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1st February, 1975.

J. H. LORD,
Director.

HYDROGEOLOGY OF THE DE GREY RIVER AREA

by W. A. Davidson

ABSTRACT

The De Grey River groundwater investigation comprised part of the search for supplies for Port Hedland. It included a bore census, exploratory drilling, geophysics, and test-pumping of alluvial sediments along the De Grey, Strelley and Shaw Rivers. Test-pumping showed that 2 000 m^3/day should be obtainable.

The volume of groundwater in storage was estimated to be 82 x 10^6 m^3. As much as 40 per cent of this quantity has a salinity of 1 000-2 000 ppm TDS and the remainder, which falls in the potable range (300-1 000 ppm TDS), includes the annual recharge over 170 km^2. These estimates are based on an assumed storage co-efficient of 0.1.

Without drawing on storage and neglecting the effects of increased river recharge and reduced transpiration losses, 7 600 m^3/day of potable water should be obtainable from the aquifer. Under prolonged pumping this estimate could be conservative.

INTRODUCTION.

The rapidly increasing demand for water, as a result of population growth and industrial development in Port Hedland, has made it necessary to find additional reserves of groundwater.

To identify areas having groundwater possibilities a pastoral property bore and well census was made during 1969. As a result the De Grey River system and its associated alluvium was chosen for a more intensive investigation between 1969 and 1972.

The aim was to find a groundwater source capable of producing more that 30 000 m^3 per day of groundwater with a salinity of less than 1 000 ppm of Total Dissolved Solids (TDS). These minimal requirements were set by the Public Works Department.

The De Grey River system is at the northern edge of the Pilbara Block, and the area investigated is approximately 100 km east of Port Hedland (Fig. 3, inset).

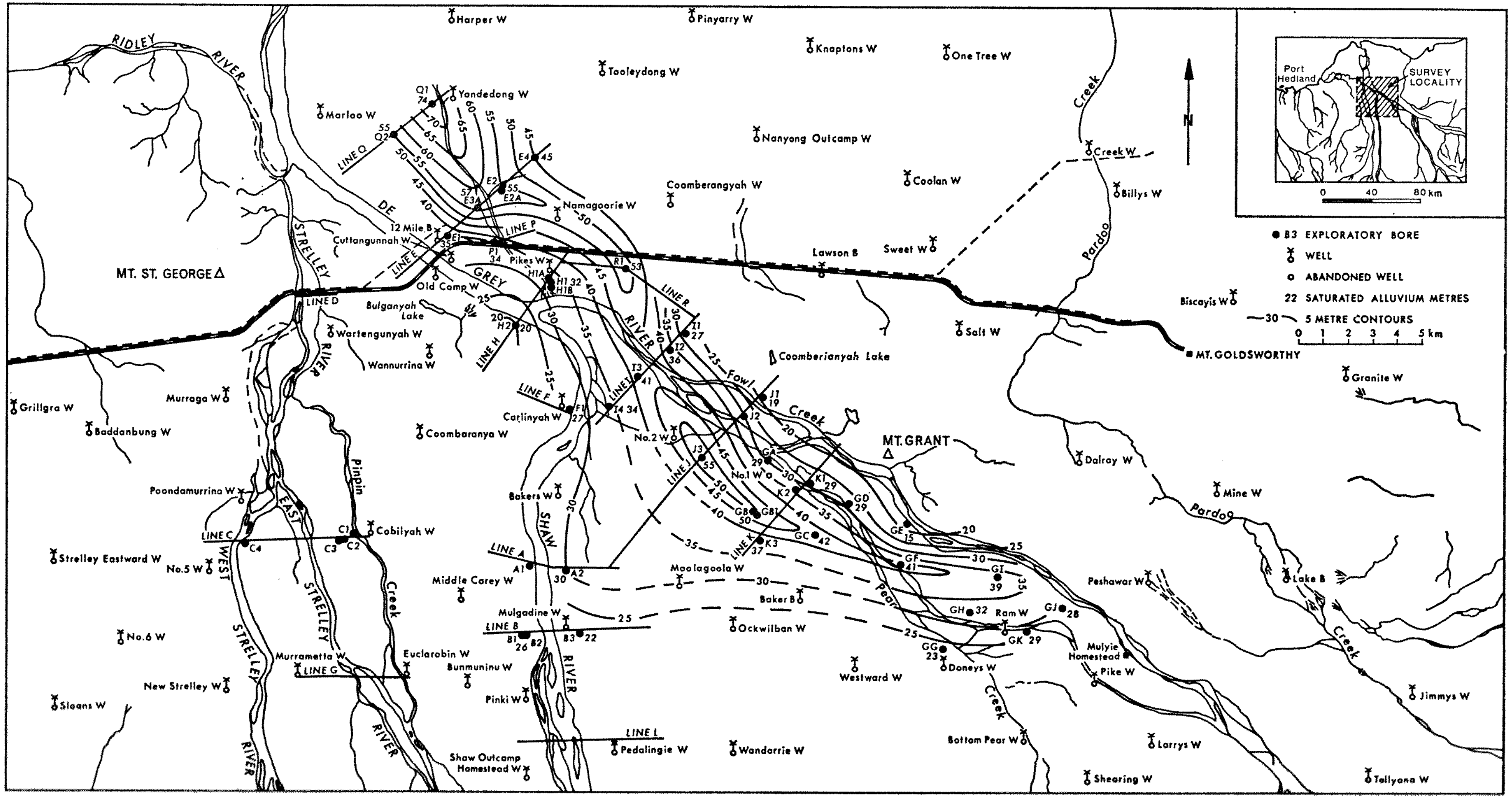

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Figure 3. De Grey River groundwater—isopachs of saturated alluvium in metres for 23/8/72.

Investigations.

Forty nine bores were drilled through the alluvium to weathered and sometimes fresh bedrock. Depths ranged between 18 m and 119 m and the aggregate depth was 2 972 m. Details of the boreholes are given in Table 1.

The bores were sited by geophysical methods (seismic refraction and resistivity profiling) in an attempt to delineate ancient buried river channels.

The seismic lines, boreheads, wells and river pools were accurately levelled and related to standard mean sea level datum.

TABLE 1. BOREHOLE DETAILS OF THE DE GREY RIVER AREA

Bore	Commenced	Completed	Reduced levels		Total depth m	Casing		Screens		Developed by surging (hours)	Drilling method
			Casing m	NS m		Length m	Diam. OD mm	Interval m	Diam. OD mm		
A1	24/8/69	2/9/69	34·49	33·83	48·8	28·7	76	4·6–28·7	76	....	Cable tool
A2	7/11/70	20/11/70	36·99	36·39	42·7	27·4	203	27·4–42·1	178	36	Cable tool
B1	2/10/69	6/10/69	38·92	38·15	47·2	47·2	76	3·1–47·2	76	....	Cable tool
B2	7/10/69	28/10/69	38·85	38·24	52·4	44·9	152	open hole		....	Cable tool
B3	28/10/69	8/11/69	39·08	38·28	37·5	35·1	76	35·1–37·5	76	....	Cable tool
C1	4/9/69	29/9/69	30·45	29·92	23·5	23·5	76	3·1–23·5	76	....	Cable tool
C2	7/9/69	10/9/69	31·78	31·08	23·8	23·8	76	3·7–23·8	76	....	Cable tool
C3	10/9/69	10/12/69	31·30	30·89	55·5	38·2	152	open hole		....	Cable tool
C4	30/9/69	1/10/69	33·91	33·11	18·3	18·3	76	4·6–18·3	76	....	Cable tool
E1	11/11/69	4/12/69	23·25	22·34	118·9	39·6	76	4·6–39·6	76	....	Cable tool
E2	24/4/70	24/5/70	24·21	23·34	112·8	61·0	76	15·2–61·0	76	....	Cable tool
E2A	22/10/70	29/11/70	23·73	23·29	54·6	17·8	203	17·8–54·4	178	84	Cable tool
E3	22/6/71	10/8/71	23·80	23·80	59·4	24·7	305	24·7–59·1	152	70	Cable tool and Rotary
E3A	5/7/71	29/7/71	24·04	23·81	91·4	24·4	76	24·4–59·7	76	Air lifted	Cable tool
E3B	11/8/71	19/8/71	23·87	23·35	59·4	59·4	101	8·2–59·4	101	Air lifted	Rotary
E4	20/8/71	13/9/71	21·56	20·93	105·4	21·3	76	21·3–51·8	76	Air lifted	Rotary
E4A	4/10/71	13/10/71	20·99	20·88	51·8	24·1	305	24·1–51·8	152	40	Rotary
E4B	14/9/71	1/10/71	21·66	20·90	51·8	21·3	76	21·3–51·8	76	Air lifted	Rotary
F1	27/10/70	5/11/70	31·05	30·58	44·2	11·0	203	11·0–29·3	178	48	Cable tool
H1	27/5/70	4/6/70	27·55	26·93	93·0	93·0	76	11·6–93·0	76	....	Cable tool
H1A	30/9/70	23/11/70	27·33	26·77	51·8	7·8	203	7·8–21·6	178	48	Cable tool
H1B	7/10/70	....	27·35	26·88	79·3	58·6	203	58·6–80·0	178	24	Cable tool
H2	8/7/70	16/7/70	27·40	26·44	48·2	48·2	76	12·2–48·2	76	....	Cable tool
I1	5/6/70	10/6/70	28·65	27·66	53·0	53·0	76	18·3–30·5	76	....	Cable tool
I2	11/6/70	21/6/70	29·96	28·98	77·4	77·4	76	15·2–42·7	76	....	Cable tool
I3	10/7/70	18/7/70	31·01	29·72	82·3	79·3	76	9·1–79·3	76	....	Cable tool
I4	14/10/70	24/11/70	29·09	28·17	70·1	17·9	203	17·9–40·5	178	24	Cable tool
J1	22/6/70	29/6/70	33·56	32·39	42·7	42·2	76	12·2–27·4	76	....	Cable tool
J2	30/6/70	7/7/70	33·55	32·03	58·8	51·8	76	21·3–33·5	76	....	Cable tool
J3	24/8/71	13/9/71	31·74	31·45	78·3	25·6	319	25·6–63·1	152	16	Cable tool
K1	31/7/70	4/8/70	34·04	33·14	36·0	35·1	76	9·1–35·1	76	....	Cable tool
K2	23/7/70	30/7/70	33·08	32·16	40·2	40·2	114	9·1–40·2	114	....	Cable tool
K3	2/8/71	21/8/71	36·30	36·07	103·0	25·3	273	25·3–95·4	Casing 152	20	Cable tool
P1	5/11/70	15/11/70	24·55	24·01	45·7	17·8	203	17·8–36·7	178	48	Cable tool
Q1	14/10/71	3/11/71	20·56	20·41	108·8	22·3	305	22·3–54·3	152	35	Rotary
Q2	3/11/71	25/11/71	18·30	18·41	100·9	22·9	305	22·9–95·4	152	70	Rotary
R1	16/9/71	14/10/71	25·84	25·39	94·5	28·7	319	28·7–62·5	152	14	Cable tool
GA	19/6/70	22/8/70	32·51	32·14	36·3	16·1	203	16·1–35·4	178	60	Cable tool
GB	18/7/70	7/8/70	35·51	35·14	106·7	59·5	203	59·5–105·2	178	72	Cable tool
GB1	8/8/70	17/8/70	35·51	35·29	47·2	22·7	203	22·7–46·2	178	60	Cable tool
GC	22/8/70	8/9/70	35·44	35·04	70·1	17·4	203	17·4–45·1	178	48	Cable tool
GD	6/8/70	15/8/70	35·31	34·80	36·0	12·0	203	12·0–36·1	178	48	Cable tool
GE	18/8/70	27/8/70	38·22	37·60	31·7	12·1	203	12·1–30·5	178	24	Cable tool
GF	28/8/70	7/9/70	37·62	37·37	50·3	22·3	203	22·3–41·8	178	36	Cable tool
GG	8/9/70	17/10/70	40·05	39·71	45·1	23·2	203	23·2–43·9	178	36	Cable tool
GH	19/9/70	4/11/70	40·66	40·28	40·5	16·1	203	16·1–39·6	178	36	Cable tool
GI	9/9/70	....	39·34	38·97	56·4	18·2	203	18·2–48·2	178	48	Cable tool
GJ	23/9/70	29/9/70	41·84	41·20	43·9	17·9	203	17·9–41·6	178	24	Cable tool
GK	21/9/70	....	42·44	42·04	44·5	11·9	203	11·9–43·0	178	60	Cable tool

TABLE 2. STRATIGRAPHIC UNITS OF THE PORT HEDLAND 1 : 250 000 GEOLOGICAL SHEET

Age	Map Symbol	Name of Unit	Lithology	Occurrence	Topography	Economic Geology
Quaternary	Qr	....	Alluvial clay, silt, sand, gravel and conglomerate	In some areas adjacent to major drainages the alluvium is up to 82 m thick	Valley floors, flats and river systems	Water
Tertiary	Tk	....	Pisolitic ironstone and kankar	Areas along Strelley River	Limited exposures on edge of some drainage channels. Isolated, small, flat-topped hills	Water—some station wells
	To	Oakover Formation	Siltstone, limestone and chalcedony	Areas along Strelley River		
	M	Anketell Sandstone	Sandstone, shale and claystone	Bore E1 proved a thickness greater than 76 m	Hill capping, small mesas and buttes	Water—some station wells
Jurassic-Triassic	M	Callawa Formation	Current-bedded, coarse sandstone and conglomerates	Possibly intersected in bores E2, E3A, E4, H1, H2, I1, I2, I3, I4, P1, Q1, Q2, and R1	Hill capping, small mesas and buttes	Water—some station wells
ANGULAR UNCONFORMITY						
Archaean	q .... d	....	Quartz reefs and blows Quartz dolerite dykes	Many of the bores H2 and possibly I2, I4 and GB	Ridges or elongated hills	Water Road metal
	Agr .... Agn	....	Granite, granite gneiss Partly granitized Archaean	Many bores	Scattered outcrops and low level sand-covered plains	Ballast for railways Water
	STRONG FOLDING AND GRANITE INTRUSION					
	Ai	Gorge Creek Formation	Argillite, quartz and conglomerate with iron-bearing formations and volcanics	Many of the bores	Dissected ranges and hills	Iron ore and manganese
	Aw	Warrawoona 'series'	Basic volcanic pillow lavas, serpentines, coarse-grained basic intrusives, conglomerate sandstone, shale, jaspilite and associated schistose rocks		Dissected ranges and hills	Iron ore

GEOLOGY

The lowermost sediments of the De Grey valley are Coongan and Shaw alluvium, overlain by Oakover and Nullagine River sediments deposited after river capture. The uppermost sediments consist of recent alluvium from all four rivers. This sequence of sediments rests on a basement floor consisting of granite, volcanics and indurated sediments of the Gorge Creek Formation, all of Archaean age.

The regional geology is shown on the Port Hedland 1 : 250 000 Geological Sheet and described by Low (1965). Table 2 illustrates the stratigraphic units.

HYROGEOLOGY

The six different aquifers that have been recognized are considered in order of increasing storage potential.

Granite. Many of the bores terminated in weathered to fresh granite, which yielded small supplies. For example bore grant B was pumped at 1 156 m^3/day for 48 hours with a drawdown of 10 m.

Drilling samples from bore A1 show exfoliation of the granite basement. Immediately below the exfoliation plates there is a build up of water-bearing clean quartz sand. This weathering profile is thought not to be very extensive and can be regarded only as a source of windmill-water for stock.

There are two types of weathered granitic material, one is a series of exfoliated plates, and the other is probably colluvial in origin. The colluvial granitic material seems to be the better aquifer because useful thicknesses can be expected (e.g. K3, 45-94.5 m).

Volcanics and Gorge Creek Formation. Several bores ended in volcanic rocks, and two were tested by pumping; e.g. H1A was pumped at 785 m^3/day for 7½ hours with about 7 m of drawdown.

Although the rocks do not have a large potential, Goldsworthy Mining Ltd. reported pumping "large volumes" of water from their open cut, presumably from joints and fractures in the cherts of the iron formation.

Mesozoic sediments. Fourteen of the exploratory bores penetrated sediments of possible Mesozoic age; most of the samples were very rich in clay and silt. Borehole E1, which terminated in a grey shale, possibly belonging to the Anketell Sandstone, had a very low yield. Others could be better, such as R1, which ended in quartz sand (possibly Callawa Formation), but was not tested.

In borehole cuttings weathered Mesozoic sandy siltstone is similar to the sandy siltstone of the Archaean Gorge Creek Formation. Gamma-ray logging has shown that the sediments at 35.5 m depth in borehole I1 have the same radiation pattern as the sediments in I2 at 45 m and I3 at 50 m. Bores I1, I2 and I3 may have terminated in either Mesozoic or Archaean sediments.

Kankar. Their are two sets of geological conditions under which the kankar has developed.

The water table kankar is the more important, and is usually the source of stock and domestic water supplies. Essentially it is a calcareous, weakly cemented alluvium about 1 m-thick and therefore not a large individual producer of water.

The kankar which develops at the top of the granite weathering profile can be quite thick, e.g. 45-62 m in bore K3. It appears to be *in situ* and is probably a product of a chemically weathered basement.

Alluvium. The aquifers in the river alluvium range in thickness from a few metres to about 75 metres, and may be roughly grouped into an upper and lower unit. This division is fairly arbitrary along the De Grey River, where there is often a hydraulic connection between the two.

The upper sand or water table aquifers usually have coarse-grained sand and gravel at the water table and sometimes a thin kankar horizon. The water in these sands may be fully confined, as in bore B2, but this is not commonly so.

The lower sands vary in thickness and permeability and are sometimes separated from the upper sands by silty clay. They occur as thin beds and lenses, so that through 75 m several sandy beds may be intersected. Occasionally a thick gravel bed is present.

The lower sand aquifers associated with the De Grey River are more extensive and also less clayey than those of the Shaw and Strelley Rivers.

Alluvial Trough

The present course of the De Grey River no longer coincides with the axis of the alluvial filled trough (Fig. 3). In its downstream part the river has migrated several kilometres southwestward, although farther up-stream it has moved to the northeast. The positions roughly coincide between cross-section lines H and I.

HYDROCHEMISTRY

There is a wide range of salinities, the better quality water generally occurring close to the present river course.

Throughout the area the salinity of the groundwater is suitable for stock consumption, and beneath nearly half of the area it is suitable for domestic use.

The isohaline map (Fig. 4) shows the regional groundwater salinity pattern and reflects the presence of the buried river channel downstream from near bore H1. Drilling has shown that the aquifer in this area has a comparatively high permeability.

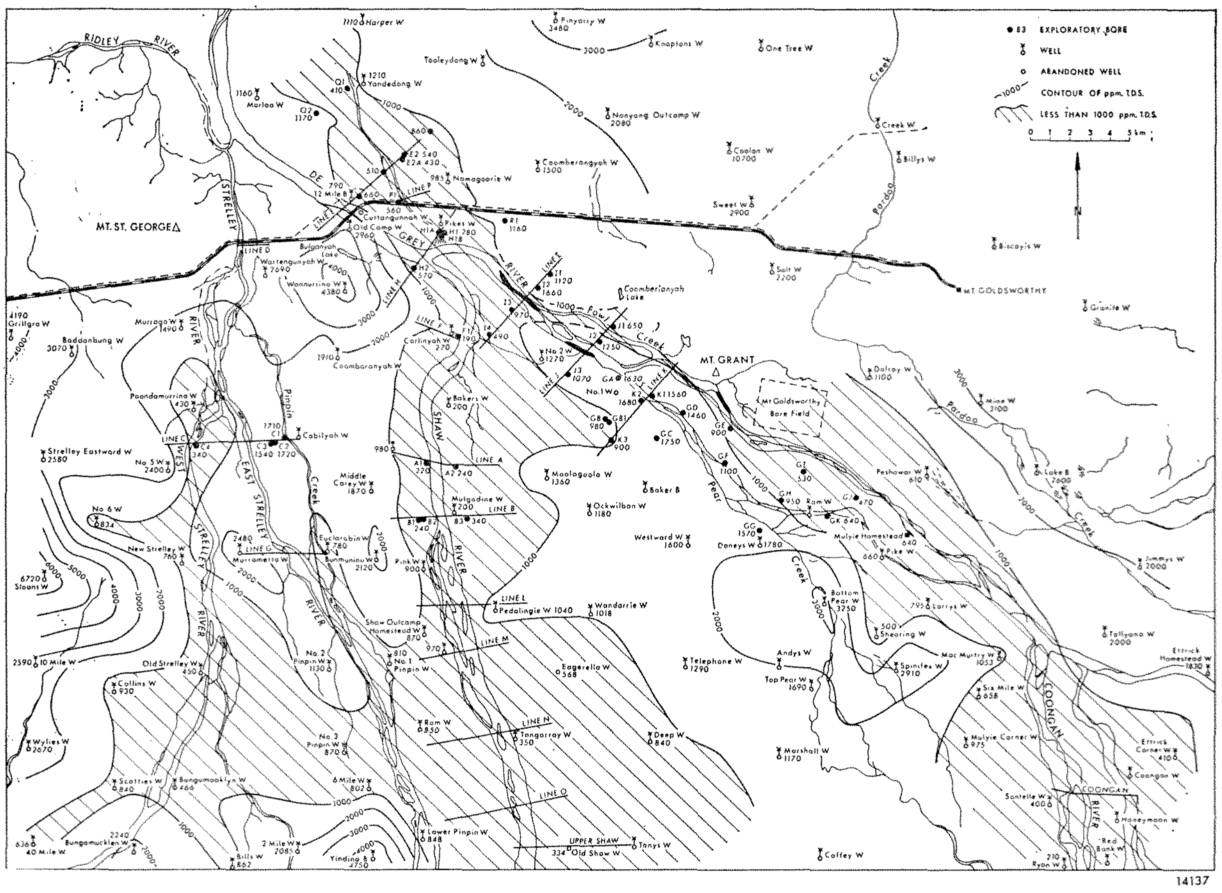

Figure 4. De Grey River groundwater—hydrochemistry and isohalines in ppm TDS.

PUMPING TESTS

Twenty-seven bores were tested for periods of up to 48 hours.

Because of the heterogeneous nature of the aquifer, and because both confined and unconfined conditions could occur at each site, leaky artesian, delayed yield, water table and boundary conditions were likely to be experienced in any one test. Most of the bores were pumped without observation bores and many were only partially penetrating.

Time-drawdown curves plotted from pumping-test data proved very difficult to analyse. A summary of results is shown in Table 3.

GROUNDWATER MOVEMENT

The direction of groundwater movement, along flow lines, is perpendicular to the poteniometric contours indicated on the flow net diagram (Fig. 5). The flow channels are defined by flow lines passing through points of origin distributed along the 18 metre poteniometric contour at equal intervals.

TABLE 3. DE GREY RIVER PROJECT PUMPING-TEST DATA

Bore	Screened Interval m	Pumping-Test			Transmissivity		Hydraulic Conductivity	
		Duration Hours	Rate m³/d	Total Drawdown m	T m³/d/m	Method	Saturated Alluvium m	K m³/d/m²
A2	27·4–42·1	1·5	200	13·41	15	Specific capacity	29·8	0·5
B3	28·0–35·1	8	349	10·13	30	Specific capacity	21·8	1·4
C3	Open Hole	0·9	273	20·91	Bore pumped on the fork			
E2A	17·8–54·4	48	2 400	2·13	1 400	Specific capacity	54·7 E2	25·6
E3	24·7–59·1	48	3 100	6·17	940	Part penetration	57·3 E3A	16·4
E4A	24·1–51·8	48	3 060	8·85	1 940	Theis curve	44·7 E4	43·4
F1	11·0–29·3	1	160	Bore pumped on the fork				
H1A	7·8–21·6	7·7	786	6·86	50·70	Delay	32·3 H1	2·2
H1B	58·6–80·0	Pumped Test Failed						
I4	17·9–40·5	48	1 266	4·72	220	Specific capacity	33·6	6·6
J3	25·6–63·1	48	4 580	8·53	500	Specific capacity	55·0	9·1
K3	25·3–95·4	48	2 620	7·77	200	Delay	36·7	5·4
Q1	22·3–54·3	48	3 900	8·38	510	Specific capacity	73·8	6·9
Q2	22·9–95·4	48	4 580	5·48	600	Specific capacity	54·9	10·9
R1	28·7–62·5	48	4 866	6·40	1 440	Const. D.D.	52·8	27·3
GA	16·1–35·4	48	1 593	4·12	370	Specific capacity	29·2	12·7
GB	59·5–105·2	48	1 156	9·91	58	Delayed yield	50·1	1·2
GB1	22·7–46·2	48	3 338	15·85	220	Theis curve	50·1 GB	4·4
GC	17·4–45·1	48	2 837	4·57	300	Delayed yeild	41·8	7·2
GD	12·0–36·1	48	1 440	2·29	300	Delayed yeild	28·8	10·4
GE	12·1–30·5	48	1 309	7·92	inadequate test		15·2	....
GF	22·3–41·8	48	1 527	2·44	280	Delayed yield	41·1	6·8
GG	23·2–43·9	0·7	854	20·12	50	Specific capacity	23·0	2·2
GH	16·1–39·6	48	2 837	6·10	200	Delayed yield	?32·4	6·2
GI	18·2–48·2	48	1 746	2·74	270	Delayed yield	38·5	7·0
GJ	17·9–41·6	40	1 811	18·29	60	Delayed yield	28·4	2·1
GK	11·9–43·0	48	2 837	2 ·90	Inadequate, not conclusive test		29·4	....

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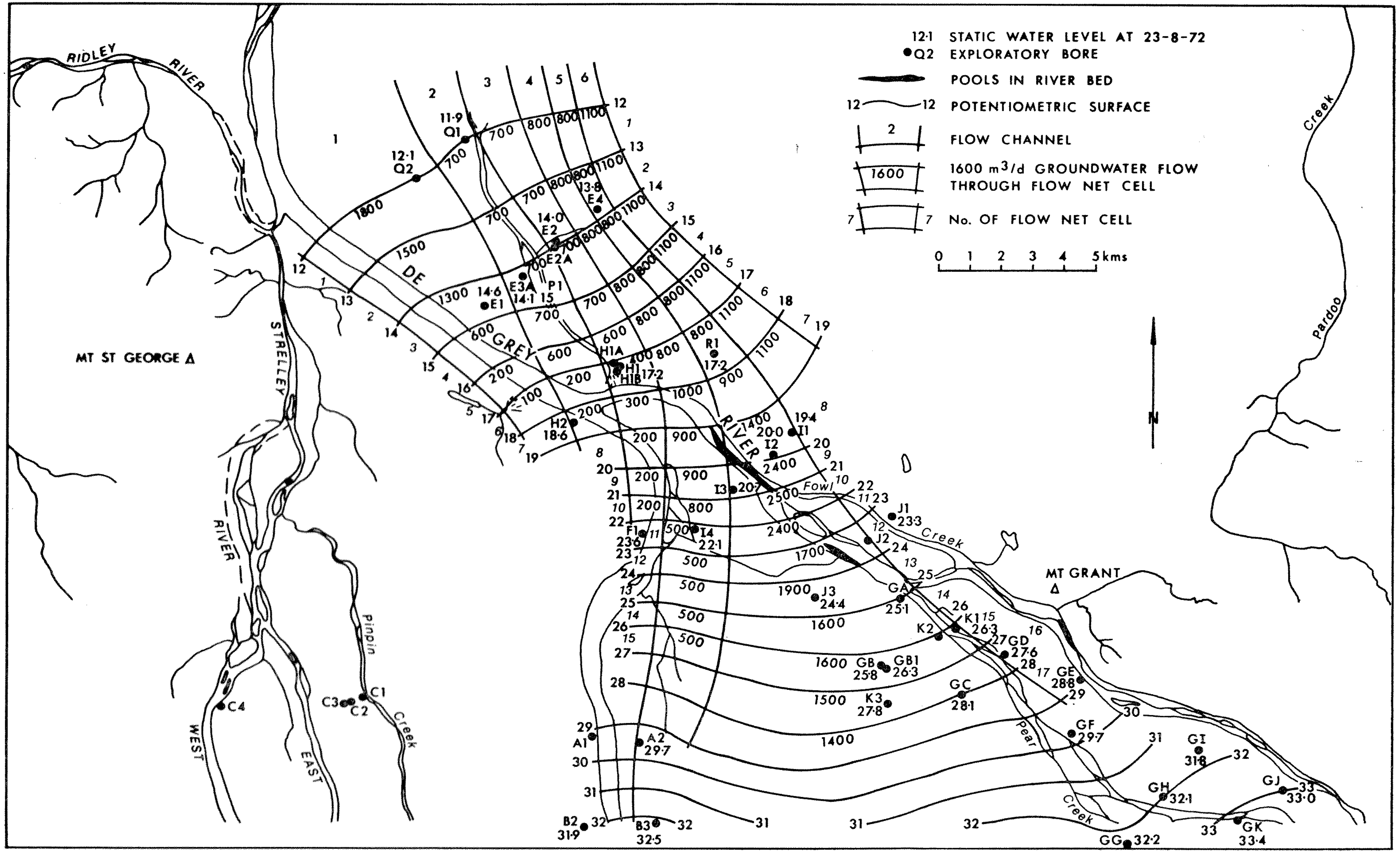

Figure 5. De Grey River groundwater—flow net for 23/8/72 potentiometric surface.

To evaluate the volume of water passing through individual cross-sectional areas defined by the flow net, the transmissivities, gradients and cross-section lengths, have to be determined. This volume can then be calculated by using the simple expression $Q = Til$.

Where Q = volume passing through section, m^3/d.

T = transmissivity, $m^3/d/m$.

i = gradient, dimensionless.

l = cross-section length, m.

The hydraulic gradient and cross section lengths may be directly measured from the flow net but the transmissivity for each section has to be estimated from the distribution of values derived by test pumping. This estimate, together with the derived flow volumes, is only roughly correct because of the variability of these values.

The flow net has six flow channels. In channel 1 there is a large net groundwater gain from the De Grey River. Along channel 2 there is a large net gain from the De Grey-Shaw River junction, with no gain or loss throughout the rest of the flow channel. Along channel 3 there is a large net gain from the De Grey River near the Shaw River junction; the remainder of the flow channel showing no gains or losses. Channel 4 shows a small net gain from the Shaw and De Grey Rivers and also some net loss which is possibly a transpiration loss. Above the granitic basement between the De Grey and the Shaw Rivers, channel 5 shows a steady increase in groundwater volumes from both rainfall and De Grey River flow. The net loss where permanent pools occur in the De Grey River, on lines J and I, is due to evaporation and transpiration. The remainder of the flow channel shows no gains or losses. Channel 6 is probably in a state of balance, though this might not be so if the channel were extended along the De Grey past Mount Grant, where evaporation and transpiration losses would be large.

The quantity of groundwater moving through the area can be calcluated by adding the contributions made by each flow channel. For example at the northern end of the flow net system a total of 5 900 m^3 per day is moving through the section indicated by the 12 m potentiometric line (i.e. about 1.3 x 10^6 imperial gallons per day).

Recharge Systems

The recharge-discharge regime is shown diagrammatically on Figure 6, the relative importance of each element being shown by the numbers on the arrows.

Recharge comes from river flow and from direct rainfall percolation.

River flow recharge is the most important source of intake to the alluvium, even though the rivers flow only for short periods. Typically the De Grey may flow twice in one year and not at all in the next, which means that there are long periods during which discharge from the aquifers takes place.

Most of the rain falling directly on the riverbed sands soaks in, whereas a high percentage of the rainfall on the interfluvial areas is lost by evaporation. In areas not affected by river recharge, if all the chloride ion in the groundwater comes from directly percolating rainfall, then the chloride concentration in the groundwater is a measure of the proportion of rainwater which becomes recharged after evapotranspiration losses.

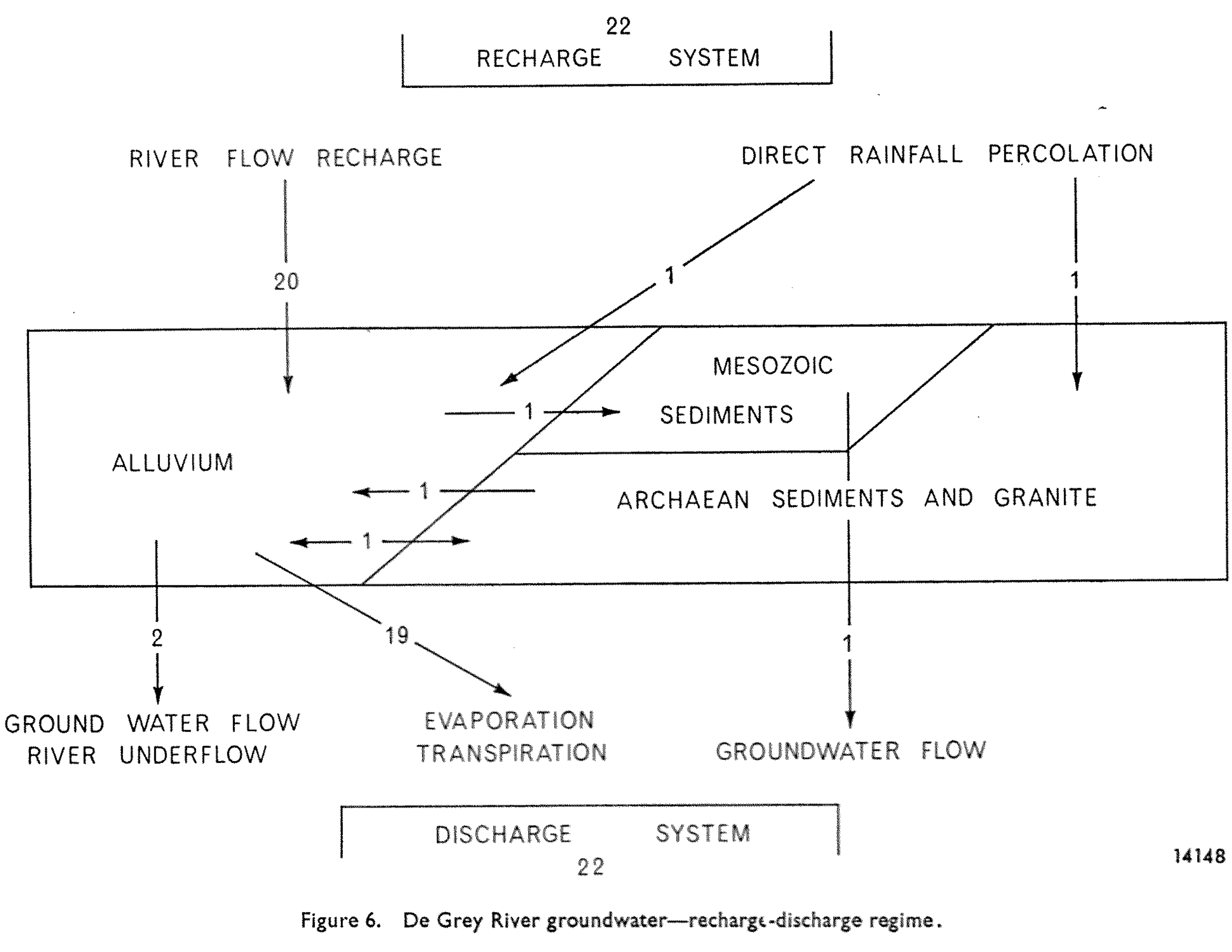

Figure 6. De Grey River groundwater—recharge-discharge regime.

There is about 8 ppm chloride in rainwater in this district, and it can be assumed that all the chloride in the groundwater in the areas listed in Table 4 comes from rainfall. It follows that about 3 per cent of the rainfall reaches the water table in an average rainfall year.

TABLE 4. RAINFALL RECHARGE BASED ON CHLORIDE CONCENTRATION.

Well bore	ppm chloride ground-water	ppm chloride rainfall	Distance from coast km	per cent rain recharged	per cent rain evapor-ated
J3	270	8	40	$\frac{8}{270} \times 100 = 3$	97
GB1	324	8	40	$\frac{8}{324} \times 100 = 2$	98
K3	225	8	40	$\frac{8}{225} \times 100 = 4$	96
Moolagoola	309	8	40	$\frac{8}{309} \times 100 = 3$	97
Ockwilban	210	8	40	$\frac{8}{210} \times 100 = 4$	96

The figure of 3 per cent can probably be applied to the whole area to derive the total volume of recharge from **rainfall.**

The area of interest, as shown by the flow net, is about 170 km^2 and the average annual rainfall is 275 mm.

$$\therefore \text{volume of infiltration} = 170 \times 1000^2 \times \frac{275}{1000} \times \frac{3}{100}$$

$$= 1\,400\,000 \text{ m}^3\text{/year.}$$

The average rise in water table, during recharging periods, is about 1 m per year. By assuming an average storage coefficient of 0.1 for the upper unconfined part of the aquifer, the total annual recharge to 170 km^2 of alluvium can be calculated.

$$\text{Total recharge} = 170 \times 1000^2 \times 1 \times 0.1$$

$$= 17\,000\,000 \text{ m}^3 \text{ per year}$$

If 1.4 x 10^6 m^3 per year results from direct rainfall the remaining 15.6 x 10^6 m^3 per year appears to come from river recharge. This means that only 8 per cent of the annual recharge of the groundwater in the alluvial flats is the result of direct downward infiltration of rain falling on the surface, the remaining 92 per cent being leakage from river flows.

Discharge Systems

The discharge components consist of transpiration, evaporation, groundwater flow and river underflow leaving the system.

From aerial photographs it has been estimated that approximately 11 x 10^6 m^2 of vegetation along river banks is contributing to transpiration. According to the Forestry Department a transpiration rate of 50 per cent pan evaporation could be applicable, and may even be conservative. If this premise is accepted, the amount of discharge through transpiration can be calculated as follows:

Annual pan evaporation = 2.5 m

Transpiration = 50 per cent evaporation
= 1.25 m

Area of vegetation = 11 000 000 m^2

$\therefore$ total volume water transpired per year

= 1.25 x 11 000 000

= 13 750 000 m^3 per year

The amount of evaporation from surface water, such as pools in the De Grey River, has been calculated as follows:

Estimate of pool surface area = 250 000 m^2

Surface evaporation per year (Bureau of Meteorology) = 2.5 m

$\therefore$ volume evaporated = 250 000 x 2.5 per year

= 625 000 m^3 per year

Groundwater and river underflow leaving the system was calculated by flow net analysis to be 5 900 m^3 per day or approximately 2.2 x 10^6 m^3 per year.

Groundwater Balance

Input m^3/year		Losses m^3/year	
Recharge from river	15 600 000	Transpiration	13 750 000
Rainfall	1 400 000	Pool evaporation	650 000
		Groundwater outflow	2 200 000
Total	17 000 000		16 575 000
		i.e. approx.	17 000 000

Groundwater Resources

When a relatively shallow aquifer is pumped for a long period of time the water levels fall, full drainage conditions are achieved, and the areas over which confined conditions occur are progressively eliminated. In this circumstance a specific yield of 0.1 or more is thought reasonable for use in calculating abstractable storage from a material that is predominantly sandy.

An isopach map (Fig. 3) was drawn of the saturated alluvium for 23/8/72 when the water table was very low. The amount of groundwater within the area shown by Figure 7 is the volume in storage, at a particular moment, and excludes the annual recharge from rain or river flow.

The area has been divided into three sub-regions, two containing groundwater of less than 1 000 ppm TDS, and the third exceeding 1 000 ppm TDS. Volumes were calculated using an assumed storage coefficient of 0.1. The volume of good quality water was found to be 37.9 x 10^6 m^3, and of poor quality water 27.1 x 10^6 m^3. Mixing the two gives 65 x 10^6 m^3 of water in storage at minimum water table level. After average annual recharge the total water in storage would be 65 x 10^6 m^3 + 17 x 10^6 m^3 or 82 x 10^6 m^3 of which about 17 x 10^6 m^3 will be lost to transpiration, evaporation and groundwater outflow per year.

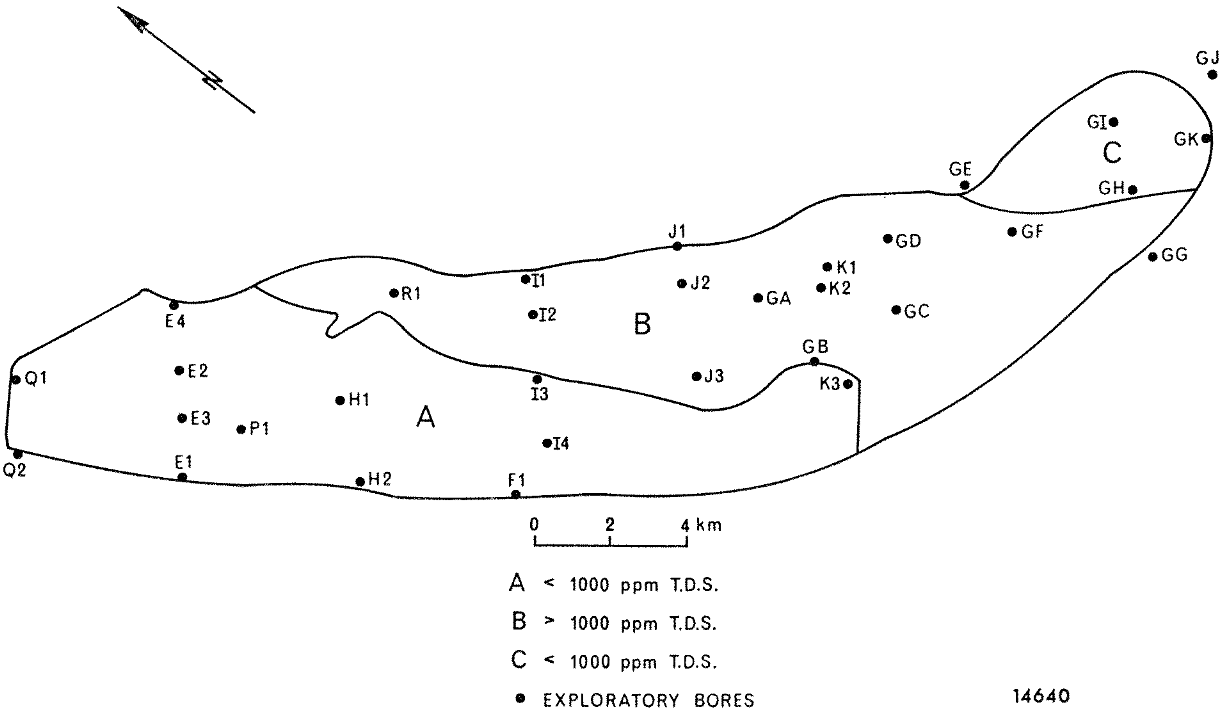

Figure 7. De Grey groundwater—salinity sub-regions.

Groundwater available for pumping

In summary, the volume of available groundwater is expressed by:

$$
\begin{aligned}
Q &= GF + IR + RT + E \\
&= 5\,900 \text{ m}^3 + IR + RT + 1\,700 \text{ m}^3 \\
&= 7\,600 \text{ m}^3 + RT
\end{aligned}
$$

Where Q = volume of groundwater available for pumping in m^3 per day.

GF = groundwater outflow in m^3 per day.

IR = portion of groundwater which is held in storage and which will be gained by induced additional recharge.

RT = the amount by which transpiratory loss is reduced by lowering the water table. This could be substantial.

E = the saving in evaporative loss when the water table is sufficiently lowered by pumping.

At present the safe yield of the aquifer is 7 600 m^3 per day, exclusive of any gain due to reduced transpiratory losses, and assuming that no additional recharge due to lowering of the water table takes place. It is not known what effect these other factors will have on the value of a new safe yield which might be arrived at after prolonged pumping, and a changed water balance. The effect could be assessed only by pumping at a rate in excess of 7 600 m^3/day and by monitoring the water levels and salinities.

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EARTH TIDE INFLUENCE ON GROUND WATER LEVELS, HILL RIVER AREA, PERTH BASIN

by A. S. Harley

ABSTRACT

Hydrographs from two unconnected bores to the east of Jurien Bay, in the Perth Basin, show water level fluctuations in confined aquifers. The generally larger more random fluctuations can be attributed to atmospheric pressure changes. The smaller, periodic, semi-diurnal fluctuations correspond closely to fluctuations of lunar-solar origin in the earth's gravity field. The ocean tides have no discernable effect on the water levels. Only the water level in bore Watheroo Line 11 shows any obvious response to rainfall. Similar fluctuations due to earth tides are noted in other bores in Western Australia.

INTRODUCTION

Bores on the Watheroo Line, W.L. 11 and W.L. 12A, are on the western end of a line of deep bores drilled by the Geological Survey along the 30° 19′ S latitude between Watheroo and Jurien Bay. Bore W.L. 11 penetrated interbedded sandstones and mudstones of the Cockleshell Gully Formation, and bore W.L. 12A intersected the Lesueur Sandstone. Regionally the geology is complicated by a series of faults (Fig. 8).

Both bores are screened in confined aquifers but, as the bores were exploratory, the extent of the aquifers and the intake areas are unknown. When formation testing was completed, water level recorders were set up on the two bores.