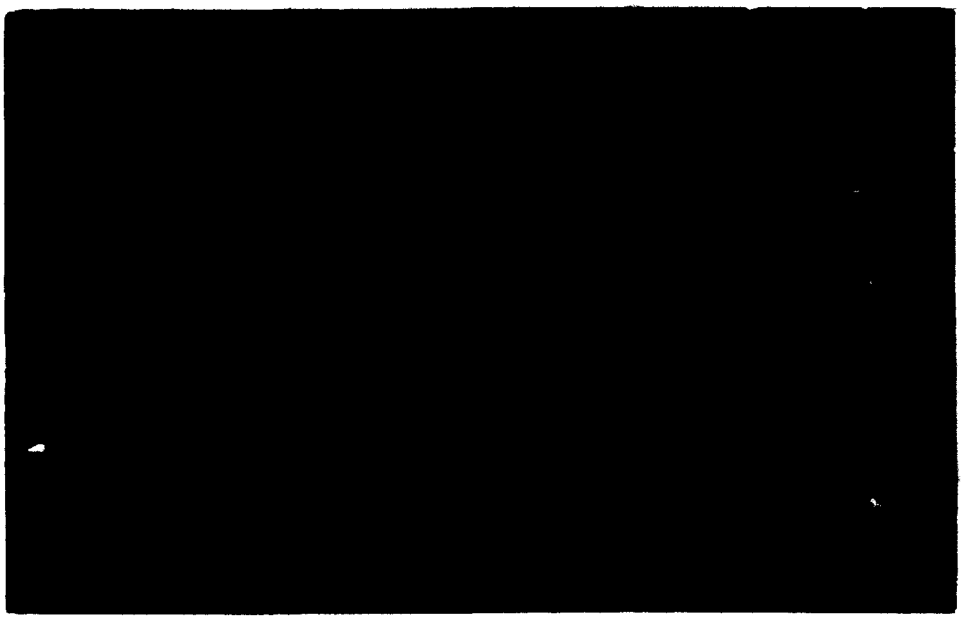

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Geothermal Circular WJMcC 2

TRACER - TESTS - WAIRAKEI

W J McCabe, M R Manning and B J Barry.

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Institute of Nuclear Sciences
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Lower Hutt, New Zealand.

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This report summarizes the results of the main tracer tests made at Wairakei.

The details of the tests are given in Table I and the results obtained from all the wells monitored are given in Tables 2,3, 4 and 5. In each test the iodine-131 tracer was released below the surface of the inflowing cool water and separated water from each of the observation wells was monitored continuously for radioactivity. The data were collected in both analogue and digital forms, the latter being used to calculate the decay and background corrections.

A second test on WK 107 using Bromine-82 as a tracer was made in August 1979 to test the suitability of the iodine-131 as a tracer. Due to the small amount of tracer used and its short half life of 36 hrs. only WK 24 and 48 showed responses. These were identical to arrival times and peak shapes to the iodine test, from which we infer that iodine is not absorbed in this system and is a reliable tracer.

While most of the headings of the tables are self-explanatory, two may need some comment. The time of first arrival of the tracer is difficult to determine precisely due to background variations, however the 10% of peak value is usually easily located.

To eliminate the effects of injecting different amounts of tracer in the various tests the concentrations of tracer per litre as measured are normalised by dividing by the amount injected and then multiplied by 10^{12}.

In the figure showing the location of the wells and the established connections the solid lines indicate recoveries greater than 1% of tracer, the long dashes show recoveries greater than 0.1% and the short dashes recoveries greater than 0.01%.

The graphs of the results from the three wells that showed responses in the February 1980 test are included. The deterioration of the data after about the 13th day following injection seems to have been associated in part at least with survey work being carried out on the wells being sampled.

Comments -

The first impression is that of the dominating effect which the faults have in isolating flows. The only common response between the WK 107 and the WK 101 and 80 tests was the very weak one in WK 108, probably associated with the transverse fault.

The second feature of the test has been the very rapid movement to the deep wells WK 121, 48 and 24, the small amount of dispersion of the tracer and the relatively large tracer return at these wells. We have interpreted this as very high permeability within the zone of the Wairakei ignimbrite into which these wells penetrate. Some indication of the depth of this permeability may be given by the information that WK 121 is fed mainly from the recent-perforations in the casing around 975m. The alternative is that it is at the depth of the slotted liner, between 2250 and 1600m, where little production appears.

The WK 107 injection showed returns along the Waiora fault wells which started during the fourth day, peaked around the tenth and had rather similar concentrations. This suggests a virtually simultaneous feed along the fault at depth and a slow vertical feed to the wells.

The results of the WK 80 and WK 101 tests show a similar pattern of returns with no responses east of the Kaiapo fault, apart from those permitted by the transverse fault. There is perhaps a slight delay in the 10% responses due to the slightly greater distances involved but the striking thing is that the peak concentration and the total returns were approximately ten times greater in the WK 80 test. This raises the questions that if WK 121 had been available would we have seen a 50% return and could this explain the 200°C temperature of its output.

The lack of response of WK 44 in any of the tests could indicate an independent input to wells located in the block lying between the Kaiapo and Wairakei faults from the transverse fault southwards.

Knowing the recovery of tracer and having a reasonable assessment of the flow down the injection well one can calculate the proportion of water in a responding well which originated from the injection well. For example, at WK 24 we had a 3.7% recovery of the (say) 50 kg/s flow down WK 107, i.e. 1.9 kg/s. The 4th quarter of 1978 list gives WK 24 as having a total output of 34 kg/s, therefore 5.5% of its discharge is from WK 107. The temperature of the water in KW 107 is 160°C and the enthalpy of WK 24 discharge is 920 J/g from which I calculate that the enthalpy of the remaining 94.5% of its discharge is only 934 J/g which is very low when compared to a value of over 1100 J/g for the Wairakei feed water. It is low even when compared to values around 1000 J/g for the cooler Waiora Valley wells.

A similar calculation for WK 48 shows that the entry of water from WK 107 drops the enthalpy from 960 J/g to 950 J/g.

To account for the low enthalpy of these two wells we need to find cool water inputs equivalent to around five times the flow of WK 107, assuming a feed of 1000 J/g water.

Malcolm Grant in MAG 25, p4, comments on the tracer tests and states that the tracer returns correlate with enthalpy. We take a slightly different a view. If enthalpy is plotted against tracer return it is tempting to draw something like an hyperbola through the points, indicating an inverse relationship. This is however really based on three out of the ten points. At one extreme WK 108 has a high enthalpy not from any effect of WK 107 but from having a partial steam feed. At the other end as discussed above, WK 24 and 48 have their enthalpies effected to some extent, by WK 107. The remainder however considered as a group show no distinct pattern and their enthalpies are being determined by cool feeds of at least an order of magnitude greater than WK 107.

Future Work -

We would attempt to extend our knowledge of the flow patterns to the northeast and if possible to the southwest. If, as we suggest, flow is isolated within the blocks between faults or is predominantly along faults we would be looking for several injection points across the field. Unfortunately a number of wells ideally situated, and with known down-flows, have been grouted up. Malcolm Grant considers that WK 54 and 47 are the most promising wells in that they do indicate some downward flow. WK 47 is probably located on the wrong side of the Upper Waiora Fault to produce any returns in present wells. WK 54 may be well situated to produce responses along the Kaiapo Fault, but because of its small down flow, in itself it cannot contribute a large part of the flow.

Coming across the field WK 78, 15, 21 and even 17 are well placed but are of uncertain value as injection wells.

At the other end of the field it would be desirable to have WK 121 discharging to some extent for any future tests. The problem of going further south to say WK 217 or 210 would be lack of cooling water and some alternative would need to be found.

There remains also the WK 107 final test if and when this become available.

An injection in one of the Waiora Fault wells would indicate whether there is any horizontal component in their feed.

(W J McCabe)

Table 1: Summary of Tests

	Injection		Tracer		Depth
Date	Time	Well	Nuclide	Quantity GBq.	m.
2.12.78	1555	WK107	I-131	74	304
14.3.79	0920	WK107	"	152	334
29.6.74	1120	WK101	"	162	400
22.8.79	1044	WK107	Br-82	3.1	320
5.2.80	1534	WK80	I-131	155	397

Table 2: Tracer recovery from injections in WK107

Well	Days to 10% of peak	Days to peak arrival	Total % recovered - in -	Days monitored
(a) December 1978				
WK48	0.3	0.7	1.4 ± 0.1	35
WK66	4.0 ± 0.5	~11	0.4 ± 0.2	35
WK67	4.5 ± 0.5	11	0.3 ± 0.1	35
WK108	0	2	0 ± 0.1	35
WK76	-	-	not detected	35
(b) August 1979		Bromine - 82		
WK 24	0.2	0.5		5
WK 48	0.3	0.7		5
No response in WK18, 44, 55, 76, 88, 103, 116,121.				5

Table 3: Tracer recovery from injection in Wk107 - March 1979

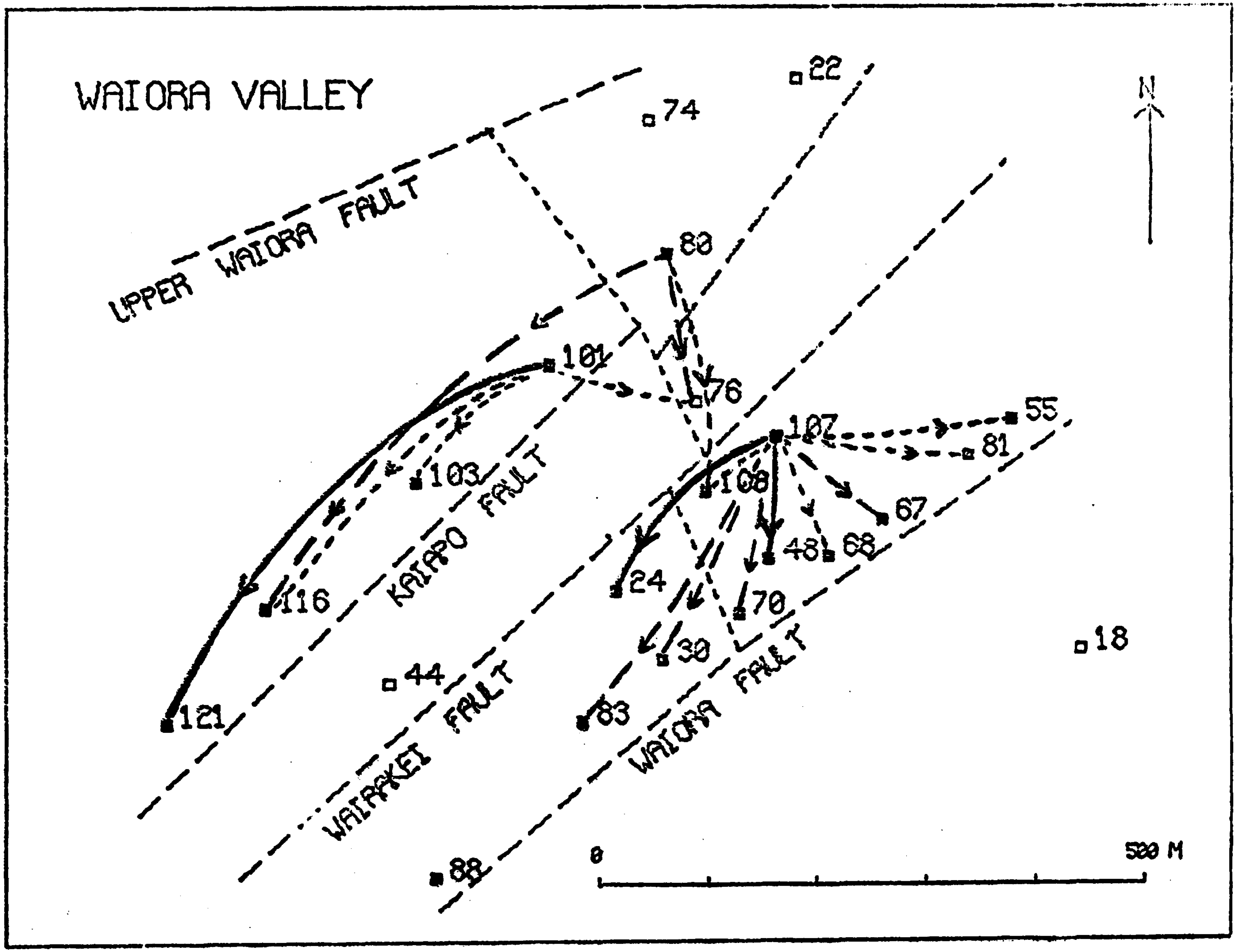
Bore	Days to 10% of peak	Days to peak arrival	Peak Concentration	Total % recovered	- in -	Days Monitored
WK24	0.2	0.4	10900	3.73		29
WK48	0.3	0.7	2360	1.33		26
WK67	2.2	>10	46	0.32		29
WK70	4.0	9.5	43	0.25		29
WK68	4.0	>10	39	0.07		26
WK30	4.5	9.0	55	0.28		29
WK83	4.5	11.0	53	0.34		29
WK81	4.8	9.5	21	0.09		29
WK55	5.5	>10	29	0.18		29
WK108	10	>10	17	~0.1		29

Table 4: Tracer recovery from injection in WK101 - June 1979

Bore	Days to 10% of peak	Days to peak arrival	Peak Concentration	Total % recovered	- in -	Days Monitored
WK121	1.2	2.5	10500	5.80		26
WK103	2.0	5.0	30	0.09		26
WK116	2.5	7.5	23	0.05		26
WK76	2.5	7-12	10	0.05		22
WK18	no response					
WK22	"					
WK24	"					
WK44	"					
WK48	"					
WK55	"					
WK74	"					
WK88	"					

Table 5: Tracer recovery from injection in WK80 - February 1980

Bore	Days to 10% of peak	Days to peak arrival	Peak Concentration	Total % recovered - in -	Days Monitored
WK116	3.3	7.6	230	0.40	20
WK76	4.0	8.7	88	0.24	14
WK108	5.5	10.0	16	0.06	20
WK18	no response				
WK24	"				
WK44	"				
WK48	"				
WK55	"				
WK70	"				
WK83	"				
WK88	"				


WAIORA VALLEY
UPPER WAIORA FAULT
KAIAPO FAULT
WAIRAKEI FAULT
WAIORA FAULT
N
22
74
80
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116
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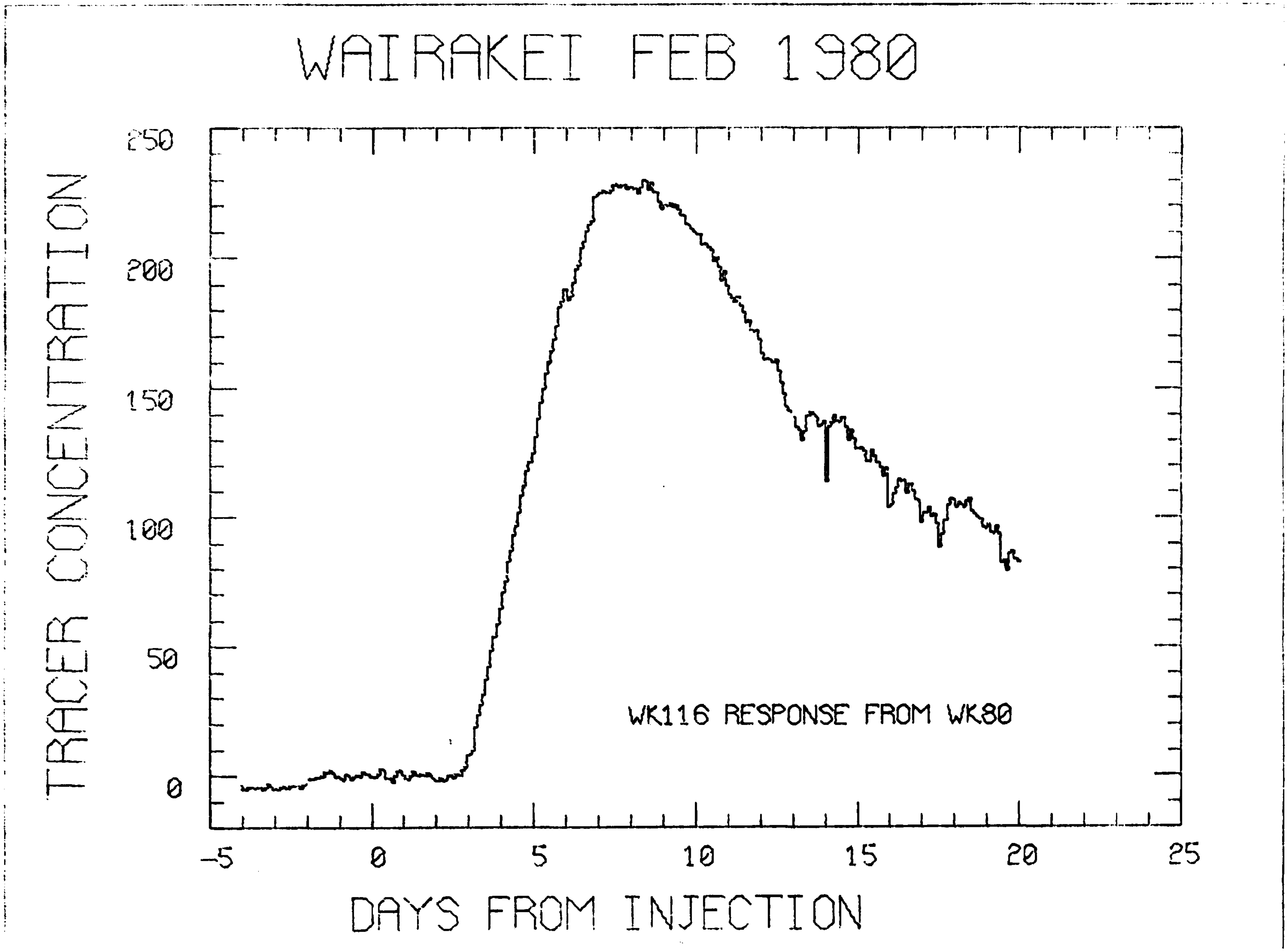
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TRACER CONCENTRATION
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100
50
0
-5
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5
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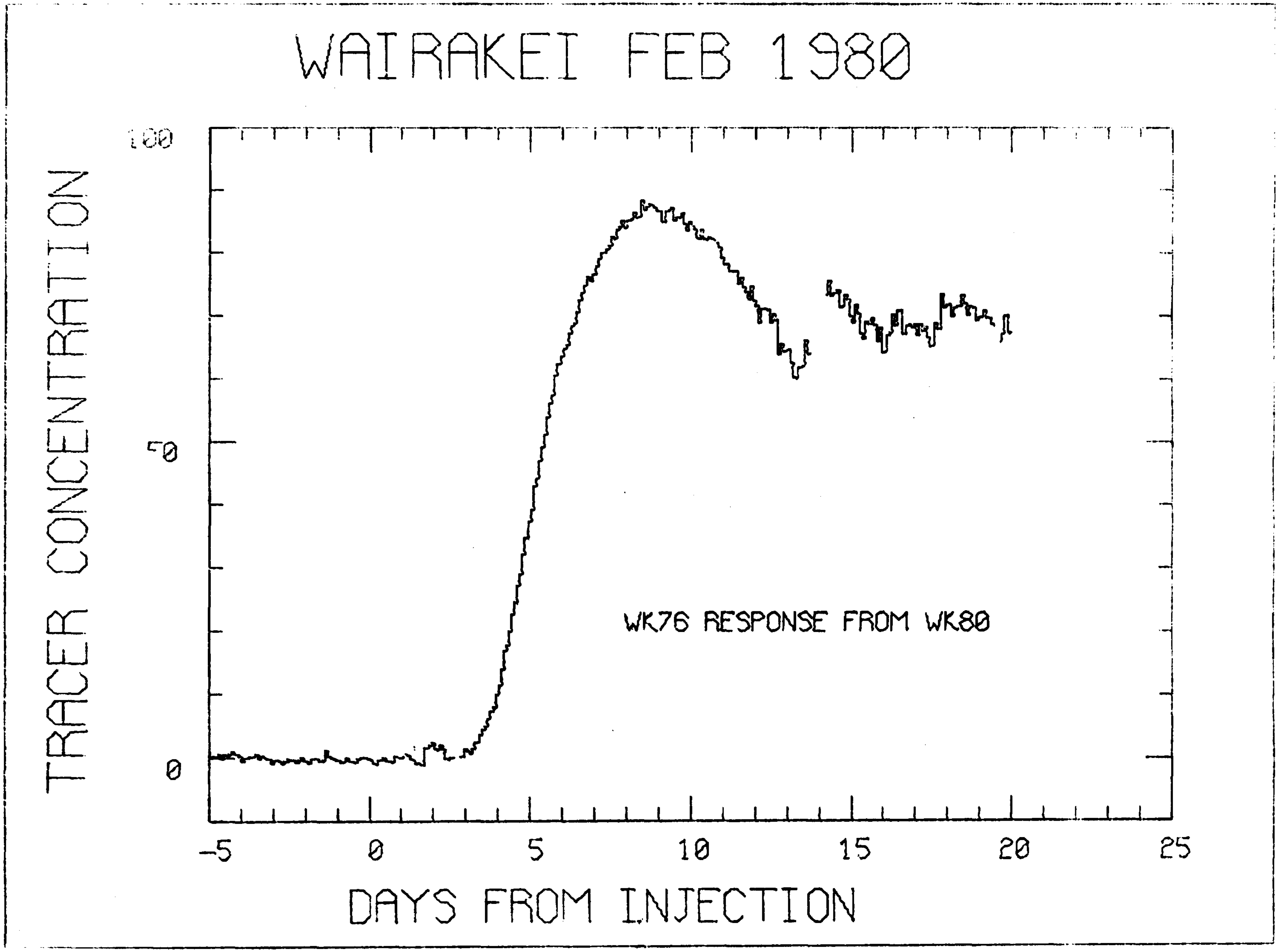
25
DAYS FROM INJECTION
WK116 RESPONSE FROM WK80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TRACER CONCENTRATION
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50
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-5
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5
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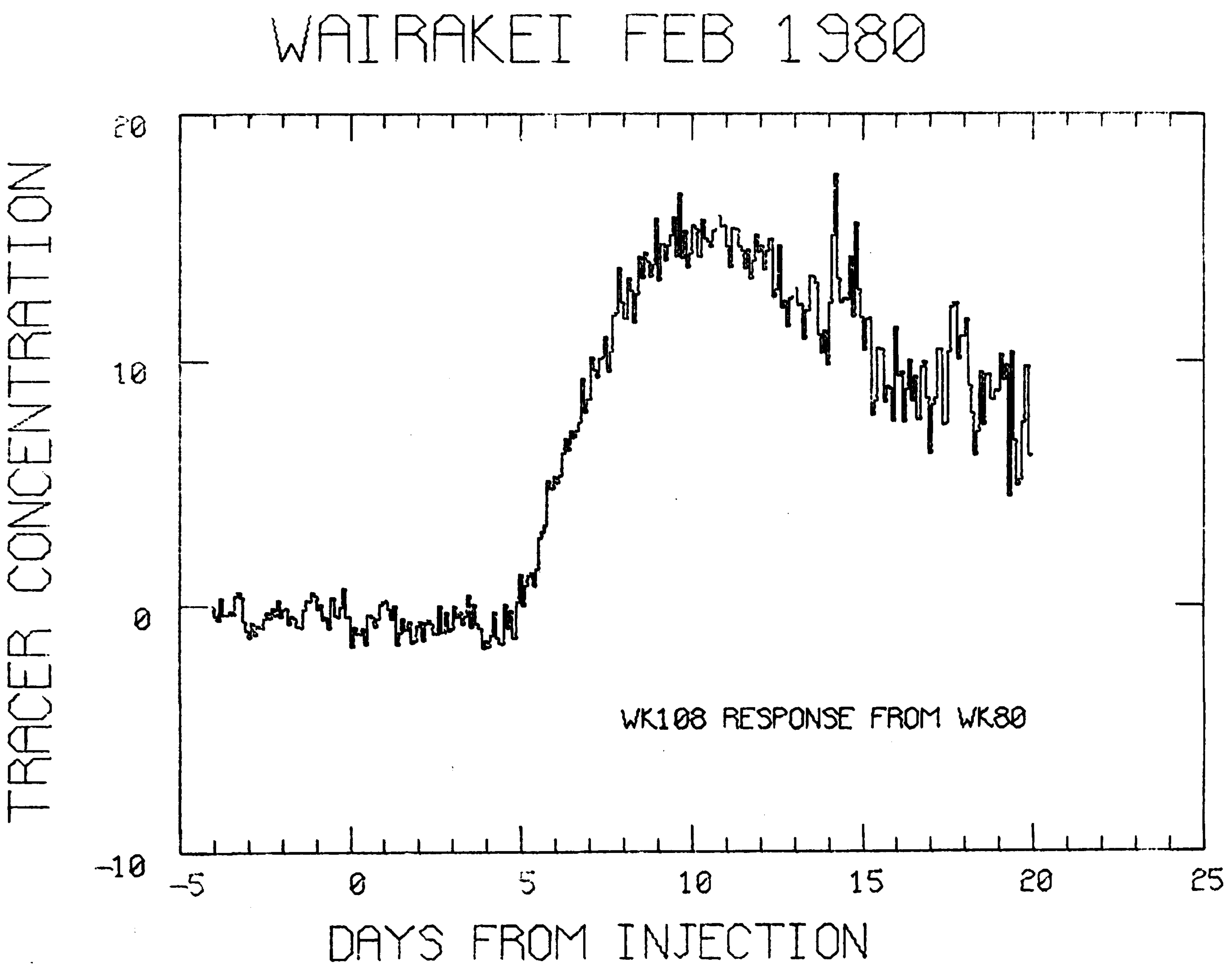
DAYS FROM INJECTION
WK76 RESPONSE FROM WK80


WAIRAKEI FEB 1980
TRACER CONCENTRATION
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DAYS FROM INJECTION
WK108 RESPONSE FROM WK80

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