0.5

May 1985 K in the 87-178 cm zone is about 5.9. In the top 87 cm it is about 9.6, probably reflecting the differences in K between frozen woodchips and soil.

Oct 1985 Significant scatter in the layer analysis. K in the top 57 cm is 11.1; in the 57-87 cm layer it is 28.5 (base of woodchips) and in the 87-178 cm layer it is 14.8. The 133 cm probe trace is difficult to interpret and produces significant scatter in the layer analysis if included.

May 1986 K varies somewhat with depth but the material appears frozen. A feature was noted on the 87 cm (9.67 ns) probe at 2.5 ns and 8.5 ns perhaps showing differing water contents within the woodchips.

Oct 1986 A great deal of scatter in the layer analysis.

May 1987 Material appears to be frozen through with a wetter layer near the base of the woodchips.

Oct 1987 Scatter exists in the layer analysis, average K is about 12.

July 1988 No reading for the 1 foot probe. Discontinuities evident along both the 4.5 and 6 foot probes.

Oct 1988 No reading for the 1 and 2 foot probes. K averages about 10.5

Summary for 2B KP

Lithologic record from the installation of thermistor cable T1 gives:

0 - 100 cm	woodchips
100 - 170 cm	clay (till)
170 - 250 cm	clayey silt
250›	shale

Cable T1

	50 cm	100 cm	150 cm	200 cm
May 1985	-0.1	-0.2	-0.5	-0.7
Oct 1985	0.7	-0.1	-0.2	-0.2
May 1986	-0.1	-0.1	-0.3	-0.4
Oct 1986	-0.4	-0.1	-0.2	-0.1
May 1987	-0.1	-0.3	-0.4	-0.4
Oct 1987	1.1	-0.2	-0.2	-0.2
Jul 1988	1.0	-0.3	-0.4	-0.4
Oct 1988	1.9	-0.3	-0.3	-0.3

May 1985 Generally frozen/dry. K in the woodchips is about 10; between 87-178 cm it is about 5.6.

Oct 1985 The 133 cm probes seems to be shorted (or near shorted) so it is not used. K is about 5 in the 87-178 cm layer; 11.7 in the top 57 cm and 16 in the 57-87 cm layer.

May 1986 Some scatter in the layer analysis exists. It appears that the 57-87 cm layer (near the base of the woodchips is warmer/wetter (K = 17.3) compared with the 0-57 cm layer (K = 9.4) and the 87-178 cm layer (K = 6.4).

Oct 1986 K relatively uniform with depth averaging about 9.5.

May 1987 K averages about 7.5 through the profile, with the surface zone being only slightly wetter. If the top 50 cm is thawed as suggested by the temperatures, then the material is relatively dry.

Oct 1987 Similar to Oct 1986.

July 1988 K averages about 7.5 in profile. Discontinuity occurs at about 5.8-6.7 ns on the 4.5 and 6 foot probes. This is very near the base of the 2 foot probe at approximately 50 cm. This feature is similar to the one noted in May 1987.

Summary for 3A KB

Notes

Lithologic record from the installation of thermistor cable T4 gives:

0 - 35 cm	organic silt		35 - 80 cm	ice + silt	
80 - 200 cm	silt				

Temperature data shows that the material is continuously frozen from the 50 cm to at least 8 m depth with the warmest temperature at the 50 cm being -0.4 (from cable T4). The base of the active layer is ` 50 cm.

May 1985 generally frozen, K 4.2 is lower portion of the profile. A feature appears at about 1.3 to 1.4 (3 - 5 cm) ns on the TDR crt displays suggesting the beginning of a thin thaw layer.

Oct 1985 wet in surface zone. K in frozen layer is 8.5. Feature appears between the 25 cm (3.53 ns) and 87 cm (9.55 ns) probes at 6 ns (50 cm) and could be a combination of lithogic features and high water content.

May 1986 wet in surface zone. K 4.7 in frozen zone. Feature appears between 1.4 and 2.8 ns and is evident on the 25, 57 and 87 cm probes, suggesting a thin thawed layer.

Oct 1986 K is 7.5 in frozen zone. No distinct features in the trace; generally frozen.

May 1987 K is 5.7 in frozen zone. Feature appears on the 26.5 cm (4.25 ns), the 45 cm (5.92 ns) and 72.4 cm (7.91 ns) probes at different times (2.9, 5, 2.8 ns respectively). The feature is probably a thin thaw layer in the 8 - 20 cm region.

Oct 1987 K is about 16 and the profile seems to have warmed. Since it is a silty material and the temperatures are below freezing, this value is not unreasonable.

July 1988 Temperatures still frozen below 50 cm. No readings for the 4.5 and 6 foot probes. Thaw feature occurs at about 11.3 ns on 3 foot probe. Layer analysis not useful but feature seems to be about 40 cm beneath the surface. The surface layer is wet with K being 32 for the 26.5 cm probe.

Oct 1988 No readings for the 1, 4.5 and 6 foot probes. K is about 14.5 in the upper 28 cm and about 10 below.

Summary for 3A KC

Notes

Lithologic record from the installation of thermistor cable T3 (4.5 m from pipeline) gives:

0 - 30 cm	organic silt	30 - 150 cm	ice + silt
150 - 530 cm	silt		

Temperature data for cable T3 shows that the material is frozen below the 100 cm depth on all observation dates except Oct 1987.

May 1985 generally frozen, K 3.4. A feature appears at about 6.7 ns (107 cm) between the 87 cm (5.44 ns) and the 178 cm (11.01 ns) TDR probes. This feature may be lithologic.

Oct 1985 wet in surface zone. K in frozen layer is 7.3. Impossible to discern features.

May 1986 wet in surface zone. K 12.0 in frozen zone. Feature appears at 5.8 to 6.2 ns on the 47 to 91.4 cm probes (between 20 and 33 cm from the surface) and is probably a thaw zone.

Oct 1986 K is 14.0 in frozen zone. No readings for the 25 cm probe. A feature appears 6.7 ns on the 84.5 cm probe; 7.5 ns on the 125 cm probe and 7 ns on the 178 cm probe. This feature is probably in the region of 60 to 63 cm beneath the surface and may be lithologic.

May 1987 K is 10.0 in frozen zone. Scatter is evident in the measurements. A feature appears around the 3.8 to 4.7 ns region on the 39, 62 and 72 cm TDR probes. This would correspond to a possible depth of about 21 to 23 cm and is probably a thaw zone.

Oct 1987 The profile is very wet and is probably thawed, possessing a graded water content profile. The temperature of recorded at 1 m on cable T3 was 0.54 C and -0.52 at 2 m.

July 1988 No reading for the 6 foot probe. 4.5 foot probe sticking 75 cm above ground making it only 62 cm in soil. Temperatures suggest the profile is thawed and K (50-65) shows it is very wet.

Oct 1988 No readings for the 1 and 6 foot probes. No discontinuities noted, however, layer analysis suggests layering in water content with surface zone wetter. Temperature of 1 m thermistor is about -0.1.

Summary for 3A KP

Notes

Lithologic record from the installation of thermistor cable T1 (1.4 m from pipeline) gives:

0 - 35 cm organic silt 35 - 155 cm ice + silt
150 - 520 cm silt

	Cable T1			
	50 cm	100 cm	150 cm	200 cm
May 1985	-0.9	-2.0	-2.7	-3.1
Oct 1985	0.6	-0.1	-0.5	-0.9
May 1986	-0.3	-1.3	-1.9	-2.2
Oct 1986	-0.2	0.0	-0.3	-0.6
May 1987	0.3	-0.8	-1.1	-1.3
Oct 1987		-0.8	-0.3	-0.5
Jul 1988		-0.2	-0.4	-0.7
Oct 1988		0.1	0.0	-0.4

May 1985 generally frozen, K 4.9. A feature appears at about 3.67 ns (25 cm) on the 87 cm (8.50 ns) probe. It does not appear on the 139 cm (13.17 ns) TDR probes. This feature may be lithologic or represents a thawing zone.

Oct 1985 the pattern is complex, see trace also. The data suggests that thaw occurred at this site to a depth of about 94 cm as evidenced by a feature at 15.33 ns on the 133 cm probe (assuming K is 7.8 in frozen section). At the time of observation, the surface began to freeze back since a feature appears at 4.75, 4.67 and 3.83 ns on the 57 cm (9.17 ns), 87 cm (14.99 ns) and 133 cm (19.29 ns) probes respectively. The shape of the TDR trace suggests a freeze back of the top 32 to 51 cm of the profile (range 32, 34, 51 cm using a K of 32 in the thawed zone)

May 1986 Generally frozen, with some surface thaw. There is scatter in the layer analysis but K is generally 7.4 in the frozen portion. A feature occurs at about 3.49 to 3.99 ns (29 to 30 cm from surface) on all the TDR probes except the 25 cm probe. This feature could be a combination of lithology and surface wetness.

Oct 1986 Surface layer (unknown thickness) has started to freeze back. It overlies a wet unfrozen layer which probably extends to the a depth of 130-150 cm (see temperatures also).

May 1987 K is 12.0 in frozen zone. Scatter is evident in the measurements. A feature appears between 4.7 and 6.2 ns

on the 50cm (6.58 ns), 105 cm (13.83) and 112 cm (13.67 ns) TDR probes lying somewhere between the 24.5 and 50 cm probes (estimates of 33, 39 and 44 cm respectively assuming a K of 12 in the frozen zone.

Oct 1987 The profile is very wet and is probably thawed, with either a drier surface or more probably a thin frozen surface layer. The temperature of recorded at 1 m on cable T1 was 0.8 C and -0.3 at 2 m.

July 1988 No discontinuities noted, however, layer analysis shows that the top 50 cm is very wet (K about35-40) but K decreases to about 14 below this. No reading for the 3 foot probe.

Oct 1988 No reading for the 3 foot probe. Profile appears to be unfrozen throughout however, the layer analysis suggests that there could be an unfrozen/frozen boundary between about 90 and 130 cm. This is not supported by the temperatures.

Summary for 3B KB

Notes

Lithologic record from the installation of thermistor cable T4 gives:

0 - 40 cm	organic silt
40 - 400 cm	sand

Temperature data shows that the material is continuously frozen from the 1 m to 20.9 m depth with the warmest temperature at the 1 m mark being $\approx$ -0.35 (from cable T4). The base of the active layer is $>$1 m.

May 1985 generally frozen, K 5.5

Oct 1985 thin freeze-back at time of reading. Active layer feature at 8.5 ns between the 57 (7.93 ns) and 87 cm (10.55 ns) probe ($\approx$ 61 cm). Frozen layer, K 5.5.

May 1986 thaw front at time of reading between 0 cm and 25 cm probes (3.15 ns) at 2.3 - 2.8 ns. Dominantly frozen, K 5.5

Oct 1986 similar to Oct 1985

May 1987 similar to other May observations

Oct 1987 top 25 or so cm frozen back, wet (unfrozen) between 25 cm (1.92 ns) and 83 cm (12.17 ns) probes. Unfrozen-frozen boundary at 11.5 ns ($\approx$75 cm), K 5.5 in frozen layer.

July 1988 No July readings

Oct 1988 No 6 foot probe reading. Discontinuity appears at 11.3 ns (depth about 125-130 cm) on the 4.5 foot probe. K value for whole profile appears to have been increasing for the various Oct readings. Temperature for 1 m thermistor is about -0.2 C.

Summary for 3B KC

Notes

Lithologic record from the installation of thermistor cables T2 and T3 gives:

0 -	40 cm	organic silt
40 -	550 cm	sand

Temperatures data from thermistor cables T3 (4.2 m from pipeline) and T2 (2.3 m from pipeline)

	T3		T2	
	100 cm	200 cm	50 cm	100 cm
May 1985	-1.1	-2.3	-0.7	-1.6
Oct 1985	0.6	-0.2	0.3	0.6
May 1986	-0.6	-1.4	2.7	-0.4
Oct 1986	-0.1	-0.1	-1.3	-0.1
May 1987	-0.1	-0.2	3.5	-0.2
Oct 1987	1.6	-0.1	2.7	2.0
Jul 1988	1.1	-0.1	8.7	3.4
Oct 1988	0.1	-0.0	-2.0	0.2

May 1985 thawed between 25 cm (5.1 ns) and 87 cm (11.0 ns) probes. Unfrozen-frozen boundary between 7.6-8.3 ns (54 cm) with K $\approx$ 7.3 in frozen layer.

Oct 1985 some lack of congruity between probes. Boundary appears between 6.7-7.7 ns ($\approx$ 65 cm) between 57 cm (6.0 ns) and 87 cm (9.99 ns) probes. K $\approx$ 15 in lower zone.

May 1986 very wet in top 25 cm (K = 45.4). Thaw front appears between 13.1-13.7 ns ($\approx$ 50 cm) between the 57 cm (14.1 ns) and 87 cm (17.72 ns) probes with K $\approx$ 11 in frozen layer.

Oct 1986 generally frozen. feature appears between 6.7 and 7.5 ns ($\approx$ 60-67 cm) with K $\approx$ 14 in lower portion of profile.

May 1987 Frozen-unfrozen boundary appears between 13.3-13.8 ns (70-75 cm) between the 56 cm (10.7 ns) and 86.4 cm (14.9 ns) depth. K $\approx$ 9 in frozen zone.

Oct 1987 Frozen-unfrozen boundary appears between 7.2-7.9 ns between the 57 cm (6.2 ns) and the 87.4 cm (10.3 ns) probes. Quite a bit of scatter in depth interpretation due to a variable water content gradient or errors in readings.

July 1988 No readings taken.

Oct 1988 Similar to Oct 1987. The discontinuities in the traces discussed in the cautionary note is most likely due to differences in material properties and not due to freeze-thaw boundaries.

Cautionary Note

From the temperature data and the lithologic record it appears that the differences in lithology show up on the trace somewhere between 50 and 65 cm. The K values and the temperature data for Oct 1985, 1986 and 1987 suggest that the whole profile is unfrozen, hence, the feature is not a freeze-thaw boundary but due to differences in materials. K is $\approx$ 15 which would correspond to a volumetric water content of about 27.5 % which is reasonable for a dense saturated sand.

Summary for 3B KP

Notes

Lithologic record from the installation of thermistor cables T1 gives:

0 - 30 cm	organic silt
40 - 500 cm	sand

Temperatures data from thermistor cables T1 (1.3 m from pipeline) shows:

	cable T1			
	50 cm	100 cm	150 cm	200 cm
May 1985	-0.9	-1.7	-2.0	-2.3
Oct 1985	0.4	0.6	0.2	-0.2
May 1986	2.7	-0.4	-0.7	-0.9
Oct 1986	-1.1	-0.1	-0.2	-0.3
May 1987	2.5	-0.2	-0.3	-
Oct 1987	2.8	2.0	1.0	-
Jul 1988	8.8	-	-0.6	-2.7
Oct 1988	-0.9	0.3	-0.4	-

May 1985 wet in upper zone. Thaw feature at 8.0 ns (65 cm) between the 25 cm (5.4 ns) and 87 cm (11.2 ns) probes. K ≈ 9 in frozen zone. (temperatures suggest that this may be a lithologic feature)

Oct 1985 some scatter in analysis due to probe error or variable water content profile. K between 12 and 15 in lower zone suggesting that it is unfrozen (see temperatures also).

May 1986 thaw feature(?) at 9.0 - 9.7 ns (55 - 60 cm) near the end of the 57 cm probe (9.2 ns). The surface is very wet and K in the lower zone is in the order of 6 - 8.

Oct 1986 No data for upper two probes (25 and 57 cm). Difficult to interpret.

May 1987 Feature appears between 7.3 - 8.5 ns (33 - 46 cm) within the top 59 cm (9.75 ns). K within the lower (frozen) soil is between 7 - 9. No readings for the 25 cm probe.

Oct 1987 Profile is thawed with an average K of about 16 - 17. A feature appears at 12.67 ns on the 120 cm probe and at 8 ns on the 160 cm probe. The feature is probably lithologic in nature

July 1988 No readings taken.

Oct 1988 No readings for the 1 and 2 foot probes. K averages about 18 in the profile. No features were noted on the longer probes.

Cautionary Note

The consistence appearance of a feature in the 30 - 60 cm region suggests that it is lithologic in nature. It may be coincidence that the thawed layer agrees at times within this range.

Summary for 5A KB

Lithologic record from the installation of thermistor cable T4 gives:

0 - 380 cm peat 380 - 400 cm clayey silt
400 > clay till

	Cable T4 100 cm	200 cm
May 1985	-0.1	-0.2
Oct 1985	-0.0	-0.1
May 1986	-0.0	-0.2
Oct 1986	0.1	-0.2
May 1987	0.0	-0.2
Oct 1987	1.0	-0.2
Jul 1988	2.1	-0.1
Oct 1988	0.7	-0.1

May 1985 Feature noted at 7.67 to 7.99 ns on the 133 cm (14.67 ns) and 178 cm (18.33 ns) probes respectively. This represents the thaw depth. K is about 5.75 in the frozen zone suggesting that the front is around 45 to 49 cm.

Oct 1985 Top 25 cm has started to freeze back or had dried during the summer months. The 25 to 87 cm zone is very wet (K = 40) but not saturated given that this is peat. The feature detected at 15 ns on the 87 cm (16.67 ns) probe; at 15 ns on the 133 cm (20.33 ns) probe and at 15.33 ns on the 178 cm (11.67 ns) probe is the freeze-back/dry layer feature. The base of the thawed layer from the layer analysis appears to be around 100 cm.

May 1986 Feature noted between 8.83 and 12 ns on the 57, 87, 133 and 178 cm probes. K in frozen zone is about 6 and the

Summary for 5A KC

Lithologic record from the installation of thermistor cable T3 gives:

0 - 320 cm peat 320 - 400 cm clayey silt
400> clay till

	Cable T3	
	100 cm	200 cm
May 1985	-0.1	-0.0
Oct 1985	0.1	-0.0
May 1986	-0.0	-0.0
Oct 1986	0.5	-0.0
May 1987	0.0	0.0
Oct 1987	2.6	0.0
Jul 1988	5.3	0.2
Oct 1988	1.3	0.0

May 1985 Profile generally frozen (given temperatures and K values). K averages about 6 in the profile with a feature being detected between 2.33 and 2.83 ns (about 25 cm).

Oct 1985 Top 25 cm dry or recently frozen. Thaw depth is about 60 cm with K about 5 in the frozen zone and grading up to 46 in the 25-57 cm zone.

May 1986 The layer analysis indicates that there is a lot of incongruity between the probes. The profile has been generally frozen but an estimate as to the position of thaw features or an average K would be inappropriate.

Oct 1986 Top 25 cm dry or recently frozen. Thaw front detected on the 127 cm (20.33 ns) and 170 cm (22.67 ns) probes at 15.33 ns and 14 ns respectively. K is about 8 in the frozen zone and the unfrozen-frozen boundary appears to be around 74 to 80 cm. The temperature record would put this feature at a much greater depth.

May 1987 Layer analysis fairly complicated. The ends of the 130 and 179 cm probes were difficult to detect with any certainty. The profile is essentially frozen.

Oct 1987 Layer analysis fairly complicated. The profile is wet (K between 45 to 65 in various layers). The profile appears to be thawed (given temperatures) but the layer analysis indicates a frozen layer (K = 8) in the 126 - 175 cm zone. This may be in error but needs to be confirmed.

July 1988 Discontinuity occurs at 18 ns on the 126 cm (4.5 foot)

and 175 cm (6 foot) probes. This is coincident with the end of the 76.5 cm (3 foot) probe. It is still difficult to resolve whether this represents an unfrozen/frozen boundary or a lithological difference. The temperatures strongly suggest that the materials are unfrozen.

Oct 1988 Discontinuity appears at 20.2 ns on the 137 cm (4.5 foot) probe and at 19.2 ns on the 165 cm probe (6 foot). K is about 9 in the 80 to 170 cm region and is very high above.

Summary for 5A KP

Lithologic record from the installation of thermistor cable T1 gives:

0 - 330 cm peat 330 - 520 cm clayey silt

	Cable T1			
	50 cm	100 cm	150 cm	200 cm
May 1985	-0.0	-0.1	-0.1	-0.2
Oct 1985	0.9	0.2	-0.2	-0.2
May 1986	6.8	0.0	-0.1	-0.1
Oct 1986	6.9	0.6	-0.1	-0.1
May 1987	12.5	0.1	-0.1	-0.1
Oct 1987	4.3	3.4	0.5	-0.1
Jul 1988		4.3	0.1	-0.1
Oct 1988		0.4	1.0	-0.0

May 1985 Profile appears to a have a dry/frozen layer over a wet layer over a frozen layer. There is no data for the 25 cm probe. The 57 cm probe gives K of 8.9. A feature is detected at 2.5 ns and 3.83 ns on the 57 cm (5.67 ns) and 87 cm (8.75 ns) probes respectively; this is the dry/frozen layer (also noted on the 133 cm and 178 cm probes at 3.33 ns). Another feature being the unfrozen/frozen boundary is noted at 8.67 ns on the 133 cm (23.66 ns) and the 178 cm (31.67 ns). K in the 87 to 178 cm zone is about 57 from the layer analysis.

Oct 1985 The profile is extremely wet throughout the profile. K is 82 in the 57 to 87 cm zone and 53 in the 87 to 52 cm zone suggesting that a frozen veneer may exist at some depth.

May 1986 Profile is very wet and assumed to be completely thawed (K = 88 in the 57 to 163 cm zone.

Oct 1986 Profile is very wet and assumed to be completly thawed.

May 1987 Profile is very wet and assumed to be completely thawed.

Oct 1987 Profile is very wet and assumed to be completely thawed.

July 1988 Profile is very wet and completely thawed. No reading taken for the 4.5 foot probe.

Oct 1988 Profile is very wet and completely thawed. Only reading taken is for the 6 foot probe.

Summary for 5B KB

Lithologic record from the temperature record indicates very thick icy peat.

	Cable T1	
	100 cm	200 cm
May 1985	-0.2	-0.3
Oct 1985	-0.1	-0.2
May 1986	-0.1	-0.2
Oct 1986	-0.1	-0.2
May 1987	-0.1	-0.1
Oct 1987	0.1	-0.1
Jul 1988	-0.1	-0.1
Oct 1988	0.3	-0.1

May 1985 Start of thaw layer in top 25 cm. K averages 4.5 over profile, hence, frozen.

Oct 1985 Top 25 cm is either drier or has started to freeze back. Feature noted on the 87 cm (11.83 ns) and the 133 cm (13.99 ns) probes at 8.99 ns and 7.33 ns respectively. K in the frozen layer is still about 4.5 putting the feature at about 39-46 cm. The top 25 cm is 9.3; between 25 to 57, K is 33.4 and below the feature about 4.5.

May 1986 Similar to May 1985. Feature (thaw boundary) appears at 4.17 ns on the 57 cm probe (8.00 ns); 3.67 ns on the 87 cm probe (9.67ns) and 2.67 ns on the 133 cm probe (11.83); essentially placing it around the 20 to 30 depth.

Oct 1986 Dry/frozen layer on top of wet zone. Feature noted at 10.5 ns on the 83.8 cm (13 ns) probe and 9.33 ns on the 130 cm (15.33 ns) probe. Layer analysis indicates incongruity between probes. The best estimate of the unfrozen/frozen boundary would be between 60 and 70 cm.

May 1987 Several features appear on the TDR crt displays indicating a wet-dry-wet-dry sequence. Profile is generally frozen with a small thaw layer appearing in the top 25 to 35 cm (between 2.0 and 4.5 ns). Another feature appears on the 85.4 cm (11.5 ns) probe at 8.67 ns and on the 130.4 cm (13.33 ns) at about 6.67 ns. The feature is somewhere around 50 to 60 cm depth and may represent thermal conditions or differences in the materials.

Oct 1987 Top 27.5 cm is dry/frozen (K = 8.5) over top a wetter (but not saturated) layer with K being about 36. A feature was noted on the 129 cm probe (16.67) at 10.8

ns but not on the shorter probes. This feature is at about 60-70 cm and probably represents the base of the summer thaw. K is 3.9 in the 83-129 cm layer (frozen).

July 1988 This profile is similar to May 1987. No 6 foot probe readings were obtained. A feature appears at 10.5 ns on the 60 cm probe; at 9.6 ns on the 82.4 cm probe and at 8 ns on the 128.2 cm probe. This suggests that the materials are experiencing slightly different moisture regimes in either the upper of lower layers. The thaw layer is within the top 50 cm.

Oct 1988 No readings were obtained for the 2 or 6 foot probes. A discontinuity was noted on the 127 cm probe (4.5 foot) at 12.33 ns but did not appear on the 82.4 cm probe (3 foot, 15 ns travel time). K in the surface zone is lower than that found during July.

Summary for 5B KC

Lithologic record from the temperature record indicates very thick icy peat.

	Cable T3	
	100 cm	200 cm
May 1985	-0.3	-0.4
Oct 1985	-0.1	-0.2
May 1986	-0.1	-0.2
Oct 1986	-0.0	-0.1
May 1987	0.0	-0.2
Oct 1987	1.2	-0.2
Jul 1988	3.5	-0.1
Oct 1988	1.4	-0.2

May 1985 Generally frozen with K averaging about 5 throughout the profile. The surface 25 cm has K at about 16 and the feature detected between 2.5 and 3.2 ns on the crt displays reflect the unfrozen/frozen interface.

Oct 1985 Top 25 cm dry/frozen over top of a wet/thawed layer; K is about 19.6. A feature was detected at about 12 ns on the 87, 133 and 178 cm probes (14.5, 18, 19.5 ns respectively) suggesting an unfrozen/frozen boundary at about 50-60 cm with K = 52 in the thawed zone and 5.5 below.

May 1986 Profile analysis is fairly complicated and subject to error. The profile is generally frozen with a feature being detected at about 2.5 to 3.33 ns. This is essentially in the vicinity of the end of the 25 cm probe. No real evidence of much surface thaw as yet.

Oct 1986 Top 30.5 cm dry/frozen (K = 15.8) over a wet layer (K = 77 in the 30.5 to 56 cm zone). A feature was detected at about 12.3 ns on the 175.3 cm probe putting it in the vicinity of 60-70 cm. The end of th 127 cm probe was not detected on the crt display but rather the feature was erroneously assumed to be the end of the line.

May 1987 Layer analysis very complicated. The profile appears to be generally frozen with varying K's in different layers giving a complex series of bumps on the crt display. The first notable feature appears on all TDR probes at about 3-3.33 ns (approximately 27.5 cm) and another was noted on the 127 and 175 cm probes at 11.3 and 9.33 respectively. This is in the vicinity of the end of the 80 cm probe and probably reflects differing wetness. If the profile is thawed as the temperatures suggest, then the peat is fairly dry but this is

unlikely.

Oct 1987 Rather complex layer analysis. Top 28.5 cm is dry/frozen (K = 16.3). The 28.5 to 76.4 cm zone is wet (K = 61) and the material appears to be frozen at depth (with K being 5.2 in the 76.4 to 169 cm region. The feature detected at 14.3 to 17 ns on the 122.2 cm (21 ns) and 169 cm (23.3 ns) probe puts the unfrozen/frozen boundary between 70 and 80 cm.

July 1988 Similar to May 1987. Bumps found in the middle of the 3, 4.5 and 6 foot probes. No pattern has emerged to suggest whether this is due to material properties or thermal conditions.

Oct 1988 Very wet in upper 75 cm with lower portion of profile having a K of about 13. No distinct features were noted on the profile and were probably masked.

Summary for 5B KP

Lithologic record from the temperature record indicates very thick icy peat.

	Cable T1			
	50 cm	100 cm	150 cm	200 cm
May 1985	4.3	-0.0	-0.1	-0.1
Oct 1985	0.9	0.2	-0.2	-0.2
May 1986	6.8	0.0	-0.1	-0.1
Oct 1986	6.7	0.6	-0.1	-0.1
May 1987	12.5	0.0	-0.1	-0.1
Oct 1987	4.3	0.5	-0.1	-0.1
Jul 1988	3.4	0.6	-0.1	-0.1
Oct 1988	4.8	-	-	0.7

May 1985 Layer analysis suggests incongruity between probes.

Oct 1985 Profile is essentially thawed. A feature was noted at 25.8 ns on the 133 cm (35.8 ns) probe and at 33.3 ns on the 178 cm (45.83 ns) probe placing it around 120 - 140 cm. The average K in the 57 - 133 cm zone is about 75.

May 1986 Profile is essentially thawed with a dry/frozen layer within the top 57 cm (9.58 ns) at around 3.6 ns.

Oct 1986 Same as above. Profile is wet and thawed.

May 1987 Same as above.

Oct 1987 Same as above.

July 1988 Profile very wet, same as May readings.

Oct 1988 Profile is very wet, same as previous Oct readings.

Summary for 6 KB

Lithologic record from the temperature record indicates very thick icy peat.

	Cable T4	
	100 cm	200 cm
May 1985	-0.0	-0.1
Oct 1985	-0.0	-0.1
May 1986	-0.0	-0.1
Oct 1986	0.0	-0.1
May 1987	0.0	-0.1
Oct 1987	0.0	-0.1
Jul 1988	-	-0.1
Oct 1988	0.2	-0.1

May 1985 K in the top 25 cm is 17.6. Feature noted between 4.5 and 5.3 ns on the 57 cm (9.67), 87 cm (12 ns), 133 cm (16.83 ns) and the 178 cm (19.3 ns) probes. This represents the base of the unfrozen/frozen zone which is about 30 - 50 cm from the surface. K in the frozen zone is about 4.5.

Oct 1985 Fairly complex profile. K in the top 25 cm is 12.5 (either dry or frozen). K is about 60.3 in the 25 - 57 cm zone and grades to smaller values with depth. The feature is noted at 17 ns on the 133 cm probe (21.33 ns) and at 16.3 ns on the 178 cm probe (23.67 ns). This places the feature past the end of the 87 cm (15.83 ns probe) in the vicinity of 90 - 100 cm.

May 1986 Several features noted on this trace. The first occurs between 4.5 and 6.3 ns on all but the 25 cm probe. The second appears at 133.3 and 15.7 on the 178 and 133 cm probes respectively. The layer analysis indicates a dry/frozen layer in the top 25 cm followed by a warmer wetter layer to about 90 cm then frozen beneath.

Oct 1986 Dry surface layer (K =16.3) followed by a wet layer between 25.4 and 86.3 (K = 56) grading to frozen material below. The feature noted at 21 ns on the 130 cm (24.3 ns) probe and at 20 ns on the 172.7 cm (27 ns) probe denotes the unfrozen/frozen boundary. Using a K of 8.0 for this layer, the boundary occurs around 100 - 110 cm depth.

May 1987 Good example of the effect of multiple layers on the TDR's crt display. The first feature is noted at 4.7 to 6.3 ns on all the probes except the shortest. The second, denoting the end of the feature is at around 7.3 to 9 ns. The unfrozen/frozen boundary appears at about 17.3 to 18 ns on the 132.2 cm (21.7 ns) and the 174 cm (24.7 ns) probes placing around 95 to 110 cm.

Oct 1987 Surface zone is dry/frozen with K = 13.5 for the top 24.5 cm. K in the 25-85 cm zone is very wet at 63.5. The unfrozen/frozen boundary appears to around 110 to 120 cm and was detected on the 129 cm (26.2 ns) and the 166 cm (end point missed) probe at 23.7 and 22.3 ns respectively.

July 1988 Discontinuities noted on the 130.2 cm (4.5 foot) probe at 25 ns and at 24.2 ns on the 165.9 cm (6 foot) probe. This represents an unfrozen layer over a frozen layer. K in the unfrozen layer is about 75 (thawed peat) with K being about 10 in the frozen layer. The thaw front is at about 100 to 110 cm.

Oct 1988 No readings obtained for the 1 or 3 foot probes. A discontinuity was noted on the 161.9 cm (6 foot) probe at 24.7 ns. This places it at about 127 cm depth

Summary for 6 KC

Lithologic record from the temperature record indicates very thick icy peat.

	Cable T3 100 cm	200 cm
May 1985	-0.3	-0.4
Oct 1985	-0.1	-0.2
May 1986	-0.3	-0.4
Oct 1986	0.0	-0.1
May 1987	-0.1	-0.1
Oct 1987	-0.1	-0.2
Jul 1988	0.1	0.4
Oct 1988	-0.1	-0.2

May 1985 Essentially frozen with K = 5.0 on average.

Oct 1985 Complicated layer analysis suggesting probe incongruity. Unfrozen/frozen boundary detected at 11.2 ns on the 87 cm probe (12.99 ns) and at 12.3 ns on the 133 cm probe (18.0 ns). This places at around 55 to 65 cm with K = 6.2 in the frozen zone.

May 1986 Similar to May 1985. Feature noted at 2.99 - 3.2 ns may be lithologic since it does not seem to be due to significant water content differences. K averages 5.5 throughout the profile.

Oct 1986 K is 16 in the top 28 cm (3.42 ns). The feature noted on the 84 cm (15 ns), 130 cm (19.7 ns) and the 173 cm (23.3 ns) probe denote the unfrozen/frozen boundary. These appear at 11.5, 14.7, and 13.3 ns respectively placing the boundary somewhere between 55 and 70 cm. K is about 7 in the frozen zone.

May 1987 Very complex profiles with many features denoted. The layer analysis also suggests poor agreement between the probes. Features were noted at 3 to 4 ns (between 26.5 and 36 cm); at 10 - 11 ns (between 57 cm (7.8 ns) probe and 87.4 cm (132 ns) probe) and at 14 ns on the 176 cm probe (19.33). The end point of th 132 cm probe was also missed.

Oct 1987 The surface 27.5 cm is dry/frozen (K = 13.2). It is very wet between the 27.5 (3.3 ns) and the 84.4 cm (19 ns) probes. A feature was noted on the 126 cm (23 ns) probe at 19 ns and at 21.3 ns on the 169 cm (26.3 ns) probes. This denotes the unfrozen/frozen boundary with K = 7 in the 84.4 to 169 cm zone.

July 1988 The traces for the 2, 3, 4.5 and 6 foot probes all

suggest multiple thaw/frozen/thaw layers. It is extremely difficult to interpret the layer analysis. The first discontinuity seems to appear at about 10.3-11.3 ns on the probes. This represents a thawed/frozen boundary and would appear to be around 45-50 cm. The two longest probes have another discontinuity at 24.2-25 ns which would place it near 130 cm.

Oct 1988 Only the 4.5 and 6 foot probes were read. No layer analysis was possible. A dip appears at 20 ns on the 169.9 cm (6 foot) probe but is not evident on the 126.2 cm (4.5 foot) probe. Again, it would seem to be in the 110-130 cm layer.

Summary for 6 KP

Lithologic record from the temperature record indicates very thick icy peat.

	50 cm	100 cm	150 cm	200 cm
May 1985	-0.0	-0.2	-0.3	-0.3
Oct 1985	0.1	-0.1	-0.1	-0.1
May 1986	-0.0	-0.1	-0.1	-0.1
Oct 1986	0.3	-0.1	-0.1	-0.1
May 1987	0.0	-0.1	-0.0	-0.1
Oct 1987	2.2	0.0	0.0	-0.1
Jul 1988	1.9	1.6	0.0	-0.1
Oct 1988	-0.7	0.8	0.3	-0.0

May 1985 Material generally frozen. Feature noted around 10 ns on the 87 cm (11.83 ns), 133 cm (18.33 ns) and the 178 cm (18.66 ns) probes.

Oct 1985 Material generally frozen but warm since K averages 20. Features detected at 15 ns on the 133 cm (18 ns) probe and at 16.5 ns on the 147 cm (21.7 ns) probe. The layer analysis suggests that this is just a layer of differing water content.

May 1986 No attempt was made to interpret the 157.5 cm probe. The material still appears to be frozen generally.

Oct 1986 Profile has begun to develop a very wet layer between 58.5 and 112 cm. The feature at 21.7 ns on the 152 cm (25 ns) probe seems to denote an unfrozen/frozen boundary.

May 1987 K is 28.4 in the top 57 cm a surface drying has occured. The feature detected at 5.3 to 7 ns on the probes seems to denote the boundary. The position of the unfrozen/frozen boundary is quite uncertain but may lie between 100 and 120 cm.

Oct 1987 Between 55 cm and 108 cm K is 66.6. Below 108 the layer analysis suggests a K of 8 but the scatter is great and the thermal properties suggest that the unfrozen/frozen boundary may be at a greater depth.

July 1988 Material seems to be very wet. No distinguishing features evident.

Oct 1988 No readings taken.

Summary for 7A KB

Lithologic record from the temperature record indicates ice rich lacustrine material with thick permafrost (> 20 m).

	Cable T4 100 cm	200 cm
May 1985	-0.9	-1.6
Oct 1985	-0.4	-0.9
May 1986	-	-0.9
Oct 1986	-0.3	-0.6
May 1987	-0.7	-0.8
Oct 1987	-0.1	-0.6
Jul 1988	-0.3	-0.6
Oct 1988	0.0	-0.5

Oct 1985 K = 36 in the top 56 cm with K = 8.2 below

May 1986 Completely frozen K averages about 7.

Oct 1986 Material appears to be completely thawed or near thawed. Feature appears on the 81.2 cm (15.5 ns) probe at 12.33 ns (approximately 56 cm) and on the 122 cm (18.33 ns) probe at 11.7 ns (approximately 50 cm). It could be litholigic.

May 1987 Essentially frozen except for the the top 24.5 cm. The feature detected at 3.33 to 3.83 ns on the remaining probes is in the vicinity of 25 cm. K averages about 7.5 in the frozen zone.

Oct 1987 The profile is extremely wet with K averaging 59 in the 25 to 69.4 cm zone. The feature detected on the 103.2 cm (20.33 ns) probe at 19 ns would suggest the boundary between unfrozen/frozen material at a depth of 80-90 cm.

July 1988 No reading for the 6 foot probe. Material is very wet in the near surface zone. K is about 10 in the frozen layer. The depth to this layer appears at about 12.7 ns on the 69.4 cm and 103.2 cm probes (3 and 4.5 foot) which would be about 48 cm.

Oct 1988 Profile has high K values throughout. No boundaries or features were noted.

Summary for 7A KC

Lithologic record from the temperature record indicates ice rich lacustrine material with thick permafrost (> 20 m).

	Cable T3 100 cm	200 cm
Oct 1985	-0.2	-0.7
May 1986	-0.8	-0.7
Oct 1986	0.0	-0.4
May 1987	-0.1	-0.3
Oct 1987	0.2	-0.3
Jul 1988	0.5	-0.3
Oct 1988	0.6	0.1

Oct 1985 K is very high (wet) in the top 86 cm being 42.5 in the 25.4 - 55.9 cm zone and 31.1 in the 55.9 - 86.4 cm zone. K is about 5.9 below this.

May 1986 The profile is essentially frozen (K = 6.5) with exception of the top 25 cm which is very wet (K = 68.4). The unfrozen/frozen boundary is between 7.0 and 7.5 ns which is almost in perfect agreement with the end of the 25.4 cm probe (7.0 ns).

Oct 1986 On average, the profile is extremely wet (K = 42).

May 1987 Probe agreement is poor as noted by the layer analysis. The profile is essentially frozen but warm (K = 20) with the surface zone very wet as in May 1986.

Oct 1987 Same as Oct 1986.

July 1988 Profile is uniformly wet. K values are in the order of 60-68. No features were noted although any features would have been masked.

Oct 1988 Similar to other Oct readings.

Summary for 7A KP

Lithologic record from the temperature record indicates ice rich lacustrine material with thick permafrost (> 20 m).

	Cable T1			
	50 cm	100 cm	150 cm	200 cm
May 1985	2.1	-0.9	-1.5	-1.8
Oct 1985	0.3	0.2	0.0	-0.5
May 1986	11.7	-0.2	-0.2	-0.4
Oct 1986	-1.9	-0.1	-0.0	-0.2
May 1987	15.9	0.7	-0.3	-0.4
Oct 1987	5.0	1.8	0.9	-0.1
Jul 1988	-	-	1.0	-0.2
Oct 1988	-	-	1.1	0.8

Oct 1985 Profile is fairly warm and wet. K is 35 in the top 25.4 cm; K is 47.4 in the 25.4-55.9 cm zone and decreases gradually. In the 86.4-157.5 cm zone K is about 15.8 suggesting that it is ice-bonded.

May 1986 Material is largely frozen with K of about 15. The surface 25.4 cm is thawed with K = 40.9.

Oct 1986 Profile is completely thawed and very wet with K = 44.8 between 25.4 and 152.4 cm.

May 1987 K = 38.1 in the top layer. It is thawed and wet. The position of the thaw front was noted on the 55.9 cm (9.67 ns), the 86.4 cm (12.2 ns) and the 117 cm (13 ns) probes at around 5.8 ns. K in the frozen zone is about 16 putting the feature at around 35-45 cm.

Oct 1987 Profile is completely thawed and very wet with K = 45 over the profile.

July 1988 Profile is very wet. The 6 foot (132.9 cm) probe is very difficult to examine.

Oct 1988 Similar to other Oct readings.

Summary for 7B KB

Lithologic record from the temperature record indicates ice rich lacustrine material with thick permafrost (> 20 m).

	Cable T4 100 cm	200 cm
May 1985	-0.8	-1.6
Oct 1985	-0.1	-0.8
May 1986	-0.6	-1.1
Oct 1986	-0.0	-0.6
May 1987	-0.7	-1.3
Oct 1987	0.5	-0.6
Jul 1988	0.1	-0.9
Oct 1988	0.0	-0.6

Oct 1985 Profile appears to be essentially frozen with a dry/frozen layer in the top 25.4 cm (K = 16.6) and a slightly warmer but still frozen layer beneath. A feature is detected at 14.0 ns on the 132 ns (18.2 ns) probe placing it between 86.4 and 132 cm. This feature may be lithologic or represents an area of higher ice content.

May 1986 The profile is frozen. K averages about 10.

Oct 1986 Top 25 cm is frozen/dry with K = 5.1. Between 25 and 127 cm, K averages about 28.5 making it essentially behave as an unfrozen material.

May 1987 Similar to May 1986.

Oct 1987 Similar to Oct 1986.

July 1988 No readings were made for the 6 foot probe. The profile has a K of about 24 being wetter than May readings.

Oct 1988 Readings were only made on the 3 and 4.5 foot probes. No layer analysis is possible and no features were seen on the existing traces.

Summary for 7B KC

Lithologic record from the temperature record indicates ice rich lacustrine material with thick permafrost (≥ 20 m).

	Cable T3		
	100 cm	200 cm	300 cm
Oct 1985	0.3	-0.2	
May 1986	-0.1	-0.4	
Oct 1986	0.0	-0.0	
May 1987	0.6	-0.2	
Oct 1987	1.9	0.8	
Jul 1988	9.3	1.1	0.8
Oct 1988	2.1	1.3	0.1

Oct 1985 K averages 28 over the 28 to 132 cm region. Essentially warm material.

May 1986 Essentially frozen with K averaging about 15.

Oct 1986 Very wet and thawed throughout.

May 1987 Similar to May 1986. K averages about 12.

Oct 1987 Similar to Oct 1986. K averages about 34.

July 1988 K is about 35 and profile is thawed.

Oct 1988 Extremely hard to interpret traces. K is high again at about 38 with a drier layer on top.

Summary for 7B KP

Lithologic record from the temperature record indicates ice rich lacustrine material with thick permafrost (> 20 m).

	Cable T1				
	50 cm	100 cm	150 cm	200 cm	250 cm
Oct 1985	-0.0	0.2	-0.2	-0.6	
May 1986	4.0	-0.3	-0.4	-0.5	
Oct 1986	-0.7	-0.0	-0.1	-0.2	
May 1987	13.2	-0.3	-0.5	-0.4	
Oct 1987	3.6	1.7	1.0	0.1	
Jul 1988	-	9.1	0.9	-0.2	
Oct 1988	0.7	2.2	1.7	1.2	0.5

Oct 1985 Material is essentially unfrozen K averages about 30.

May 1986 Profile essentially frozen with K of about 15 in frozen zone and K = 29.3 in the top 25.4 cm (4.6 ns). Thaw feature appears at about 6.2-6.3 ns on all traces placing it between 30 and 35 cm.

Oct 1986 Material is thawed with K = 38.6 in the 27-172.7 cm zone. The surface 27 cm is either freezing or dry with K = 20.1.

May 1987 Profile is essentially frozen similar to May 1986. K averages 11.5.

Oct 1987 Similar to Oct 1986. No surface thaw evident.

July 1988 Unfrozen and wet.

Oct 1988 Unfrozen and wet. Traces hard to interpret.

Summary for 7C KB

Lithologic record from the temperature record indicates ice rich lacustrine material with thick permafrost (> 20 m).

	Cable T4 100 cm	200 cm
May 1985	-1.4	-2.0
Oct 1985	-0.3	-0.8
May 1986	-1.2	-1.6
Oct 1986	-0.1	-0.7
May 1987	-1.2	-1.7
Oct 1987	-0.1	-0.7
Jul 1988	-0.4	-0.9
Oct 1988	-0.1	-0.6

Oct 1985 Top 25.4 cm freezing back or drier, K = 9.3. K in the 25.4 - 55.9 cm zone is about 21.1; in the 55.9-86.4 cm zone, K = 10.3. Profile is generally frozen except for the 25.4-55.9 cm layer which may have experienced summer thaw.

May 1986 Profile is completely frozen with K averaging 9.5.

Oct 1986 K averages 15.3 in the 25.4-127 cm zone. K is 8.2 in the top 25.4 cm layer. Essentially frozen.

May 1987 Same as May 1986.

Oct 1987 Similar to Oct 1986 except the profile is warmer with K averaging 20.

July 1988 K averages about 22 throughout profile. No distinguishing features noted.

Oct 1988 No readings taken.

Summary for 7C KC

Lithologic record from the temperature record indicates ice rich lacustrine material with thick permafrost (› 20 m).

	Cable T3 100 cm	200 cm
Oct 1985	-0.1	-0.9
May 1986	-1.0	-1.8
Oct 1986	-0.3	-0.6
May 1987	-0.8	-1.4
Oct 1987	0.8	-0.4
Jul 1988	0.7	-0.5
Oct 1988	-0.4	-0.2

Oct 1985 Profile fairly wet with K averaging 28.5. Layer analysis is complicated and suggests poor correlation between probes.

May 1986 Poor correlation between probes. Thaw feature appears between 5.2 and 6.8 ns which would place past the end of the 25.4 cm (5.0 ns) probe near 30 cm. K in the top layer is 34.8. and averages 13 in the frozen zone.

Oct 1986 Profile is essentially unfrozen.

May 1987 Thaw feature appears at 3.6 to 3.8 ns on the probes which would situate it at the base of the 22.5 cm (3.99 ns) probe. K in the thawed layer is 28.4 with K averaging about 14 in the frozen zone.

Oct 1987 Profile is essentially thawed.

July 1988 K values are high, profile must be thawed. Layer analysis reveals nothing else and no distinguishing features were noted.

Summary for 7C KP

Lithologic record from the temperature record indicates ice rich lacustrine material with thick permafrost (> 20 m).

	Cable T1			
	50 cm	100 cm	150 cm	200 cm
Oct 1985	0.2	0.1	-0.5	-0.9
May 1986	1.9	-0.8	-1.2	-1.3
Oct 1986	-4.3	-0.6	-0.0	-0.3
May 1987	2.7	-0.6	-0.8	-0.9
Oct 1987	4.0	2.4	1.3	0.0
Jul 1988	10.5	3.0	-0.1	-0.3
Oct 1988	-	-0.5	0.7	0.4

Oct 1985 The profile appears to be frozen beneath 55-60 cm although no distinct features appear on the TDR traces. K in the frozen layer is about 15. In the surface zone it is about 21.

May 1986 Fairly wet (K = 34) in the top 25.4 cm (5.1 ns) layer. A thaw front is evident on the 3 longest probes between 7.4 - 8.2 ns which would place it between 25.4 cm (5.1 ns) and 55.9 cm (9.7 ns).

Oct 1986 There is poor agreement between the probes in the layer analysis. The profile appears to be very warm (thawed) with K averaging 31.5

May 1987 A classic profile. K is 31.2 in the top 30 or cm of the profile. (feature noted at about 5 ns) with K averaging about 12.5 in the frozen zone.

Oct 1987 Wet and thawed. K averages about 33.8 in the profile.

July 1988 Profile is wet and thawed. Near surface zone is particularly wet.

Oct 1988 No features noted on trace. Layer analysis reveals nothing.

Summary for 8B KB

Lithologic record from the temperature record indicates thick peat layer with thick permafrost (< 4 m).

	100 cm	200 cm	Cable T4
May 1985	-0.1	-0.0	
Oct 1985	0.1	-0.1	
May 1986	-0.2	-0.1	
Oct 1986	0.1	-0.1	
May 1987	-0.2	-	
Oct 1987	0.4	-0.1	
Jul 1988	-0.1	-0.1	
Oct 1988	-1.3	-0.2	

Oct 1985 Top 25 cm dry and/or frozen, K = 5.6. The 25.4-87 cm layer is unfrozen and wet (but not saturated if it is peat) with K = 36. K in the 87-178 cm layer averages 8.8. A feature was noted at 13 ns on the 133 cm (19 ns) probe ant at 13.7 ns on the 178 cm (23.33 ns) probe. This feature is the unfrozen/frozen boundary and appears between 72 to 80 cm.

May 1986 The layer analysis indicates disagreement between the probes. The top 25 cm is dry/frozen with K = 16 overlying a wet (K= 31) layer between 25 and 87 cm and a drier (probably frozen) layer below (K = 14.5).

Oct 1986 Top 28 cm is dry or has recently frozen back (K = 5.8). The 28-83.8 cm layer is very wet with K = 63. K is about 18 in the 83.8-172.7 cm layer. A feature was noted at 17.3 ns on the 130 cm (22.33 ns) probe and at 20.8 ns on the 172.7 cm (29.6 ns) probe. This represents the unfrozen/frozen boundary between 94 and 110 cm depth.

May 1987 The top 24.5 cm is dry/frozen (K = 7.1) over a wet layer between 24.5 and 87.4 cm (K = 31.8). The material appears to be frozen between 87.4 and 175.9 with a K = 13.9.

Oct 1987 Top 22.5 cm dry or has recently frozen back (K = 5.4). The material is wetter beneath and seems to be frozen or dry at depth. A feature was noted on the 127.2 cm (19.67 ns) probe at 14.2 ns and at 14.3 ns on the 174.9 cm (23.83 ns) probe. This is just past the end of the 86.4 cm probe in the vicinity of 90 and 100 cm. This may reflect the unfrozen/frozen boundary.

July 1988 No readings taken for the 1 or 4.5 foot probe. End points for the 3 and 6 foot probes were difficult to see. No features were readily discernable but upper 88 cm has a K of about 16 while lower layers are higher.

Oct 1988 Only the 3 and 4.5 foot probes were recorded. Both had K values around 35.

Summary for 8B KC

Lithologic record from the temperature record indicates thick peat layer with thick permafrost (< 4 m).

	Cable T3 100 cm	200 cm
May 1985	-0.3	-0.1
Oct 1985	-0.2	-0.2
May 1986	-0.3	-0.2
Oct 1986	-0.1	-0.2
May 1987	-0.3	-0.2
Oct 1987	-0.1	-0.2
Jul 1988	-0.2	-0.2
Oct 1988	0.0	-0.2

Oct 1985 Feature noted on the 133 cm (18.67 ns) probe at 12.5 ns and at 13 ns on the 178 cm (22.67 ns) probes. K is about 7.1 between 133 and 178 cm. The feature is between 63 and 69 cm and represents the unfrozen/frozen boundary.

May 1986 Surface 25 cm is wet (K = 30.2). A feature was noted between 6 - 7 ns on the four longest probes. This feature is the unfrozen/frozen boundary which is between 30 and 40 cm.

Oct 1986 The top 25.4 cm is drier (K = 27.3) than 25.4-86.3 cm layer (K = 42). K is about 6.1 in the 86-175.3 cm layer. The feature noted at 15.5 ns on the 127 cm (22.3 ns) and the 175.3 cm (24.67 ns) places the unfrozen/frozen boundary between 75-80 cm.

May 1987 Profile is frozen (K = 6.8) below 24.5 cm. The feature detected on the four longest probes is in the vicinity of 25-30 cm. K in the surface zone is 48.2 (wet).

Oct 1987 Material still appears frozen (K = 8.5) in the 76.4 to 168.9 cm layer. The feature noted on the 121.2 cm (18.5 ns) and the 168.9 cm (23.3) ns probes places the unfrozen/frozen boundary between 66-73 cm.

July 1988 Features detected at about 7.5 ns on the 3, 4.5 and 6 foot probes. This is about 50-55 cm deep. K in this layer was about 18 with K being about 6 in the lower layers.

Oct 1988 No readings taken for the 1 and 2 foot probes. a feature was detected at 16.7 ns on the 4.5 and 6 foot probes. The unfrozen/frozen boundary is at about 70-75 cm.

Summary for 8B KP

Lithologic record from the temperature record indicates thick peat layer with thick permafrost (< 4 m).

	Cable T1			
	50 cm	100 cm	150 cm	200 cm
May 1985	-0.6	-0.5	-0.5	-0.2
Oct 1985	-0.2	-0.2	-0.2	-0.1
May 1986	-0.2	-0.2	-0.3	-0.1
Oct 1986	-0.1	-0.1	-0.3	-0.1
May 1987	-0.2	-0.2	-0.3	-0.1
Oct 1987	-0.1	-0.1	-0.2	-0.1
Jul 1988	0.3	-0.1	-0.2	-0.1
Oct 1988	0.3	-0.1	-0.2	-0.1

Oct 1985 Material essentially frozen with an average K = 7.

May 1986 Little change from Oct.

Oct 1986 Seems to get wetter with depth. If the traces are correct, there appears to be a very wet (K approx. equal to water) layer between 124.5 and 170.2 cm.

May 1987 Similar to May 1986. Frozen.

Oct 1987 Similar to Oct 1986. Very wet layer at depth (124.2-167.9 cm)

Jul 1988 Profile is wetter than during may period. Layer analysis reveals no boundaries.

Oct 1988 Surface layers dry. Profile has an average K of about 42 over top 173 cm.

Summary for 8C KB

Lithologic record from the temperature record indicates thin peat layer with thin permafrost (< 4 m).

	Cable T4 100 cm	200 cm
May 1985	-0.1	-0.2
Oct 1985	-0.1	-0.2
May 1986	-0.2	-0.3
Oct 1986	-0.1	-0.3
May 1987	-0.2	-0.2
Oct 1987	-0.1	-0.2
Jul 1988	-	-
Oct 1988	-0.0	-0.2

Oct 1985 Dry/frozen in top 25.4 cm (K = 2.2). Warmer (wetter) in the 25.4-87 cm layer (K = 15.5 and frozen beneath (K = 7 in the 87-178 cm layer. A feature was detected on the 133 cm (14.83 ns) probe at 7.83 ns and at 9 ns on the 178 cm (17.33 ns) probe but not on the 87 cm (9.33 ns) probe. This feature is in the 53-83 cm zone and may be lithologic.

May 1986 Top 25 cm is frozen/dry (K = 5.3) with a wetter layer between (K = 23) between 25 and 87 cm. The feature detected at 11.5 ns on the 133 cm (16.99 ns) and the 178 cm (19.67 ns) probes correspond to the end of the 87 cm line and represents the base of this thaw (?) layer.

Oct 1986 K in the 88.9 - 175.3 cm layer is 7.7. A wet layer exists between 58.5-88.9 cm (K = 31.3) and the surface 28 cm is very dry/frozen (K = 2.6). The feature detected between 12.3 and 13.3 ns on the 132 cm (14.67 ns) and the 175.3 cm (18.67 ns) puts the unfrozen/frozen boundary between 106 and 116 cm.

May 1987 Profile seems warmer with K averaging 16.8 over the 24.5-169.9 cm layer. The surface is dry/frozen (K = 4.8).

Oct 1987 Similar to Oct 1986.

July 1988 No July readings.

Oct 1988 6 foot probe impossible to read. No features detected on the traces but layer analysis reveals that profile is much wetter than previous years with K averaging 36.5 over the top 125 cm with a dry/frozen layer to about 25 or so cm.

Summary for 8C KC

Lithologic record from the temperature record indicates thin peat layer with thin permafrost (< 4 m).

	Cable T3	
	100 cm	200 cm
May 1985	-0.3	-0.2
Oct 1985	-0.1	-0.2
May 1986	-0.2	-0.2
Oct 1986	-0.0	-0.1
May 1987	-0.1	-0.1
Oct 1987	0.1	-0.1
Jul 1988	-	-
Oct 1988	0.2	-0.1

Oct 1985 Top 25 cm is drier (K = 15.5) than the 25.4-57 cm layer (K = 44.2). K in the frozen zone is about 7.4. The feature detected between 9.8 and 11 ns on the 3 longest probes correspond to the end of the 57 cm probe and signifies the unfrozen/frozen boundary.

May 1986 The material is frozen (K = 5) below about 25 cm. K = 22.9 in the top 25 cm. All the features detected on the 4 longest probes correspond to the 25 cm boundary which signifies the unfrozen/frozen boundary.

Oct 1986 K = 21.3 in the top 25.4 cm layer; between 25.4-55.9, K = 62 (very wet). The feature detected on the 3 longest probes between 13-13.7 ns corresponds to about 60-70 cm and represents the unfrozen/frozen boundary. K in the frozen zone is about 4.5.

May 1987 Similar to May 1986. The features detected on the 4 longest probes denote the unfrozen/frozen boundary which is around 24-30 cm.

Oct 1987 Similar to Oct 1986. The feature detected on the 3 longest probes between 13 and 13.8 ns corresponds to the unfrozen/frozen boundary. K is about 9 in the frozen zone, hence, the boundary is between 60 and 68 cm similar to the Oct 1986 position.

July 1988 No readings taken.

Oct 1988 Profile very wet with traces difficult to read. The highest values recorded yet.

Summary for 8C KP

Lithologic record from the temperature record indicates thin peat layer with thin permafrost (< 4 m).

	Cable T1			
	50 cm	100 cm	150 cm	200 cm
May 1985	-0.3	-0.6	-0.5	-0.5
Oct 1985	-0.0	-0.3	-0.2	-0.3
May 1986	-0.2	-0.4	-0.4	-0.4
Oct 1986	0.0	-0.2	-0.2	-0.3
May 1987	-0.2	-0.3	-0.2	-0.2
Oct 1987	1.4	-0.2	-0.2	-0.2
Jul 1988	-	-	-	-
Oct 1988	-1.2	0.3	-0.1	-0.2

Oct 1985 K in the 57-178 cm layer is about 7.7 (frozen). A wet zone appears between 25-57 cm. The features detected on the longest three probes between 10.7-12.8 ns corresponds to the unfrozen/frozen boundary between 62-73 cm.

May 1986 Material is completely frozen (K = 6.2). except for the top 25-30 cm (K = 30.2). All features detected on the longest 4 probes correspond to this boundary.

Oct 1986 K in the frozen zone is about 6.2. The feature at 13.83 ns on the 134.7 cm (19.33 ns) probe and at 14.7 ns on the 175.3 cm (23.33 ns) probe suggest an unfrozen/frozen boundary between 68 and 71 cm similar to the Oct 1986 boundary.

May 1987 Less agreement between probes, essentially similar to May 1986.

Oct 1987 A lot of scatter in the layer analysis. The position of the unfrozen/frozen boundary appears at two distinctly different places on the two longest probes. No guess possible.

July 1988 No readings taken.

Oct 1988 The wettest readings to date. No reading taken for the 1 foot probe. No features realy evident.

Summary for 10B KB

Lithologic record from the temperature record indicates very thin permafrost (frozen peat) over unfrozen till.

	Cable T4			
	50 cm	100 cm	150 cm	200 cm
May 1985	-0.0	-0.3	-0.2	-0.1
Oct 1985	-0.0	-0.2	-0.2	-0.1
May 1986	0.4	-0.3	-0.2	-0.1
Oct 1986	0.0	-0.1	-0.1	-0.0
May 1987	0.9	-0.2	-0.1	-0.0
Oct 1987	0.6	-0.1	-0.1	-0.0
Jul 1988	-	-0.1	-0.1	-0.0
Oct 1988	-	-0.1	-0.1	-0.0

Oct 1985 Generally frozen. A feature appears between 5.7 and 6.5 ns (near 50-60 cm) which may be lithologic.

May 1986 Frozen below 25 cm (K = 4.2); K = 25.0 in the top 25 cm layer. Feature appears at about 2.5 ns on all probes and represents an unfrozen/frozen boundary between 10 and 15 cm.

Oct 1986 Dry/frozen in the top 22.9 cm (K = 15.5) and wet/unfrozen between 22.9 and 50.8 (K = 36) and frozen beneath (K = 6). The unfrozen/frozen boundary appears between 5.7 and 7.7 on the 3 longest probes and occurs between 40-45 cm.

May 1987 Essentially completely frozen although temperatures suggest otherwise. The surface material may be dry if the temperatures are correct. Feature appearing at 2.5 ns may be lithologic (eg peat).

Oct 1987 Similar to Oct 1986 but the unfrozen/frozen boundary occurs at different places on the 3 deepest probes but is probably in the order of 45-55 cm.

July 1988 A thawed/wet layer appears between the 2 and 3 foot probes (46-73.4 cm) but its position is not constant on the other probes. This is probably a thawed veneer over frozen material.

Oct 1988 No readings taken for the 1 and 2 foot probes. A discontinuity was noted at the end of the 3 foot (73 cm) probe but it does not appear at the same depth on the 4.5 and 6 foot probes. The layer analysis suggest that K is about 3.5 to 6.5 below this probe.

Summary for 10B KC

Lithologic record from the temperature record indicates very thin permafrost (frozen peat) over unfrozen till.

	Cable T3				
	50 cm	100 cm	150 cm	200 cm	250 cm
May 1985	1.7	-0.1	-0.1	0.1	
Oct 1985	0.2	0.2	0.0	0.0	
May 1986	7.3	-0.0	0.0	0.0	
Oct 1986	0.0	0.2	0.0	0.0	
May 1987	10.8	-0.0	0.0	-0.2	
Oct 1987	0.8	2.4	1.2	0.2	
Jul 1988	-	2.8	0.2	-0.2	0.3
Oct 1988	-	1.2	3.5	2.8	2.5

Oct 1985 K in frozen zone is about 7.5. Features appear at 7.5 to 8.75 ns on the 3 longest probes. These are in the 50-65 cm zone and may be lithologic.

May 1986 Profile is essentially frozen (K = 5.4) except for a thin surface veneer (K = 16 in the top 25 cm).

Oct 1986 Top 25.4 cm dry (K = 14.0) followed by a wet layer (K = 48.5) between 25.4 and 53.4 cm. K is about 7 in the frozen portion of the soil. The features which appear on the 3 longest probes between 10.3 and 10.7 correspond to the 53 - 58 cm depth and this represents the base of the unfrozen layer.

May 1987 Similar to May 1986.

Oct 1987 Similar to Oct 1986. K in the top 23 cm is 18, followed by a wetter layer between 23 and 49 cm (K = 34.4) with K being about 8 in the frozen layer. A feature appearing at about 10.6 ns corresponds to the end of the 74.4 cm probe and may be the unfrozen/frozen boundary.

July 1988 An unrozen/frozen boundary is evident on the 3, 4.5 and 6 foot probes at about 8.7 ns placing it at about 0-60 cm. K is about 25 in the upper layer.

Oct 1988 No readings were obtained for the 1 and 2 foot probes. An unfrozen/frozen boundary appears at about 14-14.7 ns on the 4.5 and 6 foot probes. This is coincident with the end of the 3 foor probe placing the boundary at about 74 cm.

NOTE The temperature record does not seem to agree with the K record. Either the temperatures are wrong or this material has a very low water content in the unfrozen state. If the peat veneer is thin and contains water

(but not saturated) then the apparent unfrozen/frozen boundaries may indeed be lithologic. This should be confirmed in the field.

Summary for 12B KP

	Cable T1			
	50 cm	100 cm	150 cm	200 cm
May 1985	-0.2	-0.8	-1.0	-1.3
Oct 1985	0.2	-0.1	-0.2	-0.2
May 1986	0.9	-0.2	-0.3	-0.4
Oct 1986	0.1	0.0	-0.0	-0.1
May 1987	3.1	-0.1	-0.1	-0.2
Oct 1987	4.2	2.3	0.6	-0.1
Jul 1988	-	0.2	0.1	-0.0
Oct 1988	-	-0.7	1.7	0.1

May 1985 Frozen K averages 4.8

Oct 1985 Frozen in the 122-167.7 cm layer K = 7.6. The 57 and 122 cm probes don't seem right.

May 1986 Profile essentially frozen, K averaging about 6.5. Some surface thaw in the top 25 cm evident K = 16.

Oct 1986 Profile seems to have completely thawed with K averaging 44.3 in the 25.4-170.2 cm layer. Freeze back/dry layer in the top 25 cm with K = 10.6.

May 1987 Very complex layer analysis. Either the probes lack congruity or there is a sequence of differing degrees of wetness. The profile seems to be generally unfrozen with dry/frozen pockets.

Oct 1987 Thawed and wet with a surface dry/frozen layer extending to about 24.5 cm.

July 1988 Profile very wet with a dry surface layer. No features evident on the traces to help delineat boundaries. K averages 67.8 over the top 161 cm.

Oct 1988 No readings were taken for the 1 and 2 foot probes. No features noted on the remaining probes. K averages 62.5 over the top 163 cm.

Summary for 10B KP

Lithologic record from the temperature record indicates very thin permafrost (frozen peat) over unfrozen till.

	Cable T1			
	50 cm	100 cm	150 cm	200 cm
May 1985	-0.1	-0.2	0.0	0.0
Oct 1985	0.4	-0.0	0.3	0.5
May 1986	3.4	-0.1	0.2	0.4
Oct 1986	1.2	3.1	3.1	2.4
May 1987	1.7	0.0	0.5	0.6
Oct 1987	3.9	5.8	5.2	3.5
Jul 1988	-	7.8	3.8	1.8
Oct 1988	0.6	3.6	5.5	4.4

Oct 1985 K = 25.0 in the top 25 cm followed by a very wet layer (K = 64) in the 25-87 cm layer; below 87 cm K = 10.5.

May 1986 Ground is completely thawed and very wet with K averaging 60 in the top 178 cm.

Oct 1986 Same as May 1986. Very wet and unfrozen.

May 1987 Very wet.

Oct 1987 Very wet.

July 1988 Very wet again.

Oct 1988 Very wet again.

Summary for 12B KB

	Cable T3			
	50 cm	100 cm	150 cm	200 cm
May 1985	0.9	-0.1	-0.4	-0.3
Oct 1985	0.3	-0.1	-0.2	-0.1
May 1986	2.6	-0.3	-0.3	-0.2
Oct 1986	0.1	-0.1	-0.2	-0.2
May 1987	3.1	-0.3	-0.3	-0.2
Oct 1987	3.1	0.0	-0.2	-0.1
Jul 1988	-	-0.1	-0.2	-0.1
Oct 1988	-	0.0	-0.2	-0.1

May 1985 Profile essentially frozen. Evidence of a thaw front at 2.8 ns on the 57 cm (5.83 ns) probe and at 3.33 ns on the 133 cm (11.17 ns) probe. No estimate possible.

Oct 1985 Top 25 cm dry/frozen (K = 6.8) over a wetter layer between 25.4 and 57 cm (K = 25.2). Below the material is frozen with K = 7.2 on average. The feature which shows up on the 3 longest probes between 7 and 8 ns corresponds to a depth of about 50-65 cm and may reflect the unfrozen/frozen boundary.

May 1986 Similar to May 1985. The feature indicated on the longest probes is in the vicinity ot 55-65 cm. K is about 7.8 in the frozen zone.

Oct 1986 Top 28 cm is dry/frozen (K = 6.7) overlying a wet layer (K = 32) between 28-58.5 cm). K averages about 6.5 below 58.5 cm. The feature which appears on the 3 longest probes corresponds to a depth of about 55-68 cm and represents the unfrozen/frozen boundary.

May 1987 Frozen K averages 5.7.

Oct 1987 Similar to other October readings. The feature which appears on the longest three probes between 9.17 and 9.42 ns is the unfrozen/frozen boundary with occurs near 60-65 cm depth.

July 1988 Feature evident on the 4.5 and 6 foot probes is an unfrozen/frozen boundary. It is approximately coincident with the end of the 3 foot probe at about 85 cm. The layer analysis reveals quite a bit of scatter.

Oct 1988 No readings were taken for the 1 and 2 foot probes. A feature noted on the 4.5 and 6 foot probes between 8.8 and 9.3 ns is almost coincident with the end of the 3 foot probe at about 85 cm. This feature has seemed to persist regardless of the time of year. Perhaps it is lithological.

Summary for 12B KC

	Cable T3	
	100 cm	200 cm
May 1985	-1.2	-1.5
Oct 1985	-0.0	-0.1
May 1986	-0.6	-0.7
Oct 1986	-0.1	-0.2
May 1987	-0.7	-0.8
Oct 1987	-0.1	-0.2

May 1985 Frozen K = 6 on average.

Oct 1985 K averages about 7 in the frozen zone. The 3 longest probes show a feature at between 7-8 ns which is about 55-65 cm from the surface. Since the surface isn't remarkably wet, this may represent a change in lithography.

May 1986 Top 25 cm wetter than beneath (K = 22.9). K tends to gradually decrease with depth averaging 7 in the top 25 cm to 6.7 between 25-178 cm.

Oct 1986 Similar to Oct 1985.

May 1987 Similar to May 1986

Oct 1987 Similar to other October readings.

July 1988 A discontinuity appears on the 3, 4.5 and 6 foot probes between 10 and 10.5 ns with K averaging about 6.8 in the lower portions of the profile, this feature appears to be at about 65 cm.

Oct 1988 A similar discontinuity was noted on the 4.5 and 6 foot probes at about 10.3-10.8 ns; this places it at about 85 cm. No readings were taken for the 1 and 2 cm probes.