M.I.M. Exploration Pty. Ltd.

MEMORANDUM

FROM : Target Generation - Brisbane (Keith Hannan)
TO : Manager, Eastern - Ian Willis; Chief Geologist EHM - Allan Ryan
DATE : July 22nd, 1994

SUBJECT : **Ernest Henry groundwater chemistry survey**

Conclusions

This note complements the recent report by AGC Woodward-Clyde on the sampling and analysis of groundwaters in the vicinity of the Ernest Henry ore deposit and should be read in conjunction with that report (see Scott, 1994). After further analysis of the data and discussions with Peter Scott, the following conclusions were reached:

(1) Groundwater sourced from both shallow (Cretaceous and Tertiary) and deeper (unconformity and below) aquifers above and within several hundred metres of the ore deposit have elevated, possibly orebody-derived, barium contents (also Mn?).

(2) Groundwaters from the deeper drill holes (diamond) are strongly Fe, As, Mo and W anomalous directly above mineralisation.

(3) The slightly *alkaline* groundwaters in the vicinity of the Ernest Henry deposit lack *broad* (>400m?) dispersions in metal levels away from the orebody. This feature probably reflects the lack of an *oxidised* supergene resource. By contrast broad metal dispersions in groundwaters reported around the Osborne deposit (P. Scott, pers. comm., July 1994) probably reflect the influence of *acidic* groundwaters associated with the formation of an oxidised resource beneath the unconformity.

Recommendations

Despite the apparent lack of extensive dispersions in groundwater metal levels around the Ernest Henry deposit, there is sufficient encouragement from this and an earlier survey in the Osborne area to indicate that groundwater samples could be collected and analysed whenever we drill deep RAB or shallow RC holes through cover to Proterzoic target rocks. Two or three spatially associated anomalous samples (in, say, Ba, As, Mo) from a widely-spaced drilling grid would require follow-up, particularly if accompanied by anomalous hard rock assays (the water sample representing a larger volume of potentially mineralised rock).

MIMEX should obtain the required equipment (simple baler and filters) and conduct its own strategic groundwater sampling. Expensive flushing equipment may not be required in situations of measurable groundwater flow (Scott, pers. comm.). Please note it is <u>not</u> being suggested that groundwater sampling and analysis become routine Company practice!

Discussion

There is probably more than one aquifer at any given location within the extensive Tertiary and Cretaceous cover that onlaps the Eastern Succession (*e.g.*, Tables 1 and 2). The Mesozoic-Proterozoic unconformity itself is locally a zone of groundwater flow (Scott, pers. comm.); as it appears to be at Ernest Henry where high water pressures were even encountered within basement rocks in some sterilisation holes (Lewis *et al.*, 1994). Clearly, these deeper waters are the most likely to interact with pre-Mesozoic mineralisation in the vicinity of the unconformity.

Fe-Mo-As-W

The most significant feature of the Ernest Henry water analyses is the elevated Fe, As, Mo and W abundances of samples from orebody drill holes EH115 and EH126 (Fig.1). Contamination by drilling mud or drill bits is not responsible. Mo- and Zn-free drilling mud was used to drill *all* holes into the Mesozoic cover and W is most unlikely to be leached from drill bit fragments. No direct relationship is evident between water metal abundances and sample location relative to the Cretaceous-Proterzoic unconformity. For example, the two anomalous 'orebody' samples, EH115 and 126, were collected 2-6m above the unconformity, as were the barren samples from peripheral and distal holes EH160, FTCD66 and PPK (see Table 3).

It was initially suspected that total drill hole depth might control water metal values, particularly if recharge of deep holes (after flushing) occurred in response to the hydraulic head rather than influx from permeable aquifers above the unconformity. For example, the deeper diamond drill holes consistently produced metal anomalous waters (Fig.1). However, water from the deep peripheral holes EH149 and FTCD2023, sampled 5-10m below the unconformity, has considerably lower Fe, As, Mo and W values than water sampled 2-6m above the unconformity and vertically above the orebody (EH115 and 126). Thus the groundwater Fe-As-Mo-W anomaly is real and not an artifact of drill hole depth.

In the case of the water bores that surround the deposit and barely penetrate the basement (Table 3), it is reasonable to conclude that recharge after flushing was dominated by metal-poor aquifers within the cover sediments. In this respect results for the PPK borehole support the suggestion that groundwaters must 'see' mineralisation to develop anomalous metal concentrations because this hole is situated in the south of the lease where mineralisation, if present, must occur more than 300m below the unconformity. Fe, Mn and Ba levels are all lower than those in waters from bores peripheral to shallow mineralisation (Figs.1 and 2 and see next paragraph).

Ba and Mn
Mn and Ba values are elevated in groundwater samples from water bores peripheral to shallow mineralisation and the two orebody drill holes (Figure 2, note the logarithmic scale). Mn is also elevated in the peripheral hole FTCD2023. Ba might therefore be a more sensitive indicator of Ernest Henry mineralisation than the metals discussed above (the orebody is locally Ba anomalous).

Other elements
Figures 3 and 4 show how other major cation and anion abundances vary in waters from each drill hole. With the possible exception of Na, (Cl), and S (similar patterns to some metals), these elements are less amenable to interpretation than the metals discussed above.

To conclude this discussion, groundwaters that came into contact with mineralised rock have elevated Fe, As, Mo, W, Ba and Mn contents. Waters from aquifers within the permeable cover sands and silts near the Ernest Henry deposit are metal-poor with the exception of Ba (and Mn?).

Metal concentrations appear to drop sharply (within 400m?) in groundwaters away from the Ernest Henry ore deposit. At Osborne, by contrast, dispersion gradients in groundwaters are much broader (Scott, pers. comm.). Given the presence of a 300,000 tonne oxidised resource at Osborne, it is likely that Osborne groundwaters are more acidic and therefore capable of carrying higher metal loads than those in the vicinity of the Ernest Henry deposit. Both case studies indicate that there is a strong argument for groundwater sampling and analysis in situations where we are deep RAB or shallow RC drilling through cover rock units to obtain samples of uppermost Proterzoic target rocks.

References
Lewis, D., Jennings, K., Hannan, K., Barber, A., Mawer, C. and Rowston, P., 1994: Ernest Henry Supergene Project, MIMEX Technical Report 2228, 45 pp text.

Keith Hannan

cc: D Lewis, P Stoker, TGG → research file 94-8

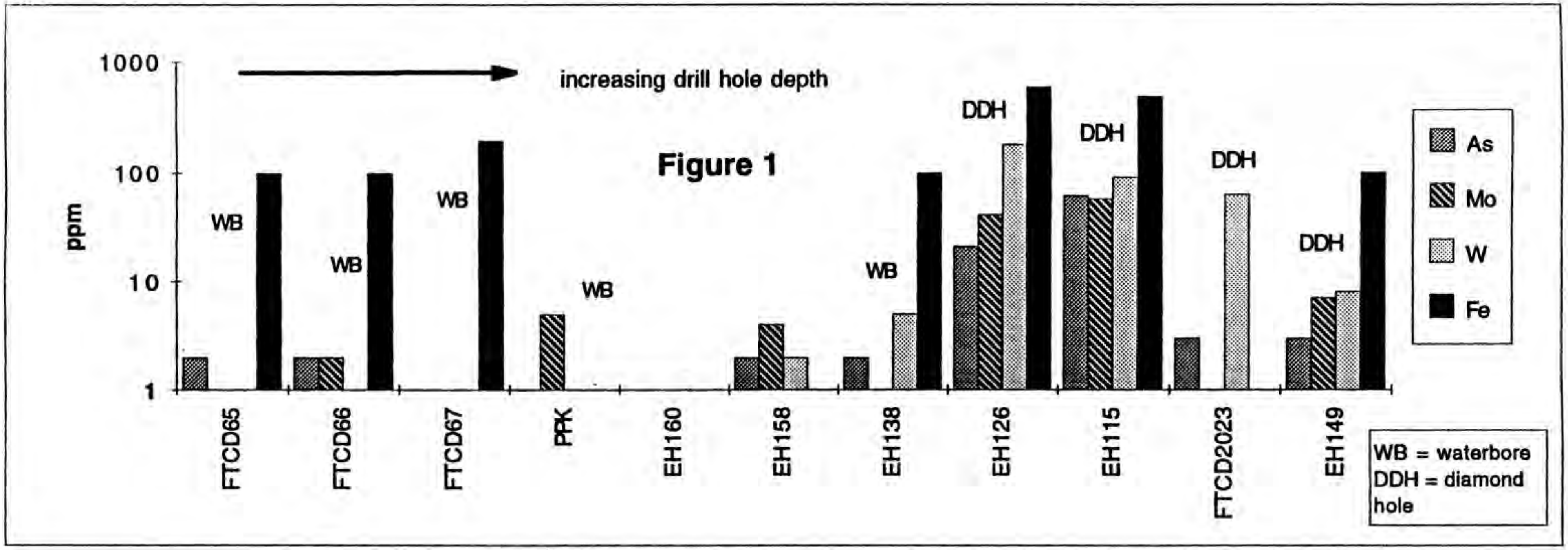


Figure 1
increasing drill hole depth
ppm
1000
100
10
1
WB
DDH
FTCD65
FTCD66
FTCD67
PRK
EH160
EH158
EH138
EH126
EH115
FTCD2023
EH149
As
Mo
W
Fe
WB = waterbore
DDH = diamond hole

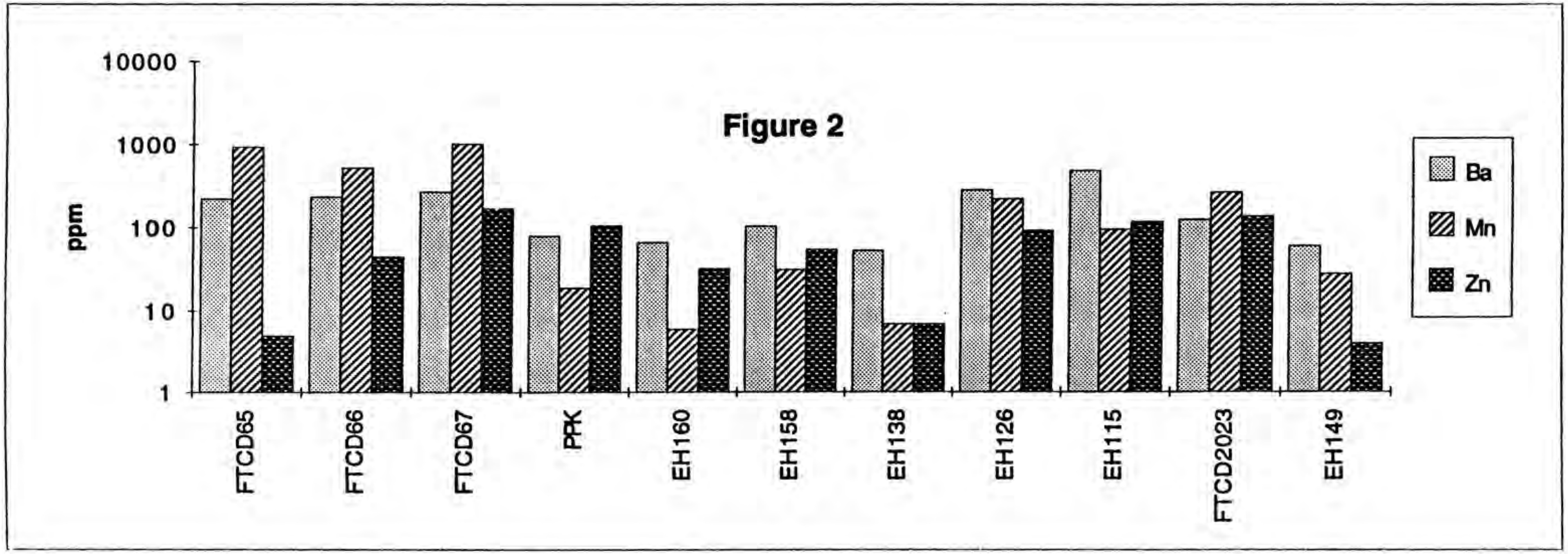
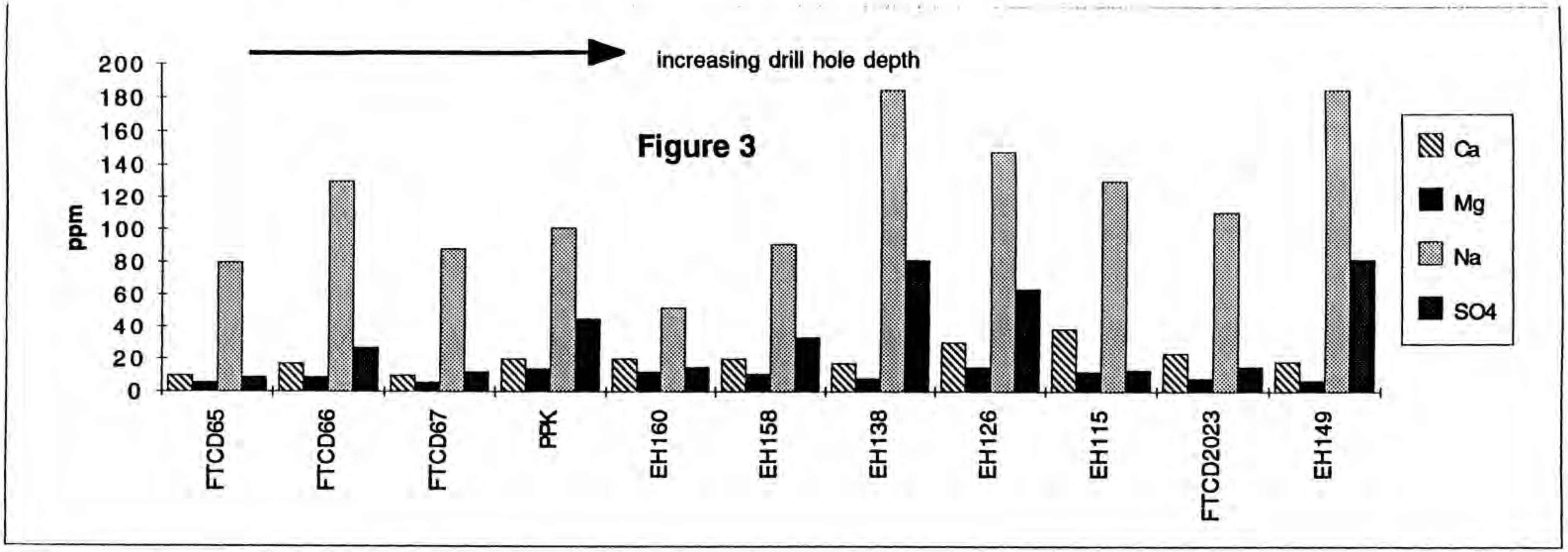


Figure 2
ppm
10000
1000
100
10
1
FTCD65
FTCD66
FTCD67
PRK
EH160
EH158
EH138
EH126
EH115
FTCD2023
EH149
Ba
Mn
Zn


increasing drill hole depth
Figure 3
ppm
200
180
160
140
120
100
80
60
40
20
0
Ca
Mg
Na
SO4
FTCD65
FTCD66
FTCD67
PRK
EH160
EH158
EH138
EH126
EH115
FTCD2023
EH149

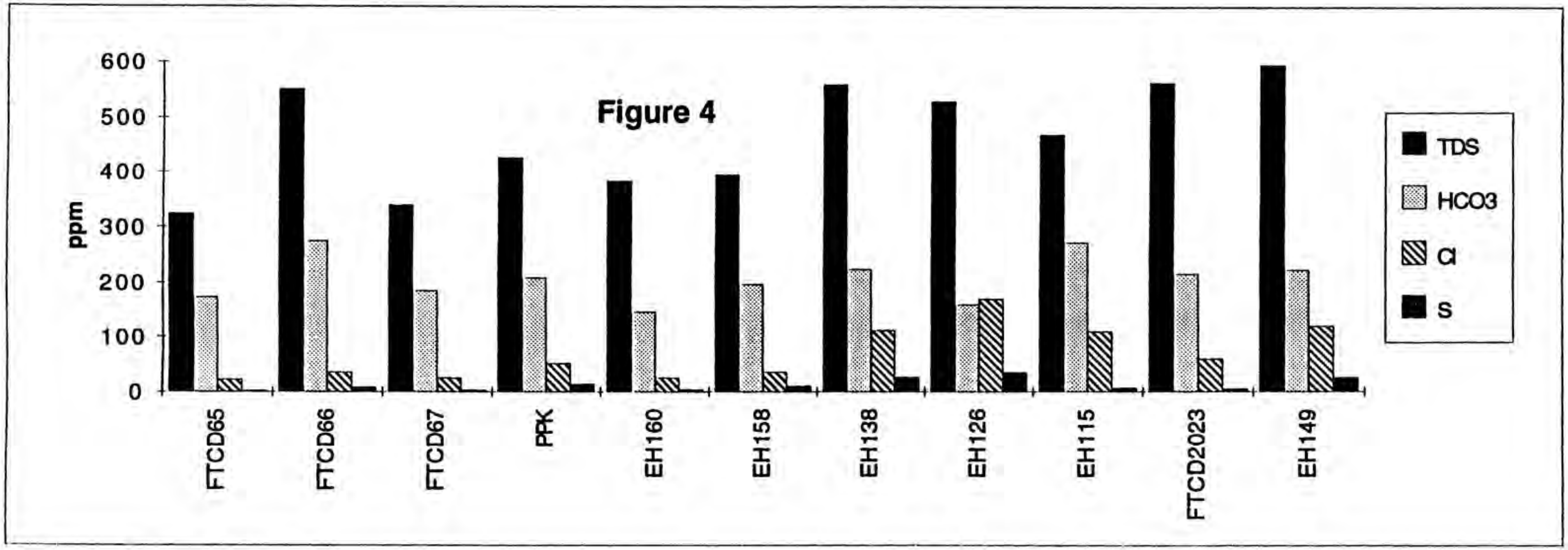


Figure 4
ppm
600
500
400
300
200
100
0
TDS
HCO3
Cl
S
FTCD65
FTCD66
FTCD67
PRK
EH160
EH158
EH138
EH126
EH115
FTCD2023
EH149

TABLE 1 ERNEST HENRY TERRAIN DRILLING: WATER DEPTHS								
HOLE	**N**	**E**	**Depth**	**Yellow Sand Depth (m)**	**Black Shale Depth (m)**	**Basal Sand Depth (m)**	**Water Depth/Host**	**Standing Water Level**
EH 155	39600	70575	60	18-26m	26-52m	52-60m	22-24m damp; yw sand	No record
							42-44m wet; 1m wh. sand 42m	
EH156	41100	69900	39	20-24m	24-28m	30-36m	28-30 damp; black musc. shale	No record
EH 157	42000	69000	39	18-22m	22-26m	26-34m	12-14m damp;sandy silt	No record
							18-22m damp; sandy conglom	
EH158	39300	67300	60	26-34m	26-32m	42-54m	30-32m wet; gy clay rich silt	21.6m
						54-60m (Si)	54-56m wet; gy sandy silt	
EH159	42000	67500	48	22-26m	26-32m	32-48m	22-26m damp; yw sand	18.2m
							32-34m; gy silty sand	
							36m wet; gy silty sand	
EH160	40700	67800	48	26-36m	36-42m	42-48m	18-20m damp; yw silty sand	18.2m
							26-36m damp; yw sand	
							42-44m damp; gy silty sand	
							46-48m damp; gy silty sand	
EH161	38100	66900	58	26-34m	34-44m	44-54m	24-26m damp; br-yw sand	Hole collapse
							42-44m wet; med gy shale	
							44-54m; damp gy sandy shale	
							55m (6000l/hr); gy sand	
EH162	37325	68250	46	26-35m	35-42m		24-32m damp; yw gritty sands	12m
							32-34m wet; yw sand	
							42-44m wet; gy silt	
EH163	37450	69900	57	30-37m	37-48m	48-56m	30m 500l/hr; yw sand	23.25
							50m 6000l/hr; gy sand	

FROM: Ernest Henry Supergene Project, 1993/4 (Lewis et al, 1994)

TABLE 2 ERNEST HENRY STERILISATION DRILLING: WATER DEPTHS							
HOLE	**N**	**E**	**Depth to basement**	**Total depth**	**Water/Flow**		
EH144	40348	69400	26m	250.4	16-26m damp		
EH145	40170	69750	36m	243.4		Gy sand 32-36m	
EH146	40000	70085	44m?	247.5	42m	Gy sand 36-44m	
EH147	39640	69920	48m	240.4	48m	Water in basal conglom. @ 48m	
EH148	39280	69750	50m	249.3	48-50m 6000l/hr		
EH149	39800	69580	38m	247.4	38m (lots!)	Flow not rec.	
					42m	as above	
					80m 1800l/hr		
					132m 3790l/hr		
EH150	40000	69230	n/s	249.4	42-48m 3000l/hr		
EH151	39640	69050	44m	249.4	135m 2880l/hr		
EH152	39670	69390	32m?	249.4	36-38m	Flow not rec.	
					78-80m	as above	
EH153	39455	69395	30m?	251.5	50m 4000l/hr		
EH154	39670	69800	36m	252.4	53m	Flow not rec.	
					72m 2400l/hr		
					90m 8000l/hr		

FROM: Ernest Henry Supergene Project, 1993/4 (Lewis et al, 1994)

TABLE 3

ERNEST HENRY GROUNDWATER GEOCHEMISTRY DRILL HOLE SUMMARY

Drill Hole	Depth of Bore m Hole Depth	Standing Water Level m	Depth of Pump m	Depth to Basement
EH115	180	22	42	49.3
EH126	98.8	21.05	31	37.3
EH138	70	21.68	40	30.35
EH149	240.4	22.16	48	38
EH158	60	21.88	40	54
EH160	48	20.46	35	>48
FTCD65	42	22.08	40	~35
FTCD66	40	22.78	39.1	>45
FTCD67	?	23.15	46	~40
FTCD2023	~200	17	43.5/65.0	<50?
PPK	?	23.07	42	~45