DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

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PITJANTJATJARA HOMELANDS NITRATE AND FLUORIDE IN OUTSTATION GROUNDWATER SUPPLIES

GEOLOGICAL SURVEY

by

R.E. READ
GROUNDWATER AND ENGINEERING

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PITJANTJATJARA LANDS, NITRATE AND FLUORIDE IN GROUNDWATER SUPPLIES

ABSTRACT

A compilation of available data for outstations in the Pitjantjatjara Homelands shows that of 45 outstations only 12 have water supplies for which both nitrates and fluorides meet WHO standards, 27 have unacceptable fluoride and or nitrate levels and 8 have not been tested for both nitrate and fluoride.

Sampling of these is recommended.

Erratic nitrate values show the need for care to prevent loss of nitrate from samples in transit to the laboratory.

The United States maximum level of fluoride of 4 mg/L is more appropriate than the WHO standard of 1.5 mg/L.

Searching for alternative supplies is not considered to be feasible.

Consideration should be given to the relevance of WHO standards to outstations. Installation of rainwater tanks should also be considered.

INTRODUCTION

Throughout the Pitjantjatjara Homelands groundwater supplies are used by settlements ranging from large permanent communities of some hundreds of people to small intermittently occupied outstation camps.

Waters with nitrate and fluoride contents exceeding World Health Organization Standards (45 mg/L and 1.5 mg/L respectively) are common.

In June 1984 the Arid Areas Water Resources Advisory Committee expressed concern at high levels of nitrates believed to be present in some outstation water supplies.

The object of this report is to document present knowledge of the occurrence of nitrates and fluorides in water supplies in this area.

HISTORY OF SAMPLING

Prior to about 1970 most groundwater development in the area away from the large communities was for stock. Water samples were not, therefore, always tested for nitrate and fluoride.

In the 1970's the move toward the setting up of outstations began. Wells drilled by the SADME for this purpose were tested for nitrates but not always for fluoride. In addition, in this period, a number of wells were drilled by a local contractor and samples were not always sent for analysis.

Some outstations were set up on wells originally drilled for stock and for which no analyses were available.

In the last few years the Pitjantjatjara Council has attempted to obtain up to date analyses for all outstation wells. The Department of Housing and Construction (formerly Public Buildings Department) has sampled some wells, but the results are not easy to obtain.

Results

Table 1 shows all known nitrate and fluoride levels for outstations.

TABLE 1

Outstation Water Supply Wells

Outstation Name	Well Unit No.	NO_3^-	F^-	TDS	Comments
Kunytjanu	4744 WW 3	35	-	1470	Drilling sample, 1977
		90	1.5	1590	Air lift sample, 1978
		108	.35	1596	4/6/84
Puta Puta	4745 WW 79	68	1.1	860	4/6/84
		20	-	834	29/12/70
		59	.8	820	22/11/85
No. 2		63	.8	940	18/11/85
Ilitjara	4745 WW 86	81	1.1	590	

Nyikukura	4745 WW 89	62	1	612	1985, when drilled
		79	1.1	640	18/4/85
Kunatjara		45	-	756	Not found in SADME records
Malara		69	.6	1070	Not in SAMDE records
Aparatjara	4845 WW 1	190	-	715	Well now abandoned
Aparatjara	4845 WW 3	3	1.7	890	Replacement for the above
Inarki	4845 WW 2	25	-	1640	April 1976 Abandoned, well dried up
		23	2.5	1710	3/8/83
Willi Willi	4845 WW 5	133	1.6	1270	
Kunamata	4944 WW 9	20	1.3	830	Ceremonial site only
Ilinitja	4945 WW 3	-	-	340	Original well (abandoned)
	4945 WW 9	81	1.1	590	Replacement well
Nyapari	4945 WW 1	21	3.1	560	31/8/75
		30	2.6	828	1967
Kanypi	4946 WW 6	30	1.9	1360	
Angatja	4945 WW 7	4	-	650	
Iltur	4942 WW 1	30	-	389	20/4/76
Ulkiya	5045 WW 7	4	0.6	375	Small supply
Wintawatu	5045 WW 1	71	1.0	920	1966
		35	1.1	650	6/9/83
		74	1.0	820	18/11/83
Walyinynga (Cave Hill)	5145 WW 51	68	2.2	1450	28/11/74 (Permanently
		52	2.2	1700	16/2/75 (occupied
		28	1.3	1245	June 1985
Yurangka	5145 WW 60	24	1.0	1430	17/5/83
		28	1.3	520	19/9/82
Manyirkanga-kana	5145 WW 57	34	.9	650	12/4/85
		27	.8	800	9/1/85
Katjikuta		28	1.0	608	Not in SADME records (1985)
		14	1.0	750	(1986)
Walalkara	5243 WW 2	2	0.3	530	Very small supply (hand pump)
Tjilpil	5244 WW 12	123	2.0	1190	
Officer Creek	5244 WW 10	52	-	1010	

Ngarutjara	5245 WW 12	<1	0.9	1730	
Turner Bore	5245 WW 7	31	1.1	1880	
Sandy Bore	5343 WW 2	-	-	830	(May not be right well)
Shirley Well	5344 WW 2	529	2.0	2160	20/2/85, presumably not used for human consumption
Pututja	5344 WW 26	-	-	545	Sampled by Dept Housing & Const, result not known
Double Tank Well	5344 WW 18	20	-	540	6/5/71
		79	1.7	859	7/10/80
		70	1.8	930	24/4/85
Mulga Bore	5344 WW 23	61	-	1430	
Tjatja	5345 WW 3	11	1.1	560	22/12/83
		20	1.1	530	30/1/85
David Well	5345 WW 5	41	2.6	1350	Rainwater tank available for drinking
Itjinpiri	5345 WW 35	1	0.9	380	
Umbagunda	5345 WW 39	17	2.0	1190	
Womikata	5345 WW 27	73	1.2	770	25/10/57
		51	1.0	803	7/10/80
		46	.7	810	22/11/83
No. 2		4	1.2	730	19/4/85
Eagle Bore (Katuyalda)	5345 WW 43	19	1.3	500	
Katjikajtitjara					
	5345 WW 32	70	-	1090	Aug 1978
		70	1.6	1150	Oct 1980
		1	1.2	1037	June 1984
No. 2		65	2.7	1050	Not found in SADME records
Wintuwintutjara					
	5345 WW 38	111	2.5	1500	5/5/83
		98	2	1546	June 72
		120	2.1	1550	3/11/83
Black Hill	5345 WW 61	83	1.3	1860	No longer used for drinking 22/11/83
Iltana	5345 WW 44	32	1.5	550	Replacement for the above 18/7/82
		36	1.3	520	30/11/85
Black Hill No. 2	5345 WW 56	86	1.0	700	24/1/85

Victory Well	5443 WW 2	-	-	1455	
No. 15	5545 WW 5	30	-	1120	20/11/71
		13.3	1.0	1330	1985
		196	.9	1980	11/9/84
Moorilyanna	5544 WW129	36	3.0	430	Not used for drinking
Paramita	5544 WW130	154	2.4	1340	Not used for drinking

Table 2 summarizes the situation and shows that of 37 outstations for which values of both nitrate and fluoride are known only 12 are within WHO (World Health Organization) standards, while 25 fall outside WHO standards.

Out of the total of 45 stations, a further 2 have nitrate in excess of WHO standards, 3 have acceptable nitrate levels but no fluoride analyses and a further 3 have no analytical information at all.

TABLE 2

NUMBER OF OUTSTATIONS WITH UNACCEPTABLE NITRATE AND FLUORIDE LEVELS

	Nitrate <45 mg/L	Nitrate >45 mg/L	Nitrate unknown	Total
Fluoride <1.5 mg/L	12	11	-	23
Fluoride >1.5 mg/L	7	7	-	14
Fluoride unknown	3	2	3	8
Total	22	20	3	45

Analyses may be available for other wells, but either have not been forwarded to SADME by the Pitjantjatjara Council, or cannot be found easily in the SADME system.

RELIABILITY OF RESULTS

Sixteen wells have been tested at least twice for nitrate.

In one case (5545 WW 5) the variation seems so extreme as to raise a suspicion that a sample has been assigned to the wrong well. Disregarding this there are 10 cases in which nitrate levels have increased by more than 5 mg/L and 4 in which it has decreased by more than 5 mg/L. (Note that four wells have been sampled three times).

The changes are too large to be accounted for by analytical error. While water composition can certainly change with time it is unlikely that so many wells could change so dramatically.

It is almost certain that nitrate is being lost from samples during transit.

This can occur if a reducing agent and appropriate bacteria are present, allowing a denitrifying reaction such as that shown below to occur.

$$4NO_3^- + 5C\ (organic) + 2H_2O \rightarrow 2N_2 + 4HCO_3^- + CO_2$$

Drilling samples are especially prone to contamination.

This is clearly reflected by the fact that drilling samples generally have lower nitrate values than samples taken during pumping (see Table 3).

Table 3 - Change in nitrate values between drilling and pumped samples.

>50mg/L decrease	21 to 50 mg/L decrease	5 to 20 mg/L decrease	Less than 5 mg/L difference	5 to 20 mg/L increase	20 to 50 mg/L increase	>50 mg/L increase
1	2	1	4	7	2	2

Field test kits are reasonably reliable and can provide a useful check.

In the past fluoride was determined by colorimetric methods which could be subject to error. In recent years specific ion electrodes have been used which are reliable and accurate.

THE NATURE OF OUTSTATIONS

Many outstations are only occupied when ceremonies are being held nearby. Others are occupied for part time usually on a regular basis at weekends or extended weekends. A few are permanently occupied.

In general permanently occupied outstations tend to be inhabited by older people rather than young families with children.

THE SIGNIFICANCE OF HIGH FLUORIDE LEVELS

In Australia the WHO limit of 1.5 mg/L fluoride has generally been followed. In the Northern Territory the Department of Health has in the past approved water supplies with up to 2 mg/L for small communities where no other supplies were available.

By contrast in the United States the Environmental Protection Agency set a maximum contaminant level 4 mg/L fluoride in March 14th 1986 (AWWA, 1986).

The reasons for setting this standard are as follows (AWWA, 1985).

a. Crippling fluorosis may occur from having long term exposure to fluoride at levels greater than 10 mg/L. Therefore the USEPA set the recommended level at 4 mg/L to allow an adequate margin of safety.

b. The US Surgeon General does not consider discoloured teeth to be an adverse health effect.

Considering the above, a Standard of 1.5 mg/L seems inappropriate for outstations.

All the outstation supplies tested lie below the 4 mg/L limit above which there is a risk of crippling fluorosis.

THE SIGNIFICANCE OF HIGH NITRATES

The WHO limit of 45 mg/L nitrate has been chosen to avoid the risk of methaemoglobinia in infants.

Nitrate levels a little over this pose no threat to adults, though nitrate concentrations of about 100 mg/L may be harmful over a long period.

No generally accepted standard for nitrates for adult consumption is known. Water with about 80 to 90 mg/L has been accepted in the UK, West Germany and Israel

The S.A. Department of Health currently gives the advice shown in Table 4 regarding nitrates.

Table 4

Suitability of Water with nitrates

(Advice of Senior Health Surveyor SA Dept of Health)

Nitrate level	
(1) 0-5 mg/L	Suitable for all drinking and cooking purposes.
(2) 5-45 mg/L	Suitable for domestic use except by women in the first three months of pregnancy or those contemplating pregnancy.
(3) 46-100 mg/L	Suitable for domestic use, except for infants under 5 years of age, or as for (2) above.
(4) Over 100 mg/L	Not suitable for human consumption or the preparation of food.

Under the classification above most outstation water supplies are not suitable for women of child bearing age.

STATISTICAL DISTRIBUTION OF NITRATE & FLUORIDE IN THE AREA

The SADME computer files were used to produce statistical distributions of nitrate and fluoride values in 36 1:100 000 map sheets roughly corresponding to the Pitjantjatjara Lands.

These are shown in Figures 5 and 6. The distribution of nitrate values is very similar to the distribution of nitrate values for outstations (Fig. 3), excepting that, as would be expected, values of nitrate over 200 mg/L are not found in outstation water supplies. 47% of these values exceed the WHO limit of 45 mg/L.

Only 21 values for fluorides were found in the computer files, very close to the number of fluoride values for outstations (19). About 30% of wells exceed the WHO limit of 1.5 mg/L, but none exceed the new US limit of 4 mg/L.

Relation Between Nitrate, Fluoride and TDS

The statistical correlation between nitrate, fluoride and total dissolved solids was tested. Correlation coefficients were 0.06 or less, thus there is no significant correlation between the three variables.

POSSIBLE SOLUTIONS

With unlimited funds the problem of nitrates in groundwater could be attacked in the following ways.

1. Alternative water supplies

Replacement wells

Exploration for groundwater in this region is expensive. Many wells are dry and excessive nitrates, fluoride and total dissolved salts are common. The occurrence of nitrate is largely unpredictable.

Drilling wells to provide an alternative supplies would be frustrating, expensive and not necessarily successful.

2. Rainwater tanks

To catch sufficient rainwater to meet a community's total needs would require a large catchment area.

In the past most outstations had only wiltjas, but with the increasing number of houses being built catching sufficient rainwater for drinking purposes should be feasible.

3. Carting water

Carting water in any quantitiy is expensive and inconvenient. However, carting could be useful where only a few young children are involved and the quantity of drinking water needed is small.

Removal of nitrates and fluorides

Nitrates can be removed in the following ways:

1. By any desalination method.
2. By ion exchange using resins.
3. By bacterial reduction of the nitrate with a reducing agent.

All methods are expensive, difficult to operate and unsuitable for remote locations.

Possibly the bacterial reduction method could be adapted to work with little attention, since this is a natural process and requires no energy other than the input of a reducing agent such as sugar.

This method would require a great deal of development before it could be suitable for remote out stations.

6. Fluorides

Like nitrates fluorides are removed by any desalination method.

Because the fluoride ion is of similar size to the hydroxyl ion fluoride can be removed by a variety of substances including bone char, activated alumina and some serpeninites.

It is understood that village scale defluoridation plants have been developed in India by the National Environmental Engineering Research Institute at Nagpur, India. (World Water Quality Bulletin, v. 9 p. 105).

CONCLUSIONS

Although a large proportion of outstation water supplies are known to have nitrate or fluoride levels in excess of WHO standards this is not known to have caused any problems.

For nitrates the best solution in the forseeable future is providing rainwater tanks for drinking water.

It may be feasible to remove fluorides by the Nalgonda process, but this requires further investigation. It is likely that rainwater tanks would be a better alternative.

RECOMMENDATIONS

1. Outstation wells should be sampled and tested for nitrate and fluoride at least every two years.

2. In the light of current increase in the US Standards for fluoride to 4 mg/L the wisdom of applying the WHO standard of 1.5 mg/L should be reviewed.

3. Where nitrate concentrations are above the WHO limit of 45 mg/L alternative supplies for drinking should be provided. Mothers would need to be educated as to the importance of providing young children with the low nitrate water.

4. In view of the fact that nearly all outstation water supplies may pose a slight risk to pregnant women the advisability of installing rainwater tanks, wherever suitable roof catchments exist, should be considered as a long term project.

ACKNOWLEDGEMENT

The assistance of Mr A. Davies of the Pitjantjatjara Council is gratefully acknowledged.

R.E. Read

R.E. READ

SENIOR GEOLOGIST

REFERENCES

AWWA, 1985. American Water Works Association Journal, July 1985 p.16B.

AWWA, 1985. America Water Works Association Journal, May 1986, p. 16B.

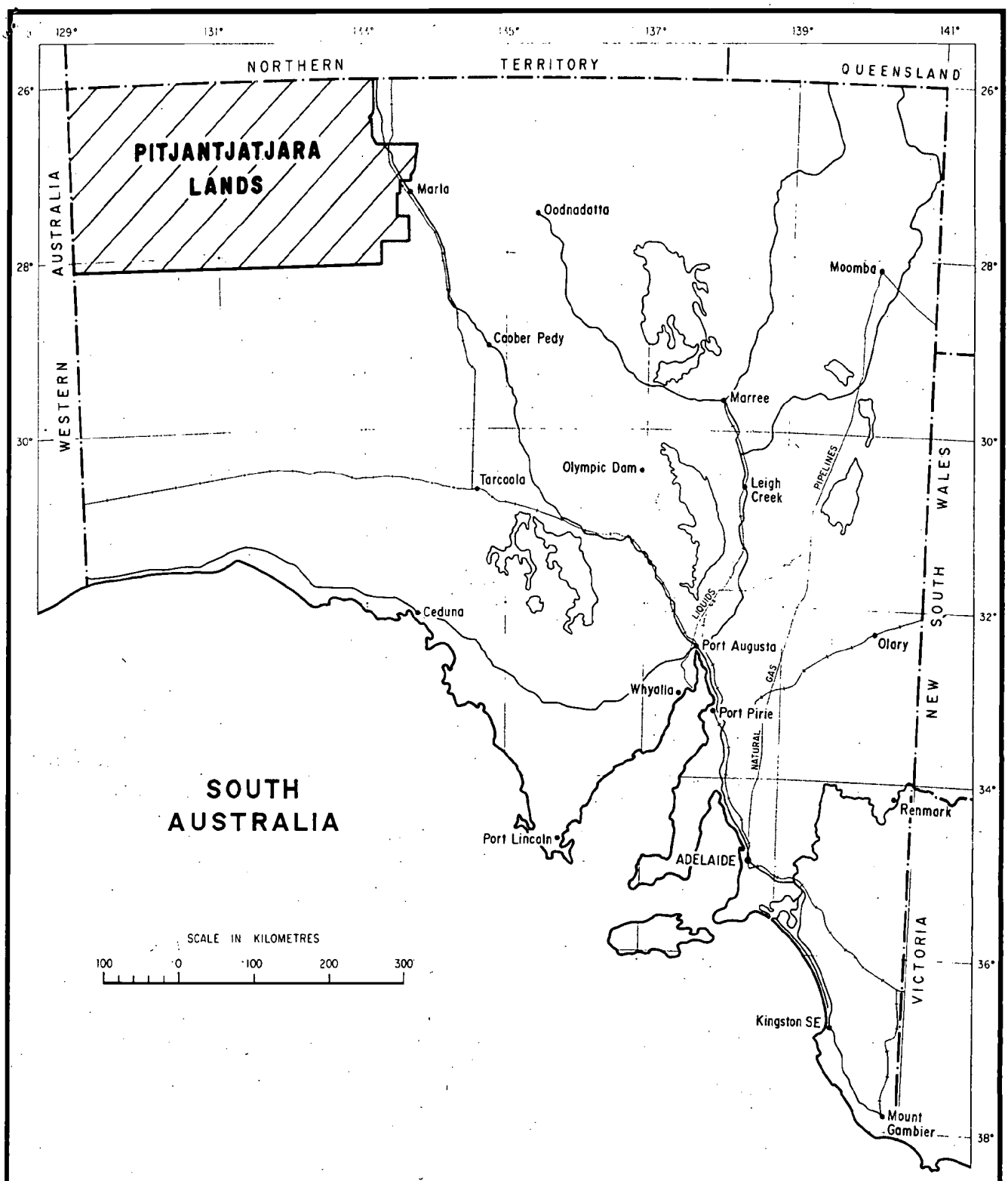

Fig..... 1

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED R.E.R.	C.D.O. 13·8·86 DATE
PITJANTJATJARA LANDS	DRAWN R.H.	SCALE As shown
NITRATE & FLUORIDE IN OUTSTATION GROUNDWATER SUPPLIES	DATE Dec. 1985	PLAN NUMBER
LOCALITY PLAN	CHECKED	S18481

3990

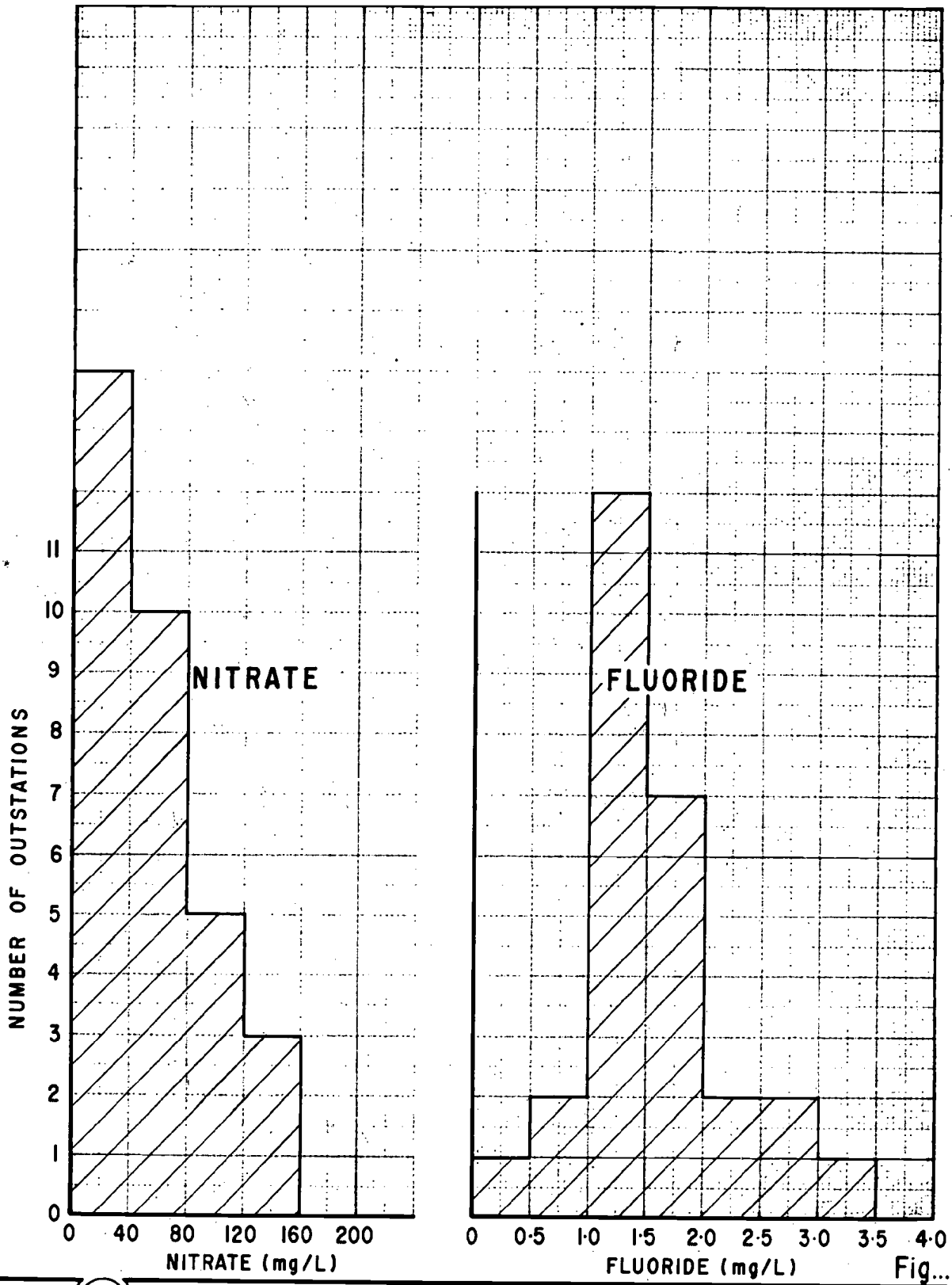

Fig.....3

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

COMPILED R.E.R.

C.D.O. 13·8·86 DATE

DRAWN R.H.

SCALE –

DATE Dec 1985

CHECKED

PLAN NUMBER S18482

PITJANTJATJARA LANDS

NITRATE & FLUORIDE IN OUTSTATION GROUNDWATER SUPPLIES

DISTRIBUTION OF CONCENTRATIONS IN OUTSTATION WELLS

3990

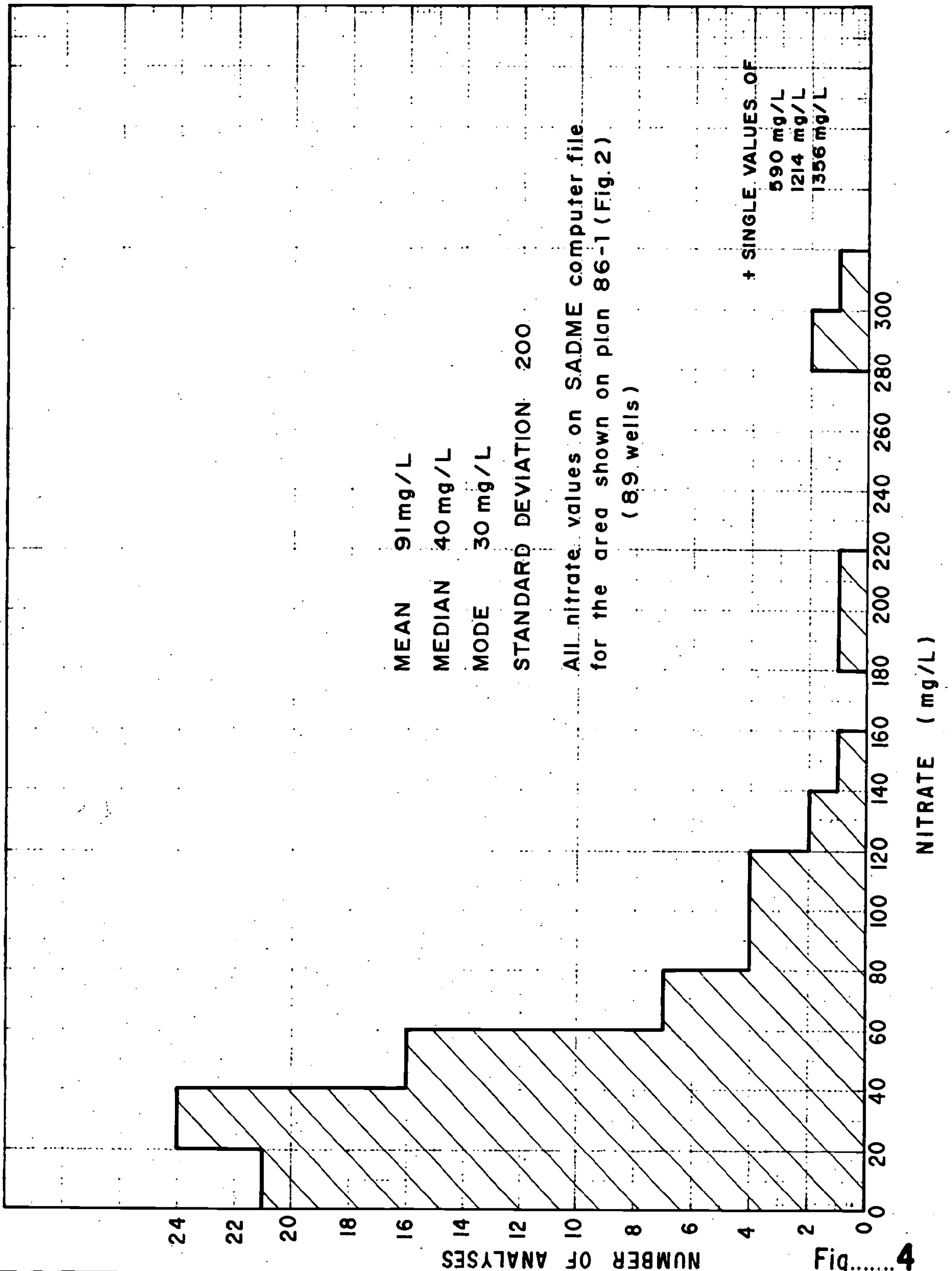

Fig......4

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED R.E.R.	C.D.O	DATE 13·8·86
PITJANTJATJARA LANDS	DRAWN R.H.	SCALE —	
NITRATE & FLUORIDE IN OUTSTATION GROUNDWATER SUPPLIES	DATE Dec 1985	PLAN NUMBER	
DISTRIBUTION OF NITRATE CONCENTRATIONS	CHECKED	S18483	

3990

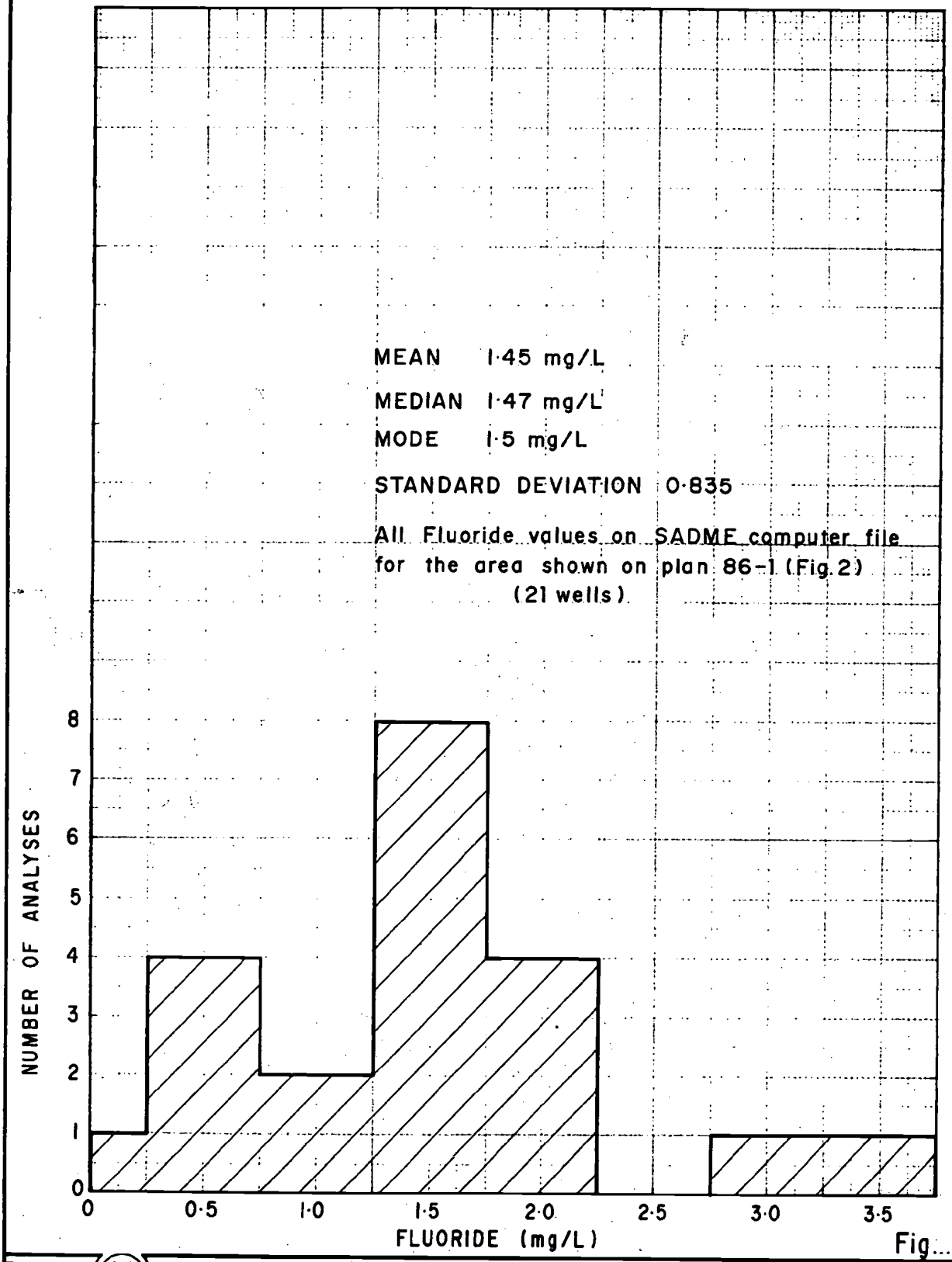

Fig. 5

DEPARTMENT OF MINES AND ENERGY
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DRAWN R.H.	SCALE
DATE Dec. 1985	PLAN NUMBER S18484
CHECKED	

PITJANTJATJARA LANDS

NITRATE & FLUORIDE IN OUTSTATION GROUNDWATER SUPPLIES

DISTRIBUTION OF FLUORIDE CONCENTRATIONS

3990