THE MANNER OF OCCURRENCE OF GROUNDWATER IN RHODESIA.

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1979.

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IMPORTANT. This report forms one part of a two-part volume of which the main part was prepared earlier and contains the other chapters. The volume is presented under the general title "GROUNDWATER BULLETIN I".

CHAPTER 4. LIST OF CONTENTS.

N.B. All relevant Tables and Diagrams are placed in the appropriate paragraphs

Chapter 4. Preamble

Dr. D. Gear, who initiated the work in this Bulletin, resigned from the Hydrological Branch in 1977, and the following chapter was compiled according to procedures set out by him. These are briefly described below.

Procedures for compiling Chapter 4

The following steps were taken in compiling the chapter:

(1) The sorting out of the rock types in the 1976 and 1952 borehole schedules into seven Simplified Lithological Classes;

(2) The preparation of tables and maps of the Mean Annual Rainfall/Erosion Surface (MAR/ES) regions and sub-regions for the various Lithological Classes; the method by which sub-regions were determined is described in the body of the chapter;

(3) The classification of borehole yields into four yield classes, viz:-

(a) Less than 1 500 litres per hour,
(b) Between 1 500 and 5 000 l/h
(c) Between 5 000 and 15 000 l/h
(d) Greater than 15 000 l/h.

(4) The classification of boreholes by depth into nine intervals of 7,6 metres (25 ft.) from 0 to 68,6 m. - boreholes deeper than this were not included in the depth versus yield analysis;

(5) Preparation of the depth versus yield analytical tables for the sub-regions of each lithological class in the various MAR/ES regions according to the procedure set out in the text;

(6) Compilation of the chapter using the data resulting from the work done.

CHAPTER 4. BOREHOLE YIELD X DEPTH ANALYSIS OF THE DATA FROM THE 1952 AND 1976 SCHEDULES.

4.1 Introduction

This chapter analyses the data contained in the 1952 (Lange's) and 1976 (Hydro) listing of borehole records. Chapter 5 treats in more detail some of the topics outlined herein.

For the purposes of the yield versus depth analysis, the 35 lithological types have been grouped into seven Simplified Lithological Classes which are shown below. It should be noted that types 1 and 13 (Alluvium and Dwyka tillite, respectively) have not been included in this analysis as there are not enough boreholes in these rocks to warrant classification at this stage.

A considerable amount of work was done on the 1976 listing before the Simplified Lithological Classification was devised (see Appendix 2). This classification was drawn up, after due consideration of the facts influencing the selection, to permit a consolidation of the 1976 and 1952 listings and thus increase the number of boreholes in each region to provide a more representative sample for analysis. Although some of the lithological grouping may seem unusual, it was considered unwise to make any change to that laid down by Dr. Gear. An examination of Appendix 2 will help to explain the criteria upon which the classification was based.

Errors which may have been made concerning the geology of some boreholes in the 1976 listing have been ignored in the conversion, mainly because of the labour involved, but also because even more errors would still remain. In any case this matter is dealt with in the course of the next chapter, where the 1976 listing is analysed separately.

The following is a list of the rock types in the 1976 listing, and their code numbers, and their appropriate Simplified Lithological Classes.

Simplified Lithological Classification

Class I:	Rocks of Granito-like Composition.
Code No.	Rock Type.
29	Gneisses
30	Post Karroo Granite
31	Dolerite and Gabbro
33	Granite
34	Pegmatite
35	Paragneisses
Class II:	**Basalts**
5	Karroo Basalt/Rhyolite

Class III:	**Sands and Sandstone**	
2	Kalahari sand (Karroo Younger Arenites, excluding recent deposits)	
3	Kalahari pipe sandstone and silcrete	
4	Cretaceous	
5	Forest sandstone etc.	
6	Forest sandstone etc.	There are few of these and they have not been identified correctly
7	Escarpment grits etc.	
10	Upper Wankie sandstones	Only those in L. Hindson's 1957 report have been recorded and their depths do not appear on the records.
12	Lower Wankie sandstones	
Class IV:	**Permian Mudstone:**	
8	Madumabisa Mudstone	Only those in L. Hindson's 1957 report have been recorded and their depths do not appear on the records.
9	Upper Carbonaceous mudstones	
11	Lower Carbonaceous mudstones	
Class V:	**Mid-PreCambrian**	
14	Sijarira	
15	Piriwiri	
16	Lomagundi argillaceous	
17	Lomagundi dolomite	
18	Lomagundi orthoquartzites	
19	Deweras	
20	Umkondo basalts	Few or no boreholes in this rock.
21	Umkondo quartzites	
22	Umkondo shales	
23	Umkondo limestone	
24	Fronteir system	Few or no boreholes listed
Class VI:	**Early Pre-Cambrian**	
25	Shamvaian metasediments	
26	Bulawayan metasediments	
27	Bulawayan metavolcanics	
28	Sebakwian ultramafics	
Class VII	**Great Dyke**	
32	Great Dyke	
"Class VIII"	**(Not included in conversion)**	
1	Alluvium	
13	Dwyka tillite	Few or no boreholes listed

Table 4.1.1. The Mean Annual Rainfall/Erosion Surface Regions

Region	Mean Annual Rainfall	Erosion Surface
9,0	Over 800 millimetres	Post African and older
9,M	Over " "	Mixed O and Y
7,0	600 - 800 millimetres	Post African and older
7,M	" " "	Mixed
7,Y	" " "	Pliocene and younger
5,0	400 - 600 millimetres	Post African and older
5,M	" " "	Mixed
5,Y	" " "	Pliocene and younger
3,Y	Under 400 millimetres	Pliocene and younger

Pliocene - 20 million years or younger age
African - (middle Cretaceous to early Miocene age) 20 - 120 million years

The table above shows the MAR/ES regions used in this chapter. It will be noted that, for convenience, the boundaries of the regions (and consequently the sub-regions) follow lines defining quarter-degree squares (See Diagram Gen. 3), in Chapter 1 of the Bulletin.

For the purpose of determining sub-regions, two maps of borehole numbers, one of the 1952 listing and the other of the 1976 listing, were prepared. The sub-regions were obtained by combining the numbers of boreholes in similar locations so that each sub-region contained not less than 200 boreholes, and as nearly as possible, 300. These figures were reckoned to be optimal for analytical purposes. (See Appendix 3).

The 1952 land divisions are the coarser of the 1952 and 1976 divisions - the latter being in quarter-degree squares while the former may occupy several quarter-degree squares. Thus the sizes of the sub-regions have been governed mainly by the 1952 land divisions.

Sub-regions may not cross the boundary of a MAR/ES region; they are in fact sub-regions of a MAR/ES region of each lithological class. Boundaries of sub-regions of different lithological classes, though of the same MAR/ES region, coincide only by chance.

When grouping the land divisions to obtain the 200/300 boreholes of a sub-region, the numbers of boreholes in adjacent land divisions were combined. There was no attempt to select them in any kind of order except that of proximity, since the exact location of many boreholes in the 1952 listing is unknown.

Geographically isolated locations such as the Matetsi basalts, the Jurassic granites and the Featherstone sandstones have been treated as separate sub-regions even though they do not attain 200/300 boreholes.

In those cases where the total number of boreholes in a lithological class in a MAR/ES region exceeded 300 but did not exceed 400, it was not worthwhile to make sub-regions. There is one case however, that of the Salisbury Central area, where there are over 500 boreholes in one quarter-degree square. Since it was undesirable to further divide a quarter-degree square, the area was treated as a single sub-region.

At the time of writing, the only Lithological Classes where sub-regions worth analysing have been obtained are (in order of the numbers of boreholes in each Class) the granitic rocks (Class I), the sandstones (Class III), the Early PreCambrian (Class VI) and the Mid-PreCambrian (Class V) rocks.

The object of establishing the sub-regions was to ascertain whether there are factors not accounted for by the lithological/MAR/ES classification, which affect the groundwater supplies. These will be apparent when the analyses of the depth/yield relationships are made in following sections. The regions and sub-regions have been defined by the 1976 quarter-degree listing and, with a few exceptions, all sub-regions have 200/300 boreholes.

Table 4.1.2 List of Sub-Regions : Analysis of Success for Boreholes Yielding (A) ± 1 500, (B) + 5 000 (C) + 15 000 Litres/Hour Lithological Classes I, III, V and VI. Mean Annual Rainfall/ Erosion Surface Regions 9-0, 7-0, 7-M, 7-Y, 5-0, 5-M and 5-Y.

MAR/ES	LITHOLOGICAL CLASS	SUB-REGIONS	NO. (43)
9,0	I	A B C D E F G H I J K	11
	VI	B C D E	4
7,0	I	B E F G I J K L	9
	III	B C D	3
	VI	C D	2
7,M	I	A B	2
	III	D	1
	V	A C	2
	VI	A	1
7,Y	III	B	1
5,0	I	A B	2
	III	A	1
	VI	A	1
5,M	I	A	1
5,Y	I	C D	2
	II	B	1

Table 4.1.2 shows only those regions and sub-regions which have been analysed. A comprehensive set of maps and tables has been prepared. It shows:

(a) The regions and sub-regions for all the lithological classes, regardless of whether or not those sub-regions have 200/300 boreholes:

(b) The numbers of boreholes in each quarter-degree square making up a sub-region (from the 1976 listing), and the numbers of boreholes from the corresponding land divisions (from the 1952 listing);

(c) The borehole totals in each sub-region, lithological class and MAR/ES region.

The above-mentioned set of maps and tables runs into several pages and is available for reference from the Hydrological Branch. A summary of the information is given in the form of tables at the end of the chapter.

Of the total of 170 sub-regions in all classes and MAR/ES regions, only 43 attained the desired number of boreholes (See Table 1.2), and an analysis of each sub-region is presented in following sections.

Finally, the list below is a summary of the information used to determine the lithological classes of rock types in Lange's listing. The list also gives the land divisions, their administration codes and the MAR/ES regions and sub-ordinate regions.

CLASSIFICATION OF LANGE'S 1952 INFORMATION.

PAGE	NAME N.R - Native Reserve NPA - Native Purchase Area GR - Game Reserve	Granite	Basalt	Sandstone	Mid-PreCambrian	Early PreCambrian	Permian Mudstones	Great Dyke	Admin Code No.	Rainfall (R)	Erosion Surface(ES)	Region	Subordinate R/ES Region
1	Angwa North	G			M				0 1	7	M		
4	Angwa South	G			M				0 2	7	M		
10	Arcturus	G				E			0 3	9	0		
15	Banket	G						K	0 4	9	0		
18	Battlefields	G		S		E			0 5	7	0		
20	Bubi	G	B	S		E			0 6	7	0		7M
25	Bromley	G							0 7	9	0		
31	Bembezaan	G						K	0 8	7	0		
33	Beatrice	G	B	S		E			0 9	7	0		
35	Belingwe-Shabani	G				E			0 10	5	0		70
37	Belingwe NR	G				E			0 11	5	M		50
39	Bindura	G				E			0 12	9	0		9M
48	Buhera NR	G		S		E			0 13	7	0		50
50	Cashel	G			M				0 14	7	0		90
52	Chiredzi	G	B	S					0 15	5	Y		
54	Chibi NR	G							0 16	5	0		
56	Chikwiso NR	G							0 17	7	Y		
58	Darwendale	G							0 18	9	0		
60	Doma	G			M				0 19	7	M		
64	Eldorado	G				E			0 20	7	M		90
66	Essexvale-Ncema	G				E			0 21	7	0		
68	Enkeldoorn	G		S		E			0 22	7	0		
73	Feathersone	G	B	S					0 23	7	0		
77	Figtree	G	B	S					0 24	5	0		
79	Filabusi	G				E			0 25	5	0		
81	Gwaai NR		B	S					0 26	5	Y		70
93	Glendale	G				E			0 27	9	0		
98	Gwanda	G							0 28	5	M		50 5Y
102	Gutu	G				E			0 29	7	0		
104	Gwelo	G				E			0 30	7	0		
111	Gwelo East	G				E			0 31	7	0		
114	Lr. Gwelo NR	G		S					0 32	7	M		
118	Gwanda NR	G							0 33	5	M		3Y
121	Gwanda NPA	G							G 34	5	M		
125	Gwebi Hunyani	G				E			0 35	9	0		70
131	Gutu NR	0				E			0 36	7	0		50
136	Gwampa NR	G		S		E			0 37	7	0		
138	Gwelo NPA	G		S		E			0 38	7	0		
140	Headlands	G				E			0 39	9	0		70 7M
142	Inyati	G	B	S		E			0 40	7	0		50
144	Inyati NR	G				E			0 41	7	0		
146	Insiza	G				E			0 42	5	0		70
148	Insiza NR	G				E			0 43	5	0		
150	Karoi	G			M				0 44	7,	M		90

PAGE	NAME NR - Native Reserve NPA - Native Purchase Area GR - Game Reserve	Granite	Basalt	Sandstone	Mid-PreCambrian	Early PreCambrian	Permian Mudstones	Great Dyke	Admin	Code	Rainfall (R)	Erosion Surface(ES)	Region	Subordinate	R/ES Region
159	Khami Upper	G		S	M				0	45	5	0			
168	Khami Lower	G	B	S					0	46	5	0			
170	Lundi NR	G				E			0	47	7	0		50	
172	Lupani NR		B	S					0	48	7	0			
177	Marandellas North	G							0	49	9	0			
182	Maquadzi North	G						K	0	50	7	M		90	
188	Mtoko-Mrewa	G							0	51	7	0		90	
195	Mkota NR	G							0	52	7	Y			
198	Mtoko NR	G				E			0	53	7	0		7M	
201	Marodzi-Tatagura	G				E			0	54	9	0			
207	Mchingwe River	G				E			0	55	7	0		50	
209	Matopos North	G				E			0	56	5	0			
211	Matopos South	g				E			0	57	5	0			
213	Manyeni NR	G							0	58	7	0			
215	Maribeha NR	G				E			0	59	5	0			
217	Maranke NR	G				E			0	60	7	0		50	5Y
219	Musikawanhu NR	-	-	-		-		-	0	61	7	Y			
221	Mondoro NR	G	B	S		E			0	62	7	0		90	
223	Mphoeng's NR	G							0	63	5	0			
225	Maitengwe NR	G	B	S					0	64	5	Y		50	
227	Mkosikas NR	G	B	S					0	65	7	0			
229	Macheke	G							0	66	9	0			
231	Mombale NR								0	67	3	Y		5M	
233	Matetsi		B	S					0	68	7	M		5Y	70
235	Nata NR	G	B	S					0	69	5	0			
242	Norton	G	G			E			0	70	9	0			
248	Nyamandhlovu & Umgusa Lower		B	S					0	71	5	0			
254	Ndanga NR	G				E			0	72	7	M		90	
256	Nthabasinduna NR	G				E			0	73	7	0			
258	Nuanetsi	G	B	S		E			0	74	5	Y			
260	Odzi	G				E			0	75	7	0			
266	Prospect NR	G				E			0	76	5	M		50	
271	Rusape	G							0	77	9	0			
273	Raditladi NR	G				E			0	78	5	0			
275	Sabi Catchment	G		S					0	79	5	Y		90	70
280	Sabi Valley	G			M				0	80	5	Y			
283	Sessombi	G		S		E			0	81	7	0			
287	Shashani N.R.	G							0	82	5	0			
289	Samenani	G							0	83	5	0			
291	Shangani	G		S		E			0	84	7	0			
293	Salisbury	G				E			0	85	9	0			
311	Semokwe NR	G				E			0	86	5	0		5M	
314	Salisbury South	G	B						0	87	9	0		70	
320	Silobela NR	G		S		E			0	88	7	0			
323	Shangani NR	G	B	S		E			0	89	7	0			

PAGE	NAME NR - Native Reserve NPA - Native Purchase Area GR - Game Reserve	Granite	Basalt	Sandstone	Mid-PreCambrian	Early PreCambrian	Permian Mudstones	Great Dyke	Admin. Code	Rainfall (R)	Erosion Surface(ES)	Region	Subordinate R/ES Region
336	Sokis	G				E			0 90	7	0		
339	Shamva-Poti	G				E			0 91	7	0		90
343	Salisbury West	G				E			0 92	9	0		70
347	Selous	G						K	0 93	7	0		90
354	Suri-Suri	G			M				0 94	7	0		7M
359	Sebungwe NR			S	M		P		0 95	7	Y		
365	Sanyati NR			S	M		P		0 96	7	M		7Y
370	Tsungwesi	G				E			0 97	7	0		90
377	Trelawney	G						K	0 98	9	0		
383	Tuli NR	G	B	S		E			0 99	3	Y		5Y
389	Umvuma	G		S				K	0 100	7	0		
391	Umvukwes	G						K	0 101	9	0		
397	Umgusa Upper	G	B	S		E			0 102	5	0		
403	Umsweswe	G				E			0 103	7	0		7M
409	Umshandige	G				E			0 104	7	0		50
412	Umtali South	G				E			0 105	9	M		90 70
414	Victoria Central	G				E			0 106	7	0		
417	Victoria East	G				E			0 107	9	0		
420	Wankie GR	G	B	S					0 108	5	Y		70 7M
425	Wenimbi-Ruzawe	G							0 109	9	0		
432	Wedza	G				E			0 110	7	0		
434	Umtali North	G				E			0 111	9	M		
436	Umfuli	G				E			0 112	7	0		90

4.2 The Depth x Yield Analysis - Procedures

To begin with, depth/yield distribution lists were prepared from the two listings. Metric equivalents were adopted for the imperial units used in the 1952 listing. On these lists, there are ten depth intervals of 7,6 metres, from 0 to over 68,6, and four yield classes, from under 1 500 litres/hour to over 15 000 litres/hour. On the analytical sheets three yield classes are shown, and nine depth intervals are used, i.e. up to a depth of 68,6 metres.

The analysis of success was based on the assumption that all boreholes which ceased without striking sufficient water should attain higher yields if:

(a) they are continued until they do obtain sufficient water, or to a depth of about 61 metres;

(b) Those that do obtain sufficient water do so in the same proportion as those boreholes which actually did continue to greater depths (See Appendix 6, para. 5, case 2).

The analysis shows, firstly, the observed percentage success for yields of (i) 1 500 litres and better
(ii) better than 5 000 l/h
(iii) better than 15 000 l/h and, secondly, the percentage chance of success should those boreholes not yielding the desired amounts be drilled deeper.

The procedure adopted for the analysis in this chapter is as follows:

Column	Operation	Full Tital of Column
1	-	Depth at 7,6 m intervals, down to 68,6 metres.
2	-	Numbers of boreholes with yields equal to/less than the specified yield ceasing within the depth interval shown.
3	-	Numbers of boreholes with yields equal to/better than the specified yield ceasing within the depth interval shown.
3(b)	-	Numbers of boreholes with yields equal to/better than the specified yield, cumulative.
4	Totals of Cols. 2 and 3	Total numbers of boreholes ceasing within the depth intervals shown.
5	$\frac{\text{Col 3 (b)}}{\text{Col 4}} \times 100$	Boreholes with yields equal to/better than the specified yield ceasing within the depth interval shown, expressed as a percentage of the total number of the boreholes commenced.
6	Total commenced minus Col. 4	Number of boreholes remaining in each interval after subtraction of all those boreholes which struck water above.
7	(See Table 4.2 below)	Number of boreholes in each depth interval if those not striking sufficient water are continued until they do.
8	$\frac{\text{Col 3} \times \text{Col 7}}{\text{Col 6}}$	Number of boreholes in each depth interval when the condition in Col. 7 is met.

Column	Operation	Full Title of Column
9	-	Number of boreholes striking water in each interval, cumulative.
10	$\frac{\text{Col 9}}{\Delta\Delta\text{Col 4}} \times 100$	Percentage chance of striking water with depth, cumulative

1	2	3	(b)	4	5	6	7	8	9	10
DEPTH INTERVAL (m)	NO. OF B/Hs IN INTERVAL LESS THAN 1 500 l/h	NO. OF B/Hs IN INTERVAL EQUAL TO OR GREATER THAN 1 500 l/h	CUMULATIVE	TOTAL NO. OF B/Hs IN INTERVAL	% RATE OF SUCCESS CUMULATIVE	NO. OF B/Hs PENETRATING TO EACH INTERVAL.	NO. OF B/Hs IN INTERVAL IF THOSE NOT STRIKING WATER ARE CONTINUED	NO. OF B/Hs IN EACH INTERVAL.	NO. OF B/Hs STRIKING WATER CUMULATIVE	% CHANCE OF STRIKING WATER CUMULATIVE
0 - 7,6	0	0	0	0	0	118	118	0	0	0
7,6 - 15,2	0	0	0	0	0	118	118	0	0	0
15,2 - 22,9	0	0	0	0	0	118	118	0	0	0
22,9 - 30,5	2	2	2	4	1,69	118	118	2	2	1,69
30,5 - 38,1	3	4	6	7	5,08	114	116	4,07	6,07	5,14
38,1 - 45,7	12	4	10	16	8,47	107	111	4,18	10,25	8,69
45,7 - 53,4	16	14	24	30	20,34	91	107,75	6,58	26,83	22,74
53,4 - 61,0	21	18	42	39	35,59	61	91,17	26,90	53,73	45,53
61,0 - 68,6	10	12	54	22	45,76	22	64,27	35,06	88,79	75,25
TOTALS	64	54		118						
Over 68,6	17*	21*		38*						
Total No. of b/h's in Sub-Region = 156										

NOTES

(i) Col. 5 = $\frac{\text{Col. 3 (b)}}{\text{Total commenced}}$

(ii) Col. 6 = Total b/h's commenced, minus Col. 4.

(iii) Col. 8 = $\frac{\text{Col. 3 x Col. 7}}{\text{Col. 6}}$

* These figures not used in Analysis.

Table 4.2 Analysis of Success for Boreholes with Yields of 1 500 Litres/Hour.
(EXAMPLE) Class I, MAR/ES Region 9,0 Sub-Region A

4.3 Sub-Regions : Description and Analytical Results by MAR/ES Regions and Lithological Classes.

The main section of this chapter deals with the description of the sub-regions of each Lithological Class, and the results obtained in the depth versus yield analysis. For each Class in a particular MAR/ES region, there is:

(a) A map showing the location of the sub-region of the Class;

(b) Table containing
- (i) a brief description of the areas comprising the sub-region
- (ii) the size of the sub-region in square kilometres
- (iii) the numbers of boreholes in the sub-regions and Class (including those over 68,6 m), and
- (iy) the observed and potential rates of success for each yield class.
- (v) depth x yield distribution

(c) An interpretation of the results and an appraisal of the water supply situation in the various sub-regions of each Lithological Class.

The section is arranged in the following order.

MAR/ES Region	Lithological Classes
9,0	I and VI
7,0	I, III and VI
7,M	I, III, V and VI
7,Y	III
5,0	I, III and VI
5,M	I
5,Y	I and III

The phrase "rate of success" as used in the tables and text requires explanation. The object of the analysis is

(1) to ascertain what percentage of boreholes which attained yields
- (a) equal to or greater than 1 500 l/h
- (b) greater than 5 000 l/h and
- (c) greater than 15 000 l/h and,

(2) the increased rate of success if unsuccessful holes were deepened as outlined in paragraph 4.2.

The boreholes which attained the specified yield are said to have "succeeded" and these are then expressed as a percentage of the total drilled, and the percentage is termed "rate of success".

On all the tables the letters 'O' and 'P' represent the observed and potential rates of success (cases (1) and (2) above).

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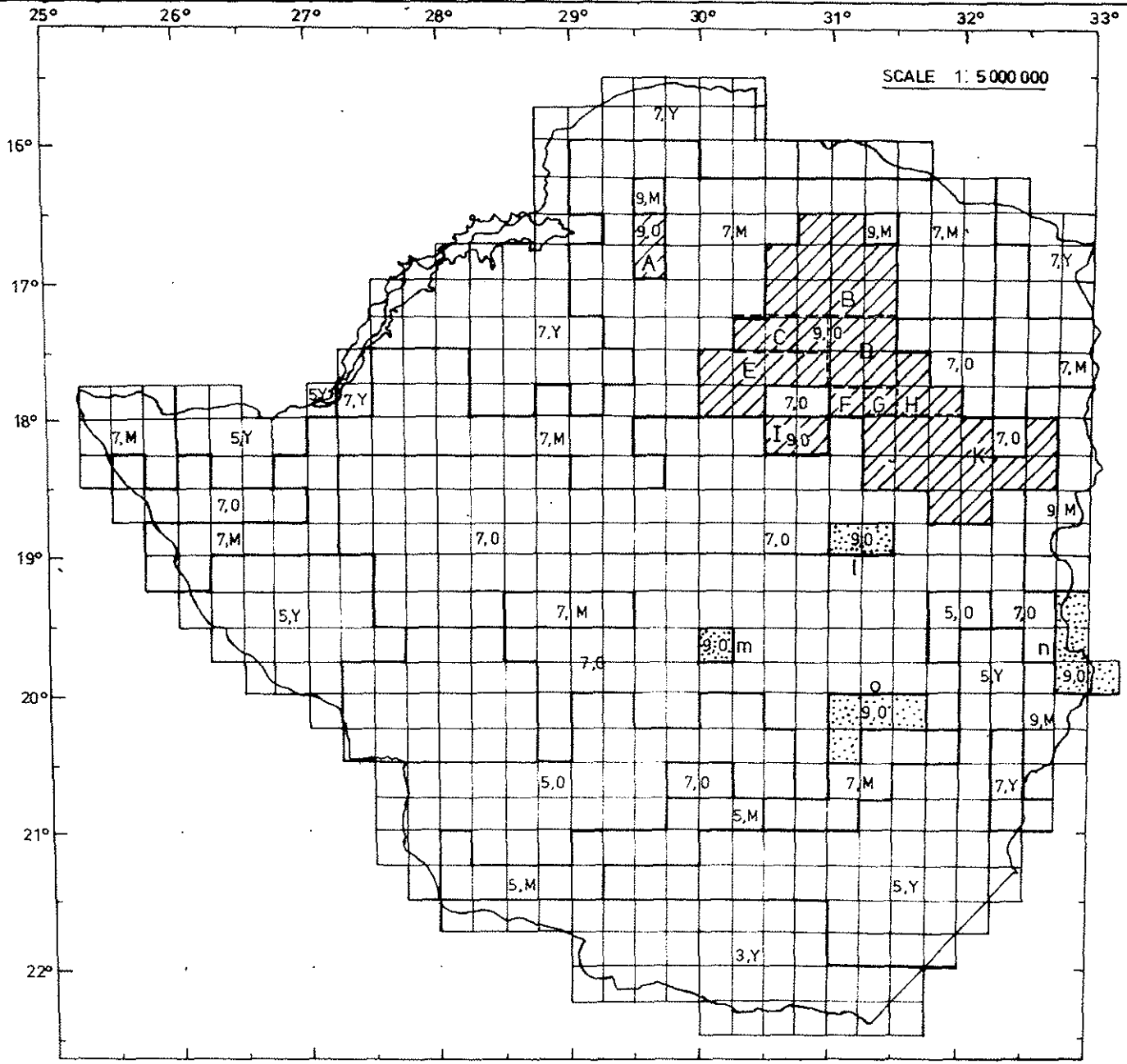

NOTES

CLASS I, MAR/ES 9,0 SUB-REGIONS.

Mean Annual Rainfall (mm)	Erosion Surfaces: Post African and Older	Mixed O and Y	Pliocene and Younger
	O	M	Y
Over 800 = 9	9,0	9,M	-
600 - 800 = 7	7,0	7,M	7,Y
400 - 600 = 5	5,0	5,M	5,Y
Under 400 = 3	-	-	3,Y

Constructed from Diagrams 1 and 2

(N.B. Those sub-regions for which a depth × yield analysis has been made are shaded.)

Combined Mean Annual Rainfall And Erosion Surfaces (MAR/ES)	P 16

Manner of Occurence of Groundwater in Rhodesia — Diagram 4.4

M.O.W.D. HYDRO SK 385/1

TABLE 4.4.1 DEPTH X YIELD ANALYSIS

CLASS I; MAR/ES 9,0

SUB-REGION	LOCATION	AREA KM^2	NO. OF B/H'S		RATES OF SUCCESS %					
			TOTAL	ANALYSED	±1 500 l/h		+5 000 l/h		+15 000 l/h	
					O	P	O	P	O	P
A	Karoi I.C.A.	15	156	118	46	75	19	49	4	16
B	Umvukwes I.C.A.	74	299	293	53	79	18	39	1	2
C	Banket, Marodzi-Tatagura I.C.A's	22	262	260	61	96	32	72	3	10
D	Glendale, Bindura, Sby W. Arcturus I.C.A's	29	301	297	73	97	33	77	3	38
E	Trelawney, Drawendale, Gwebi-Hunyani I.C.A's	44	371	362	48	85	19	50	4	11
F	Salisbury I.C.A.	7	304	297	64	94	26	53	3	8
G	Salisbury I.C.A.	7	225	223	67	90	23	67	4	7
H	Shamva-Poti, Bromley, Marandellas, Mtoko-Mrewa I.C.A's	22	200	200	58	84	22	33	2	4
I	Norton, Selous, Sby S. I.C.A's Mondoro T.T.L.	15	239	233	60	100	21	73	3	8
J	Wenimbi-Ruzawi I.C.A.	29	238	237	66	92	25	54	0	11
K	Macheke, Headlands, Rusape, Tsungwesi, Sabi Catchment (Wedza) I.C.A's	66	298	287	65	95	34	80	6	26
TOTAL: 11	TOTAL AREA COVERED (KM^2) (APPROX.)	330	2893	2807	Mean 60	90	25	59	3	12

N.B. These areas are based on Lange's listing and not on the more accurate 1976 schedule which gives latitude and longitude figures.

4.4 Class I. (Granitic Rocks) MAR/ES Region 9,0

4.4.1 Introduction

MAR/ES Region 9,0 covers an area of about 397 km^2, the main area lying in the North eastern part of the country and the other four smaller areas being to the South of it.

The region consists of various rocks of Post African or older age, and of which granitic types are dominant. It receives the highest amount of rainfall, the mean annual amount being over 800 m.m.

Class 1 of MAR/ES region 9,0 has the largest number of sub-regions (15) and also the largest number of boreholes (2976). There are eleven sub-regions covering some 330 km^2 and containing 2893 boreholes, 2807 of which have been analysed. Of these eleven which have been investigated, seven (B,C,G,H,I,J,K) have 200 or more boreholes, and three (D,E,F,) have 300 or more, the highest being E with 371 boreholes (362 analysed). Sub-region A (Karoi Area), though containing a total of only 156 boreholes, has been included, since the holes are concentrated in an area covering only two quarter-degree squares (about 15 km^2). The location of all the sub-regions is shown in Diagram 4.4.

Table 4.4.1 briefly describes the areas covered by each sub-region, its area, borehole totals (sub-regional and number analysed) and the observed and potential rates of success in three yield classes. Sub-regions c, m, n and o did not contain enough boreholes to permit an analysis. All such sub-regions are shown in small letters on the maps.

4.4.2 Depth x Yield Distribution and Analysis

At a glance, granitic rocks in this region appear to yield some water in most cases, and this applies evenly over the whole region. However, a closer examination reveals a great difference in the rates of success for the various yield classes, a trend which is manifested in other rock types and MAR/ES regions.

For yields of 1 500 l/h or better, the observed percentage varies between 46% in sub-region A(Karoi) and 73% in sub-region D (Glendale/Salisbury W. area). The mean rate of success is 60%, a typical figure for the various rock types and MAR/ES regions.

The chance of success should boreholes be drilled until they attain the desired yield, or to a depth of 68,6 m, varies between 75% for the Karoi area and a maximum of 100% for sub-region I (Norton/Salisbury S. Area, observed rate 90%). The mean for the region is 90%.

In the absence of the results from test drilling to determine the validity of the chance of success figures, it may be worthwhile to examine the depth/yield distribution pattern of boreholes in this class and region. The object of the exercise is to see if the successful boreholes tended to strike sufficient water supplies at a certain depth. The resultant information may shed some light on the nature of the rock fracturing, permeability and other related factors.

The table below shows the depth intervals and the numbers of boreholes in each interval. These numbers are also shown as percentages of the total of successful boreholes. In this and other such tables, the depths shown are those observed only.

Table 4.4.2 Lithological Class I, MAR/ES Region 9.0

Depth x Yield Distribution

DEPTH INTERVAL (M)	YIELD CLASS ± 1 500 l/h		+ 5 000 l/h		+ 15 000 l/h	
	No. of B/H's	% of Total	No.	%	No.	%
0 - 7,6	0	0	0	0	0	0
7,6 - 15,2	10	0,6	4	0,2	1	0,1
15,2 - 22,9	66	3,9	24	1,4	0	0
22,9 - 30,5	296	17,5	97	5,7	2	0,1
30,5 - 38,1	456	26,9	196	11,6	16	1,0
38,1 - 45,7	323	19,1	146	8,6	18	1,1
45,7 - 53,4	334	19,7	136	8,0	29	1,7
53,4 - 61,0	156	9,2	66	3,9	13	0,8
61,0 - 68,6	53	3,1	29	1,7	5	0,3
No. of Boreholes Yielding ± 1 500 l/h (Those analysed only) in Region = 1694						
These as Percentage of Total Commenced = 60%						

N.B. The figures in the ± 1 500 l/h yield class also include thos in the two higher classes and similarly, those in the + 5 000 l/h class also include those in the top yield class.

In the first two yield classes most of the boreholes are between 22,9 and 53,4 metres whilst the high yielding holes are between 30,5 and 53,4 m. deep. There is one exceptional case in the Salisbury area where a high yield was obtained at a depth of about 15 m.

It is significant that there are no boreholes yielding considerable amounts of water less than about eight metres deep and also, the observed figures reflect no continuous increase in supply when boreholes are drilled beyond 53,4 m. (See Table 4.4.3). This is due to the fact that the rocks generally contain fewer fissures with depth and become less permeable.

Table 4.4.3 Lithological Class I, MAR/ES Region 9.0

Extended Depth x Yield Distribution.

Depth (M)	YIELD CLASS ± 1 500 l/h		+ 5 000 l/h		+ 15 000 l/h	
	No.	%	No.	%	No.	%
Over 68,6	41	2,4	15	0,9	3	0,2

N.B. 45 boreholes failed to yield 1 500 l/h.

As is to be expected, the observed and potential percentages decrease in the higher yield classes. Table 4.4.1 shows this decrease; for example, the observed figures for the Karoi area (with the potential rates in parentheses) are 46% (75), 19% (49) and 4% (16) for the three yield classes. The percentages for sub-region I (Norton area) reflect the differences even better, i.e.

Yield Class	± 1 500 l/h	+ 5 000 l/h	+ 15 000 l/h
	60% (100)	21% (75)	3% (8)

Very few boreholes have yields better than 15 000 l/h. In the Trelawney/Darwendale area (sub-region E) where 362 boreholes were analysed, only 14 holes, 3,9% of the total, exceeded this amount. These are between 30,5 and 61 m. deep. Of the total of 371 boreholes, 9 were drilled beyond 68,6 m. and only two produced yields equal to or greater than 1 500 l/h, and neither of these attained 15 000 l/h. This reflects the decrease in yields beyond a certain depth in the granitic rocks in the rebion, a characteristic which is noted in following paragraphs.

Investigations show that the rocks will yield some water in most areas and the observed yields are fairly uniform over the whole area. With a few exceptions, yields do not exceed 15 000 l/h, but this is compensated for the fact that there is a good chance of striking reasonable quantities over a wide area, provided the sites are scientifically selected . However, where yields higher than 15 000 l/h are desired, the fact that the observed percentages of boreholes in this yield category are low (and the risk of failure therefore considerable), must be borne in mind.

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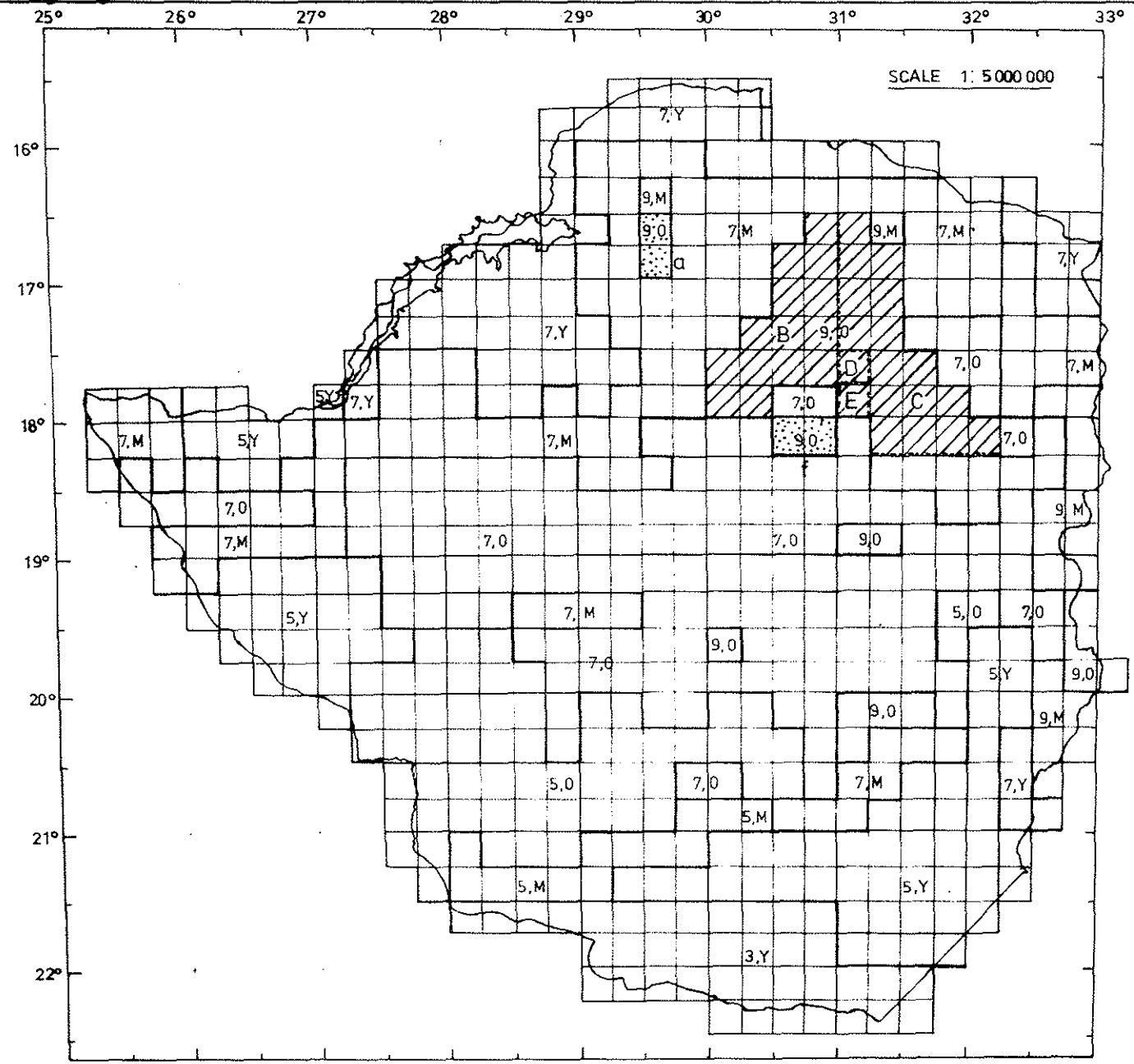

NOTES

CLASS VI, MAR/ES 9,0 SUB-REGIONS

Mean Annual Rainfall (mm)	Erosion Surfaces: Post African and Older (0)	Mixed O and Y (M)	Pliocene and Younger (Y)
Over 800 = 9	9,0	9,M	-
600 - 800 = 7	7,0	7,M	7,Y
400 - 600 = 5	5,0	5,M	5,Y
Under 400 = 3	-	-	3,Y

Constructed from Diagrams 1 and 2

(N.B. Those sub-regions for which a depth × yield analysis has been made are shaded.)

Combined Mean Annual Rainfall And Erosion Surfaces (MAR/ES)	P 21

TABLE 4.5.1. DEPTH X YIELD ANALYSIS

CLASS VI, MAR/ES 9,0					RATES OF SUCCESS %					
SUB-REGION	LOCATION	AREA	NO. OF B/H'S		+ 1 500 l/h		+ 5 000 l/h		+15 000 l/h	
		KM²	TOTAL	ANALYSED	O	P	O	P	O	P
B	Banket, Marodzi-Tatagura, Trelawney, Darwendale Gwebi-Hunyani, Sby W., Norton I.C.A's	103	294	283	82	99	59	90	22	60
C	Bindura, Glendale, Arcturus, Sby; Bromley, Marandellas N. I.C.A's	118	313	310	82	96	38	78	10	39
D	Salisbury W. I.C.A.	7	266	259	77	100	51	100	11	100
E	Salisbury W; Ruwa I.C.A's.	7	564	561	83	97	56	89	10	35
TOTAL: 4	TOTAL AREA COVERED (KM²) (APPROX.)	235	1437	1413	Mean 81	98	51	89	13	59

4.5 Class VI (Early PreCambrian Rocks) MAR/ES Region 9,0

4.5.1 Introduction

Class VI comprises Shamvaian and Bulawayan metasediments, Bulawayan metavolcanics and Sebakwian ultramafics. The main belt containing these rocks lies between Salisbury and (i) Bindura to the North
(ii) Bromley and Marandellas to the East
and (iii) Banket to the North-west.
The areas are well defined on the 1:1 000 000 geological map of 1977. The belt is surrounded mainly by the granitic rocks dealt with in Section 3.1.

The class contains the second largest number of boreholes in region 9,0 (1477). Four of the six sub-regions, B,C,D, and E cover an area of some 235 km^2 and contain a total of 1437 boreholes, 1413 of which have been analysed. Sub-region E (Salisbury I.C.A.) consists of a single quarter-degree square containing 564 boreholes. This sub-region constitutes an ideal study area should any field studies be contemplated.

Table 4.5.1. describes the location of the sub-regions and displays other relevant data.

4.5.2 Depth x Yield Distribution and Analysis

The rocks in this Class give yields higher than those of the granitic rocks in the same region. In the 1 500 l/h or better yield classes, the observed rate of success is between 77 and 82%, the mean being 81%. This is the highest rate for any class of rocks in any M/R/ES region. The potential rate for the same yield class lies between 86 and 100%, (the latter obtained in the Salisbury West I.C.A.). The mean is 98%, the highest figure so far obtained.

In the +5 000 l/h yield class the observed figures are considerably lower, varying between 38% for the area stretching from Bindura to Marandellas, and 59% in the Norton/Banket/Darwendale area. The mean figure is 51%, twice the figure obtained for this yield class in Class I rocks. The potential figures, varying between 78 and 100% (mean 89%) are again the highest obtained.

In the high yield class, the mean observed and potential rate of success figures are 13 and 59% respectively.

In view of the high rates of success obtained, it is worthwhile to note the depths to which boreholes were drilled and then compare these with the depth of boreholes in the granitic rocks. This might provide an insight into the water bearing qualities of the rocks in the two lighological Classes. Table 4.5.2. displays the yield classes, and numbers and percentages of observed boreholes by depth interval.

Table 4.5.2 Lithological Class VI, MAR/ES Region 9.0

Depth x Yield Distribution

DEPTH INTERVAL (M)	YIELD CLASS ± 1 500 l/h		+ 5 000 l/h		+ 15 000 l/h	
	No. of B/Hs	% of Total	No.	%	No.	%
0 - 7,6	0	0	0	0	0	0
7,6 - 15,2	2	0,2	0	0	0	0
15,2 - 22,9	28	2,1	10	0,8	0	0
22,9 - 30,5	142	10,7	76	5,7	7	0,5
30,5 - 38,1	315	23,8	181	13,7	31	2,3
38,1 - 45,7	330	24,9	179	13,5	40	3,0
45,7 - 53,4	312	23,6	173	13,1	56	4,2
53,4 - 61,0	164	12,4	93	7,0	32	2,4
61,0 - 68,6	31	2,3	16	1,2	8	0,6
No. of Boreholes Yielding ± 1 500 l/h (Those analysed only) in Region = 1324 These as Percentage of Total Commenced (1413) = 94%						

The table shows that there is practically no difference in the depths at which most boreholes attained the yields in both the granitic and Early PreCambrian rocks. The difference lies in the rates of success in the yield classes. In lithological Class I, 60% of the analysed boreholes struck yields of 1 500 l/h and better, compared with 94% in Class VI.

The information shows that, firstly, much of the water available is found at depths of between 22,9 and 53,4 metres and, secondly, the older Early PreCambrian rocks generally have a higher rate of success than the younger granitic types. Another fact which becomes apparent is that there are fairly well-defined depth limits above and beyond which satisfactory yields cannot be obtained. The upper limit in both Classes is about 15 metres whilst the lower limit is between 53,4 and 61 metres.

The following sections deal with the occurrence of groundwater in the other regions and classes, and, whereever possible, an attempt is made to compare and contrast any characteristics displayed by the various rock types.

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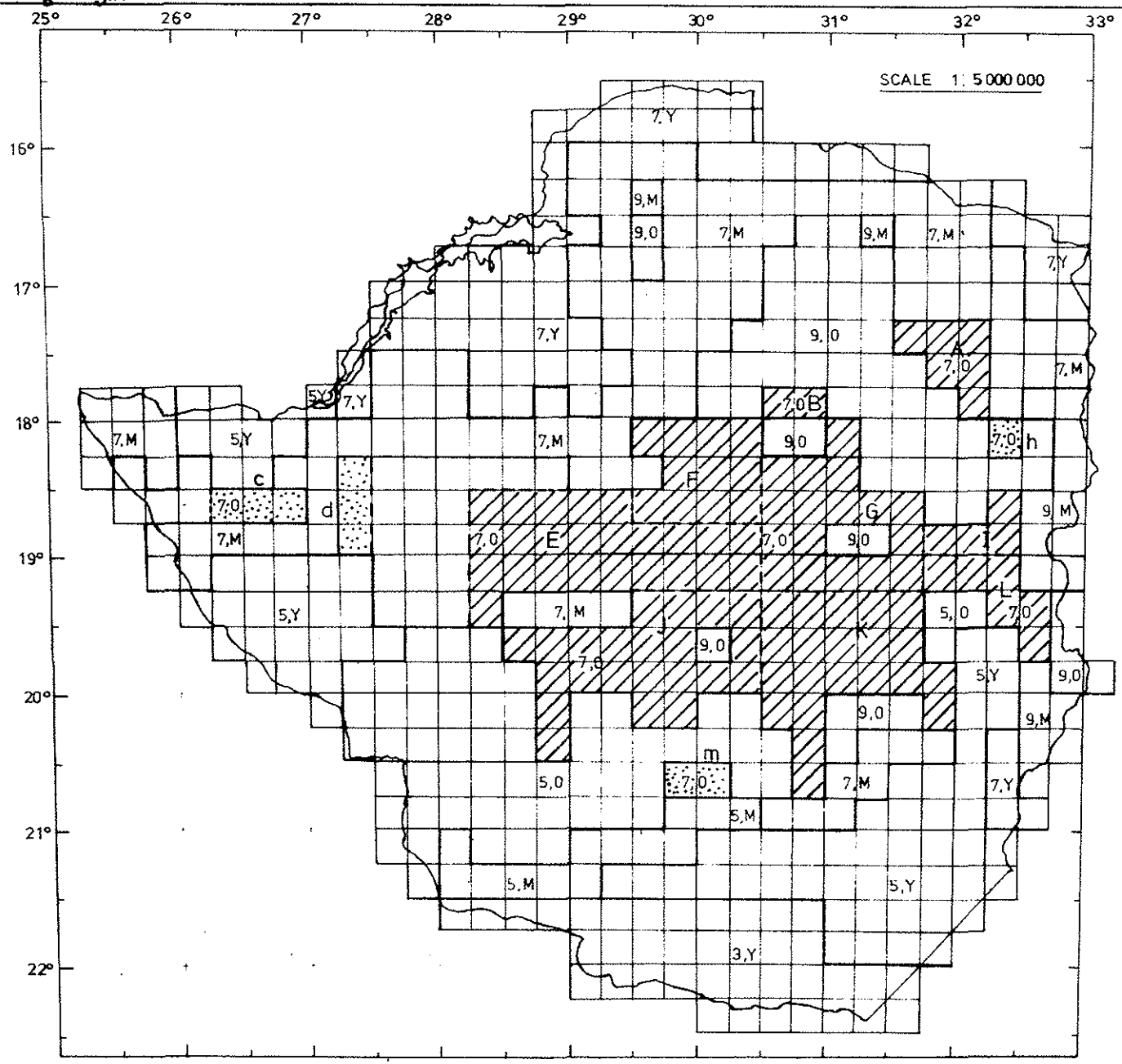

NOTES

CLASS I MAR/ES REGION 7,0 SUB-REGIONS

Mean Annual Rainfall (mm)	Erosion Surfaces: Post African and Older	Mixed O and Y	Pliocene and Younger
	O	M	Y
Over 800 = 9	9,0	9,M	-
600 - 800 = 7	7,0	7,M	7,Y
400 - 600 = 5	5,0	5,M	5,Y
Under 400 = 3	-	-	3,Y

Constructed from Diagrams 1 and 2

(N.B. Those sub-regions for which a depth × yield analysis has been made are shaded.)

Combined Mean Annual Rainfall And Erosion Surfaces (MAR/ES)	Diagram 25

Manner of Occurence of Groundwater in Rhodesia Diagram 4.6

M.O.W.D. HYDRO SK 385/3

TABLE 4.6.1 DEPTH X YIELD ANALYSIS

CLASS I, MAR/ES 7,0					RATES OF SUCCESS %					
SUB-REGION	LOCATION	AREA KM^2	NO. OF B/H's		± 1 500 l/h		+ 5 000 l/h		+15 000 l/h	
			TOTAL	ANALYSED	O	P	O	P	O	P
A	Mtoko-Mrewa, Shamva-Poti I.C.A's. Mtoko T.T.L.	44	297	293	57	87	25	51	3	10
B	Gwebi-Hunyani, Sby. W; I.C.A's	15	186	180	69	85	31	56	4	15
E	Sessombi, Bembezaan, Bubi, Gwelo I.C.A's, Shangani, Silobela, Inkosikazi T.T.L's.Gwelo A.P.A	176	215	202	52	76	21	32	4	11
F	Suri-Suri, Selous, Umsweswe, Umfuli, Sokis, Battlefields I.C.A's	81	261	240	57	83	22	50	4	19
G	Sby. S; Beatrice, Featherstone, Wedza, Umvuma, Enkeldoorn, Sabi Catchment I.C.A's, Mondoro, Manyeni T.T.L's	125	391	384	61	92	29	58	5	23
I	Tsingwezi, Odzi I.C.A's	29	237	230	61	94	26	77	3	11
J	Gwelo E; Shangani, Inyati, Insiza, Essexvale-Ncema, Mchingwe R. I.C.A's. Inyati Ntabazinduna T.T.L's	162	210	195	65	37	30	55	4	12
K	Gutu, Victoria C; Umshandige I.C.A's, Buhera, Gutu T.T.L's	154	308	292	57	89	30	69	7	20
L	Umtali S. etc. (Umtali area) I.C.A's Maranke T.T.L.	44	232	224	53	80	21	53	4	28
TOTAL: 9	TOTAL AREA COVERED (KM^2) (APPROX.)	830	2337	2240	Mean 59	86	26	56	4	17

4.6 Class I, MAR/ES Region 7,0

4.6.1 Introduction

MAR/ES Region 7,0, the largest of all the regions, covers an area of about 1073 Km^2. The main belt includes places as far apart as Mtoko, Gwelo and Fort Victoria, and takes in much of the central watershed stretching roughly from the North-east to the South-western part of the country. There are three smaller areas, all quite near the main belt. (See Diagram 4.6).

The mean annual rainfall is between 600 and 800 m.m., and the Erosion Surface is of Post African and older age.

In Class I there are 13 sub-regions and containing 2375 boreholes. Nine of these (A,B,E,F,G,I,J,K,L) have been investigated. They contain 2337 boreholes, of which 2240 have been analysed. Sub-region K has over 300 boreholes and the rest over 200, with the exception of B, which has 186 boreholes in two quarter-degree space squares. Table 4.6.1 describes the location of these sub-regions and gives appropriate data.

4.6.2 Depth x Yield Distribution and Analysis

The granitic rocks in MAR/ES region 7,0, like those in region 9,0, yield some water in most places and, in some cases, a comparison of the tables for the two regions will show that the areas with the best yields in 7,0 correspond with those in 9,0.

The percentage of boreholes attaining yields of $\pm$ 1 500 l/h or better varies between 53% in sub-region I (Umtali South/Maranke T.T.L. area) and 69% in the Gwebi/Hunyani/Salisbury West areas. The mean figure for the nine sub-regions is 59%, only 1% lower than the figure for Class I rocks in region 9,0.

The potential figures in the same yield class for the two regions are only slightly different (90% for region 9,0, 86% for region 7,0).

This similarity in percentages is repeated in the two higher yield classes. For example, the mean observed rates for the two regions in the + 5 000 l/h and + 15 000 l/h classes are (those for 7,0 in parenthesis): 25 (26) and 3 (4) whilst the potential figures are 59 (56) and 12 (17).

At this point the depths to which boreholes in the various yield classes were drilled are examined for purposes of comparison with those in region 9,0. Table 4.6.2 illustrates the situation.

Table 4.6.2 Lithological Class I. MAR/ES Region 7.0

Depth x Yield Distribution

DEPTH INTERVAL (M)	YIELD CLASS					
	± 1 500 l/h		+ 5 000 l/h		+ 15 000 l/h	
	No. of B/H'S	% of Total	No.	%	No.	%
0 - 7,6	0	0	0	0	0	0
7,6 - 15,2	4	0,3	2	0,2	0	0
15,2 - 22,9	68	5,2	23	1,8	1	0,1
22,9 - 30,5	215	16,4	106	8,1	6	0,5
30,5 - 38,7	375	28,6	165	12,6	18	1,4
38,1 - 45,7	291	22,2	108	8,2	17	1,3
45,7 - 53,4	227	17,3	116	8,9	35	2,7
53,4 - 61,0	98	7,5	57	4,4	21	1,6
61,0 - 68,6	32	2,4	11	0,8	2	0,2
No. of Boreholes Yielding ± 1 500 l/h (Those Analysed only) in Region = 1310						
These as Percentage of Total Commenced (2240) = 58%						

In the first two yield classes, most of the borehole lie between 22,9 and 53,4 metres, whilst in the high yield class they are between 30,5 and 53,4 metres deep. These are the same sort of figures obtained in region 9,0.

Two points emerge from the foregoing observations. The first is that there is only a small difference in the magnitude of yields in the same rocks in the two MAR/ES regions. The second is that the depths to which most of the observed boreholes have been drilled are the same for the various yield classes in both regions. These points indicate that the movement of water in, and the yield capacities of, the granitic rocks are not affected to a very great extent by differences in the MAR/ES regions, although it might have been assumed that the higher mean annual rainfall in region 9,0 should in the long term account for the higher potential success rates. So far, however, the observed rates reflect no particular tendency for boreholes in rocks in region 9,0 to give invariably better yields than those in region 7,0.

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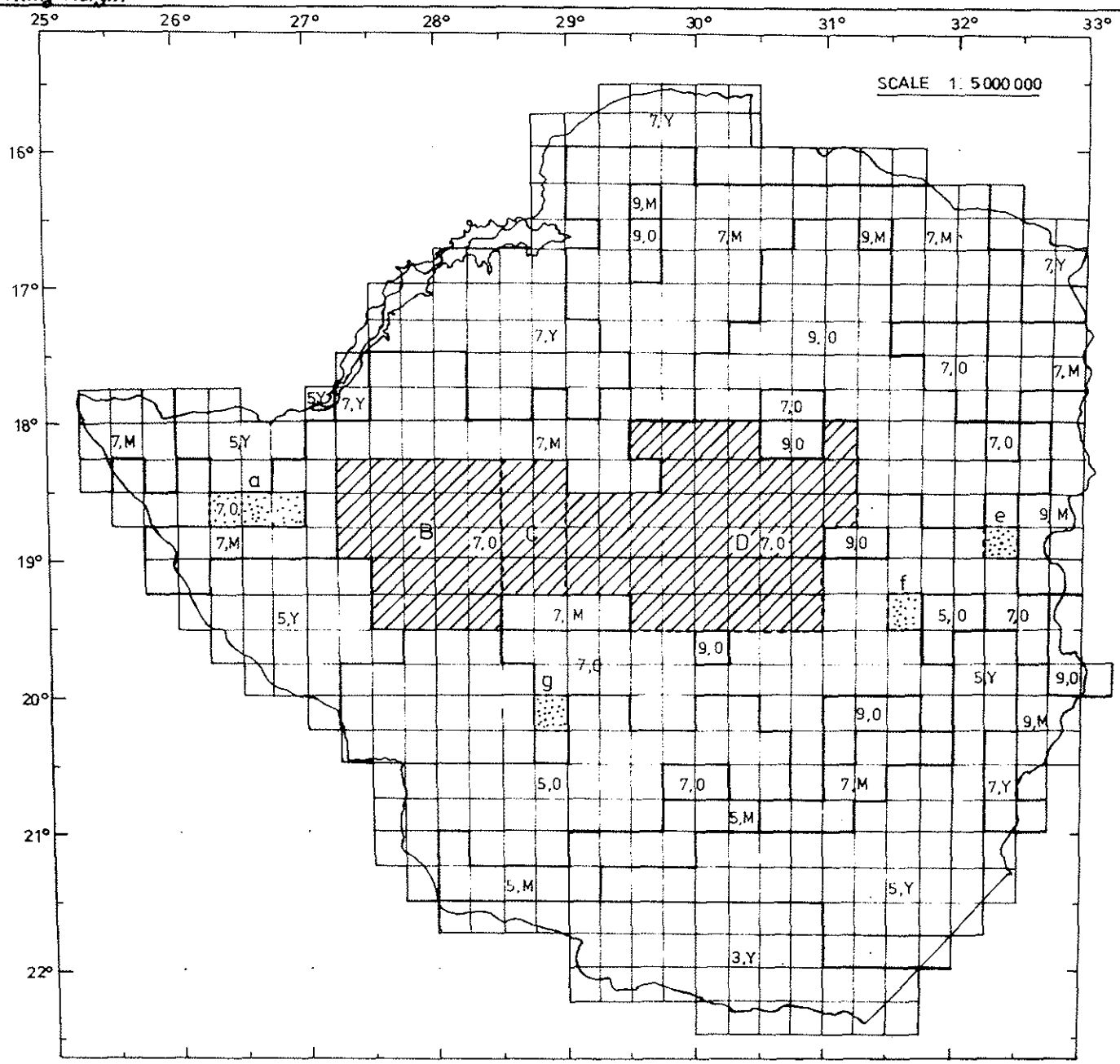


NOTES

CLASS III MAR/ES REGION 7,0

SUB-REGIONS

Mean Annual Rainfall (mm)	Erosion Surfaces: Post African and Older (0)	Mixed 0 and Y (M)	Pliocene and Younger (Y)
Over 800 = 9	9,0	9,M	-
600 - 800 = 7	7,0	7,M	7,Y
400 - 600 = 5	5,0	5,M	5,Y
Under 400 = 3	-	-	3,Y

Constructed from Diagrams 1 and 2

(N.B. Those sub-regions for which a depth × yield analysis has been made are shaded.)

Combined Mean Annual Rainfall And Erosion Surfaces (MAR/ES)	Page 28

M.O.W.D. HYDRO SK 385/4

TABLE 4.7.1 DEPTH X YIELD ANALYSIS

CLASS III MAR/ES 7,0					RATES OF SUCCESS					
SUB-REGION	LOCATION	AREA KM^2	NO. OF B/H's		+ =1 500 l/h		+ 5 000 l/h		+15 000 l/h	
			TOTAL	ANALYSED	O	P	O	P	O	P
B	Lupane, Gwaai, Inkosikazi T.T.L's (Gwaai Area)	169	260	175	69	89	10	16	0	0
C	Bubi I.C.A., Shangani, Gampa T.T.L's	59	279	194	48	79	6	11	0	0
D	Sby; Beatrice, Featherstone, Umvuma, Enkeldoorn, Gwelo I.C.A's. Mondoro, Manyeni, Shangani etc. T.T.L'S	309	333	274	63	92	21	37	1	2
TOTAL: 3	TOTAL AREA COVERED (KM^2) (APPROX.)	537	872	643	Mean 60	87	12	21	0	1

4.7

4.7 Class III (Sands and Sandstone), MAR/ES Region 7,0.

4.7.1 Introduction.

Although this class of rocks is found in MAR/ES region 9,0, it has not been investigated because there are too few boreholes listed to consitute a sub-region and therefore it is first considered in region 7,0.

Sands and sandstones cover large areas in the North-western part of the country, especially in the Wankie, Lupane and Nyamandhlovu districts. They are also found in many other parts of the highveld, notably in the area between Salisbury and Enkeldoorn.

In this class in region 7,0 there are 893 boreholes in five sub-regions. Three of these, B, C, and D, together containing 872 boreholes (643 analysed), have been investigated. The first two have more than 200 boreholes and the last, D, has over 300 spread over an area of about 309 km^2.

Diagram 4.7 and Table 4.7.1 illustrate and describe the location of the sub-regions and the relevant information on them.

4.7.2. Depth x Yield Distribution and Analysis

Due to their generally high porosity and permeability, sands and sandstones would be expected to be correspondingly high yielders of groundwater. A study of the areas in region 7,0 does not appear to support this; in fact the rates of successes are low in the higher yield classes.

The mean observed and potential rates of success in the first yield Class (60 and 87% respectively) compare favourably with those in Class I, but the figures differ greatly in the second yield class, where those for the Class III rocks are less than half of those for granitic rocks. The figures for the high yield class are insignificant (0 and 1%).

Table 4.7.2 below shows that only three boreholes, representing a mere 0,9% of the total number of boreholes with yields equal to or better than 1 500 l/h attained yields of over 15 000 l/h.

Table 4.7.2. Lithological Class III, MAR/ES Region 7,0.

Depth x Yield Distribution.

DEPTH INTERVAL (M)	YIELD CLASS					
	± 1 500 l/h		+5 000 l/h		+ 15 000 l/h	
	No. of B/H's	% of Total	No.	%	No.	%
0 - 7,6	0	0	0	0	0	0
7,6 - 15,2	0	0	0	0	0	0
15,2 - 22,9	21	5,5	4	1,0	0	0
22,9 - 30,5	58	15,1	21	5,5	0	0
30,5 - 38,1	67	17,4	17	4,4	1	0,3
38,1 - 45,7	67	17,4	15	3,9	0	0
45,7 - 53,4	76	19,8	18	4,7	1	0,3
53,4 - 61,0	54	14,1	7	1,8	1	0,3
61,0 - 68,6	41	10,7	4	1,0	0	0

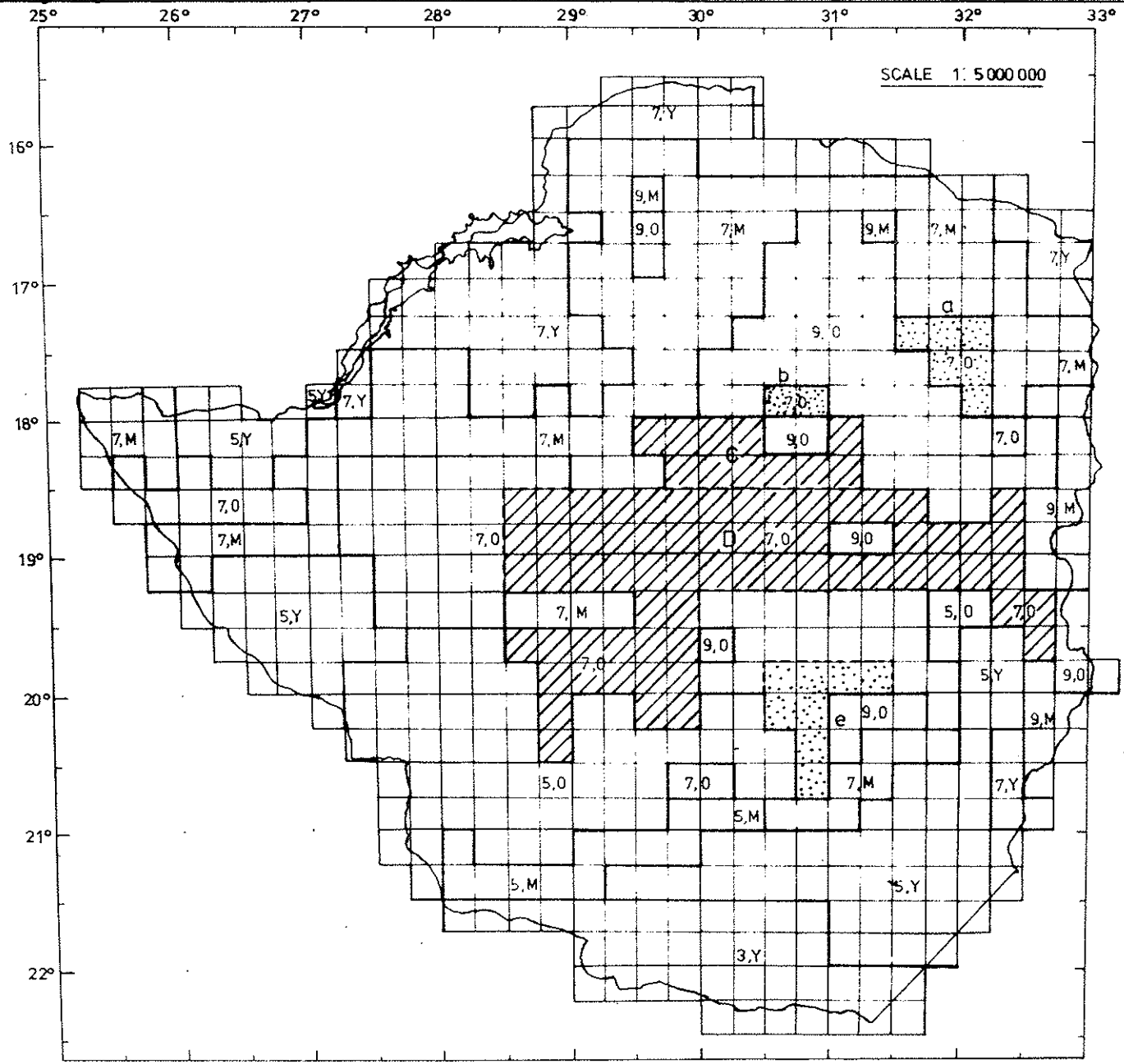
No. of Boreholes Yielding ± 1 500 l/h (Those Analysed only) in Region = 384
These as Percentage of Total Commenced (643) = 60%

The table shows that in the first two yield classes, most boreholes that struck supplies lie at depths of between 30,5 and 53,4 metres, and beyond the last figure there was a decline. These figures are similar to those of the Class I rocks in the same region. The three boreholes that did attain a high yield were in the 30,5 - 38,1 and 45,7 - 61,0 m. intervals.

It is significant that, of the 229 boreholes which were drilled to depths greater than 68,6 m. none attained yields over 15 000 l/h, and only 11 had yields better than 5 000 l/h. 121 boreholes yielded less than 1 500 l/h.

It is evident that sands and sandstones do not necessarily give better yields than the granitic rocks in the same MAR/ES region. Nevertheless, incorrect drilling techniques, boreholes not deepened, insufficient open area in slotted cases are known to be factors which adversely affect yields from sedimentary formations. In T.T.L's boreholes are usually stopped when the first water is struck. Holes are not drilled deeper to obtain more water because only hand pumps are installed and these supply only small amounts of water. Because of these factors, an incorrect assessment of the groundwater potential is given. It is known that important aquifers exist in this class.

Filing Margin



NOTES

CLASS VI MAR/ES REGION 7,0 SUB-REGIONS

Mean Annual Rainfall (mm)	Erosion Surfaces: Post African and Older (0)	Mixed O and Y (M)	Pliocene and Younger (Y)
Over 800 = 9	9,0	9,M	-
600 - 800 = 7	7,0	7,M	7,Y
400 - 600 = 5	5,0	5,M	5,Y
Under 400 = 3	-	-	3,Y

Constructed from Diagrams 1 and 2

(N.B. Those sub-regions for which a depth × yield analysis has been made are shaded.)

Combined Mean Annual Rainfall And Erosion Surfaces (MAR/ES)	P 33

M.O.W.D. HYDRO SK 385/5

TABLE 4.8.1 DEPTH X YIELD ANALYSIS

CLASS VI, MAR/ES 7,0					RATES OF SUCCESS %					
SUB-REGION	LOCATION	AREA KM^2	NO. OF B/H'S		± 1 500 l/h		+5 000 l/h		+15 000 l/h	
			TOTAL	ANALYSED	O	P	O	P	O	P
C	Suri-Suri, Selous, Umfuli, Umsweswe, Sokis Salisbury S; I.C.A's	81	287	272	75	95	47	84	21	41
D	Battlefields, Featherstone, Sessombi, Bembezaan, Gwelo & E; Umvuma, Umtali etc. I.C.A's. Lundi etc. T.T.L's	485	354	335	67	92	35	77	7	32
TOTAL: 2	TOTAL AREA COVERED (KM^2) (APPROX.)	566	641	607	Mean 71	94	41	81	14	37

4.8 Class VI. (Easly PreCambrian Rocks) MAR/ES Region 7,0.

4.8.1 Introduction

Some 914 boreholes, the second largest number after that in Class 1, have been drilled in this lithological Class. The boreholes are found in five sub-regions, A to E, and two of these C and D, containing 641 boreholes, (607 analysed) form the basis of the following section. The two sub-regions cover an area of about 566 km^2, with D accounting for the larger part stretching from Umtali in the East to Gwelo in the West. (See Diagram 4.8).

4.8.2 Depth x Yield Distribution and Analysis

Although only two sub-regions have been investigated, the results obtained are quite similar to those in MAR/ES region 9,0. A look at the mean figures in Table 4.8.1 reveals figures considerably higher than those of both the granitic and sandy rocks. For example, the mean observed figures for boreholes with yields of 1 500 l/h are 59, 60 and 71% for Class I, III and VI respectively, whilst the corresponding potential figures are 86, 87 and 94%. The figures for the higher yield classes show a similar pattern.

The figures for the + 5 000 and + 15 000 l/h classes compare favourably with those in MAR/ES region 9,0 as illustrated below:

MAR/ES	+ 5 000 l/h		+ 15 000 l/h	
	Observed	Potential	Observed	Potential
(9,0	51%	89%	13%	59%
(7,0	41	81	14	37

As observed in earlier sections, the depths to which most of the observed boreholes were drilled lie in much the same range. Table 4.8.2 below shows that in this case the upper limit is somewhat deeper, being between 30,5 and 38,6m; but the lower limit is still around 53,4m for the first two yield classes, and around 61,0m for the top yield class.

Table 4.8.2. Lithological Class VI, MAR/ES Region 7,0.

Depth x Yield Distribution

DEPTH INTERVAL (M)	YIELD CLASS					
	± 1 500 l/h		+ 5 000 l/h		+ 15 000 l/h	
	No. of B/H's	% of Total	No.	%	No.	%
0 - 7,6	0	0	0	0	0	0
7,6 - 15,2	1	0,2	0	0	0	0
15,2 - 22,9	9	1,8	2	0,4	1	0,2
22,9 - 30,5	51	10,4	20	4,1	2	0,4
30,5 - 38,1	123	25,1	58	11,8	14	2,9
38,1 - 45,7	121	24,7	59	12,0	22	4,5
45,7 - 53,4	108	22,0	51	10,4	16	3,3
53,4 - 61,0	67	13,7	37	7,6	15	3,1
61,0 - 68,6	10	2,0	7	1,4	1	0,2

No. of Boreholes Yielding ± 1 500 l/h (Those Analysed only) in Region = 490
These as Percentage of Total Commenced (607) = 81%

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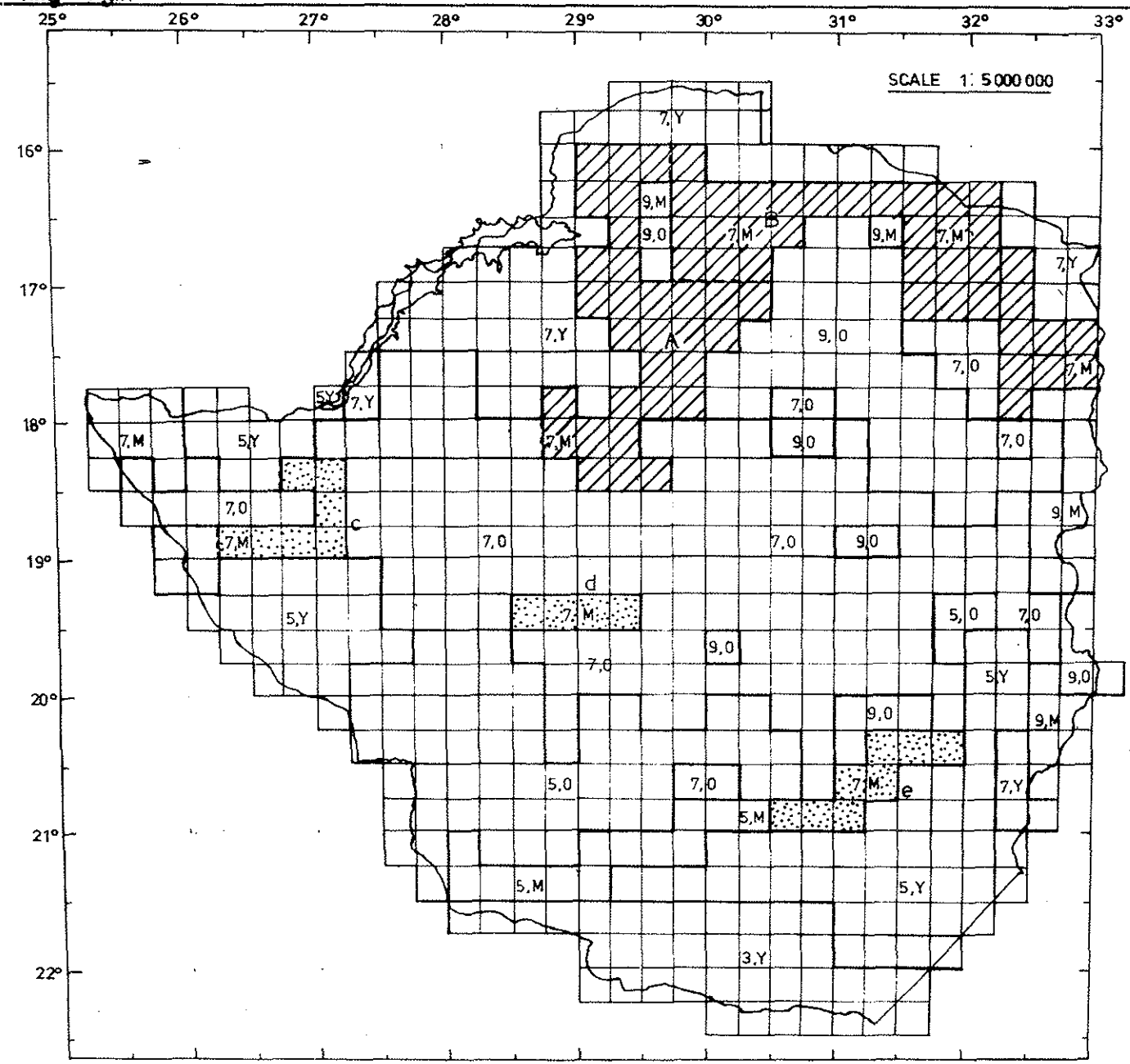

NOTES

CLASS I MAR/ES REGION 7,M SUB-REGIONS

Mean Annual Rainfall (mm)	Erosion Surfaces: Post African and Older (0)	Mixed 0 and Y (M)	Pliocene and Younger (Y)
Over 800 = 9	9,0	9,M	-
600 - 800 = 7	7,0	7,M	7,Y
400 - 600 = 5	5,0	5,M	5,Y
Under 400 = 3	-	-	3,Y

Constructed from Diagrams 1 and 2

(N.B. Those sub-regions for which a depth × yield analysis has been made are shaded.)

Combined Mean Annual Rainfall And Erosion Surfaces (MAR/ES)	Page 36

Manner of Occurence of Groundwater in Rhodesia — Diagram 4.9

M.O.W.D. HYDRO SK 385/6

TABLE 4.9.1 DEPTH X YIELD ANALYSIS

CLASS I,	MAR/ES 7,M				RATES OF SUCCESS %					
SUB-REGION	LOCATION	AREA	NO. OF B/H's		±1 500 l/h		+5 000 l/h		+ 15 000 l/h	
		KM²	TOTAL	ANALYSED	O	P	O	P	O	P
A	Angwa N & S; Eldorado/Maquadzi, Suri Suri I.C.A's. Sanyati T.T.L.	221	370	326	55	90	21	58	3	24
B	Karoi, Mtoko-Mrewa etc. I.C.A's Mtoko T.T.L.	265	331	301	62	89	24	53	3	7
TOTAL: 2	TOTAL AREA COVERED (KM²) (APPROX.)	486	701	627	Mean 59	90	23	56	3	16

4.9 Class I (Granitic Rocks). MAR/ES Region 7,M.

4.9.1 Introduction

Region 7,M consists of mixed Post African and older, and Pliocene and younger Erosion Surfaces. It comprises much of the northern part of the country, stretching from the North-eastern border to the Wankie area. There are also three smaller areas, one in the North-western tip of the country, and the other two in the lower Gwelo and Ndanga areas.

Two large sub-regions consist of the area from the Eastern border to the Gokwe district. They each contain over 300 boreholes, the total being 701, of which 627 have been analysed. Their total area is about 486 km^2. There are few of no boreholes in Class I in the North-western portion of the region. Diagram 4.9 and the corresponding table give details of the sub-regions.

4.9.2 Depth x Yield Distribution and Analysis

The mean percentage figures for boreholes attaining various yields in Class I rocks in MAR/ES regions 7,0 and 7,M are displayed below for the purpose of comparison.

Yield Class Percentages	(Observed/Potential)	± 1 500 l/h O	± 1 500 l/h P	+ 5 000 l/h O	+ 5 000 l/h P	+ 15 000 l/h O	+ 15 000 l/h P
MAR/ES	7,0	59	86	26	56	4	17
	7,M	59	90	23	56	3	16

The figures illustrate that there is little difference in the numbers of boreholes in these rocks attaining certain yields in the two regions.

The comparison of Tables 4.6.2 and 4.9.2 reflects a slight difference in the depths of most of the boreholes yielding 1 500 l/h or more; the upper limit in region 7,0 is around 22,9 m whilst that in region 7,M is around 30,5 m. The lower limit differs by the same magnitude. This means that most the water in the granitic rocks in region 7,M is found at a slightly deeper level than in region 7,M. A point to note here is that the percentage of boreholes attaining 1 500 l/h or more out of the total number of analysed boreholes is the same (58%) for Class I rocks in the two regions.

Table 4.9.2. Lithological Class I. MAR/ES Region 7,M.

Depth x Yield Distribution

DEPTH INTERVAL (M)	YIELD CLASS ± 1 500 l/h No. of B/H'S	± 1 500 l/h % of Total	+ 5 000 l/h No.	+ 5 000 l/h %	+ 15 000 l/h No.	+ 15 000 l/h %
0 - 7,6	0	0	0	0	0	0
7,6 - 15,2	1	0,3	1	0,3	0	0
15,2 - 22,9	18	5,0	2	0,6	0	0
22,9 - 30,5	44	12,1	14	3,9	0	0
30,5 - 38,1	84	23,1	22	6,1	1	0,3
38,1 - 45,7	63	17,4	29	8,0	5	1,4
45,7 - 53,4	67	18,5	28	7,7	3	0,8
53,4 - 61,0	63	17,4	31	8,5	6	1,7
61,0 - 68,6	23	6,3	10	2,8	3	0,8

No. of Boreholes yielding ± 1 500 (Those Analysed Only) in Region = 363
These as Percentage of Total Commenced (627) = 58%

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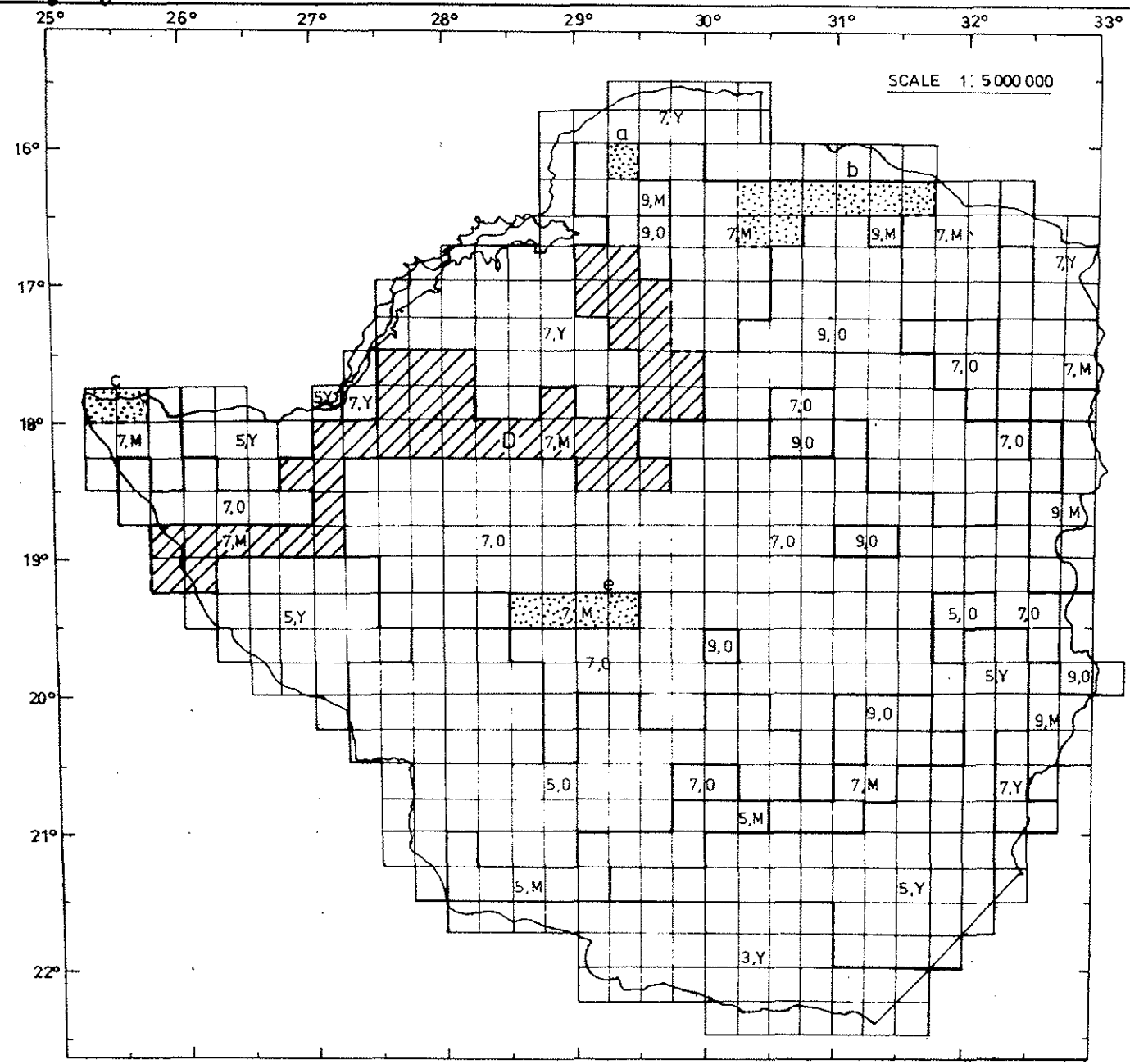

NOTES

CLASS III MAR/ES REGION 7,M SUB-REGIONS

Mean Annual Rainfall (mm)	Erosion Surfaces: Post African and Older 0	Mixed 0 and Y M	Pliocene and Younger Y
Over 800 = 9	9,0	9,M	-
600 - 800 = 7	7,0	7,M	7,Y
400 - 600 = 5	5,0	5,M	5,Y
Under 400 = 3	-	-	3,Y

Constructed from Diagrams 1 and 2

(N.B. Those sub-regions for which a depth × yield analysis has been made are shaded.)

Combined Mean Annual Rainfall And Erosion Surfaces (MAR/ES)	39

Manner of Occurence of Groundwater in Rhodesia Diagram 4.10

M.O.W.D. HYDRO SK 385/7

TABLE 4.10.1 DEPTH X YIELD ANALYSIS

CLASS III, MAR/ES 7,M											
SUB-REGION	LOCATION	AREA KM^2	NO. OF B/H's		RATE OF SUCCESS %						
			TOTAL	ANALYSED	+ = 1 500 l/h		+5 000 l/h		+15 000 l/h	
					O	P	O	P	O	P
D	Wankie G.R. (Gwaai Area), Sanyati T.T.L.	316	229	142	64	81	13	25	0	0
TOTAL: 1	TOTAL AREA COVERED (KM^2) (APPROX).	316	229	142	Mean 64	81	13	25	0	0

4.10 Class III (Sands and Sandstone) MAR/ES Region 7,M.

4.10.1 Introduction

As shown in Diagram 4.10, there are five sub-regions with a total of 331 boreholes. Only one of these, D (Gwaai area) has enough boreholes, and these are scattered over an area of 316 km^2. The sub-region has 229 boreholes, 142 of which have been analysed. The rest are more than 68,6 m. deep and it is intended, in view of the low success figures obtained in region 7,0, to evaluate the degree of success, if any, these have achieved.

4.10.2 Depth x Yield Distribution and Analysis

The figures displayed in Table 3.7.1 differ little from those in 7,0. The observed percentages are higher in region 7,M for the first two yield classes, but there is no clear pattern for the potential rates, and in any case differences are small.

It was noted earlier on that the numbers of boreholes exceeding 15 000 l/h for this lithological Class were insignificant. The same applies in region 7,M where none of the boreholes analysed attained a yield better than this figure. In the + 5 000 l/h yield class, the observed figures in regions 7,0 and 7,M are only 12 and 13% respectively.

These figures were, of course, based only on boreholes drilled to a depth of between 61 and 68,6 metres. Table 3.7.2 shows the depth/yield distribution down to this level. As in previous cases most of the observed boreholes attained the various yields within the 30,5 and 61 m depth range.

Table 4.10.2 Lithological Class III, MAR/ES Region 7,M.

Depth x Yield Distribution

DEPTH INTERVAL (M)	YIELD CLASS					
	± 1 500 l/h		+ 5 000 l/h		+15 000 l/h	
	No.of B/H'S	% of Total	No.	%	No.	%
0 - 7,6	0	0	0	0	0	0
7,6 - 15,2	0	0	0	0	0	0
15,2 - 22,9	1	1,1	0	0	0	0
22,9 - 30,3	8	8,8	1	1,1	0	0
30,5 - 38,1	16	17,6	3	3,3	0	0
38,1 - 45,7	16	17,6	4	4,4	0	0
45,7 - 53,4	13	14,3	2	2,2	0	0
53,4 - 61,0	27	29,7	6	6,6	0	0
61,0 - 68,6	10	11,0	2	2,2	0	0

No. of Boreholes Yielding ± 1 500 l/h (Those analysed only) in Region = 91
These as Percentage of Total Commenced (142) = 64%

The investigation of the proportion of boreholes drilled to greater depths and attaining the specified yield resulted from the fact that sands and sandstones were not yielding higher quantities at shallower levels. These rocks are usually high permeable and porous and would therefore be expected to produce higher yields. There was a possibility that high yields would be attained at greater depths. The distribution results are illustrated on Table 4.10.3.

Of the 87 boreholes which exceeded 68,6 m, 46, representing 53% of the total, attained yields of 1 500 l/h or better. A point of interest is that one borehole which was drilled to a depth of 230 m. produced only 900 l/h. In order to determine whether or not the optimum depth range for Class III rocks is greater(ie.at deeper levels) than that in other rocks (and so determine whether or not Table 4.10.2 is misleading), the following Table was compiled. It shows the numbers of the boreholes which equalled or exceeded 1 500 l/h in the Class by depth interval.

Table 4.10.3. Class 1, M&R/ES Region 7,M.

Extended Depth x Yield Distribution.

DEPTH INTERVAL (M)	YIELD CLASS					
	± 1 500 l/h		+ 5 000 l/h		+ 15 000 l/h	
	No.of B/H's	% of Total	No.	%	No.	%
0 - 7,6	0	0	0	0	0	0
7,6 - 15,2	0	0	0	0	0	0
15,2 - 22,9	1	0,7	0	0	0	0
22,9 - 30,5	7	5,1	1	0,7	0	0
30,5 - 38,1	13	9,5	3	2,2	0	0
38,1 - 45,7	12	8,8	4	2,9	0	0
45,7 - 53,4	11	8,0	2	1,5	0	0
53,4 - 61,0	21	15,3	6	4,4	0	0
61,0 - 68,6	8	5,8	2	1,5	0	0
68,6 - 76,2	14	10,2	3	2,2	0	0
76,2 - 83,8	8	3,8	1	0,7	0	0
83,8 - 91,4	6	4,4	0	0	0	0
91,4 - 99,1	5	3,6	2	1,5	0	0
99,1 - 106,7	3	2,2	0	0	0	0
106,7 - 114,3	1	0,7	0	0	0	0
114,3 - 121,9	1	0,7	0	0	0	0
121,9 - 129,5	2	1,5	1	0,7	0	0
129,5 - 137,2	1	0,7	0	0	0	0
137,2 - 144,8	1	0,7	1	0,7	0	0
144,8 - 152,4	3	2,2	1	0,7	1	0,7
152,4 - 160,0	1	0,7	0	0	0	0
No. of Boreholes Yielding ± 1 500 l/h in Region					=	137
These as Percentage of Total in Sub-Region (229)					=	60%

It is clear that there is no direct relationship between depth and yield. In the low yield class, the lower depth limit does not lie between 61 and 68,6 metres, but between 76 and 83,8 m. However, a general decline in numbers of boreholes is noted beyond 106,7 metres. Most holes are between 53,4 and 76,2 m. deep.

The majority of those boreholes which yielded more than 5 000 l/h lie between 30,5 and 99,1 m. It must nevertheless be noted that good yields have been obtained in comparatively recently drilled boreholes in some areas.

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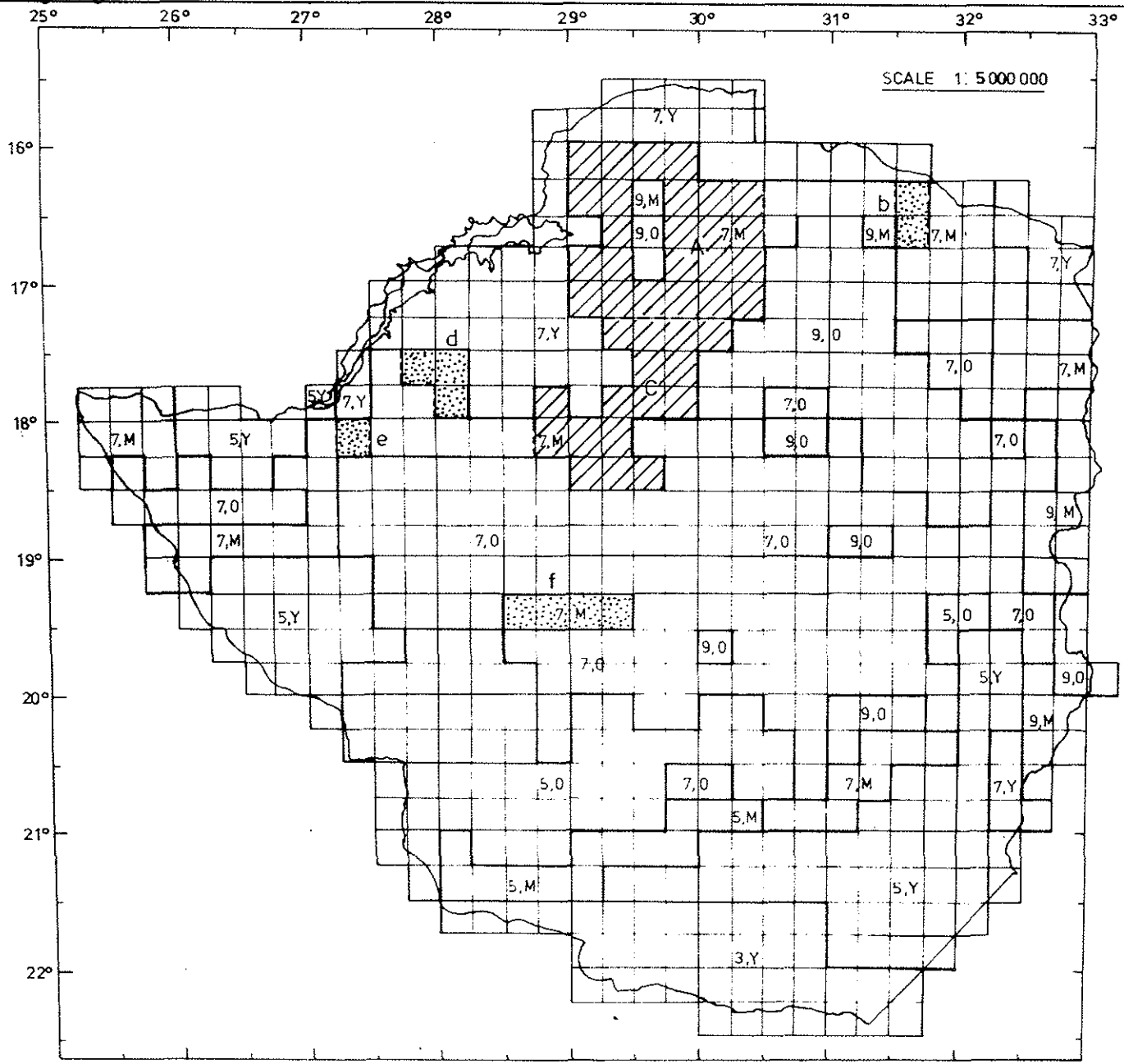

NOTES

CLASS V MAR/ES REGION 7,M SUB-REGIONS

Mean Annual Rainfall (mm)	Erosion Surfaces: Post African and Older (0)	Mixed O and Y (M)	Pliocene and Younger (Y)
Over 800 = 9	9,0	9,M	-
500 - 800 = 7	7,0	7,M	7,Y
400 - 600 = 5	5,0	5,M	5,Y
Under 400 = 3	-	-	3,Y

Constructed from Diagrams 1 and 2

(N.B. Those sub-regions for which a depth x yield analysis has been made are shaded.)

Combined Mean Annual Rainfall And Erosion Surfaces (MAR/ES)

P 43

TABLE 4.11.1 DEPTH X YIELD ANALYSIS.

CLASS V, MAR/ES 7,M					RATES OF SUCCESS %					
SUB-REGION	LOCATION	AREA KM^2	NO. OF B/H's		± 1 500 l/h		+5 000 l/h		+15 000 l/h	
			TOTAL	ANALYSED	O	P	O	P	O	P
A	Doma, Angwa N; etc. I.C.A's	176	273	212	69	90	34	65	13	37
C	Angwa S; etc. I.C.A's. Sanyati T.T.L.	118	225	178	67	88	28	57	14	35
TOTAL: 2	TOTAL AREA COVERED (KM^2) (APPROX.)	294	498	390	Mean 68	89	31	61	14	36

4.11 Class V (Mid-PreCambrian Rocks) MAR/ES Region 7,M.

4.11.1 Introduction

This Class, which has not been encountered in earlier sections, consists of a number of rocks, mainly the argillaceous types, dolomite and limestone, shales and quartzites and orthoquartzites of the Lomagundi and Umkondo systems (see p. 2 for details).

Diagram 4.11 shows that this Class has six sub-regions in MAR/ES Region 7,M. Two of these, A and C, comprising mainly of the Doma and Angwa I.C.M's, extend over an area of 294 km^2 and contain some 498 boreholes, 390 of which have been investigated.

4.11.2 Depth x Yield Distribution and Analysis.

Table 4.11.1 shows that 68% of the boreholes drilled had yields of 1 500 l/h or better. The observed figures are higher than those for Class I rocks and exceed those for Class III rocks in the same region. The table below shows that the mean observed and potential figures for Mid-PreCambrian rocks compare with those for granitic rocks in region 9,0 with its higher mean annual rainfall.

Yield Class Rates of Success (Observed/Potential)%		± 1 500 l/h		+ 5 000 l/h		+ 15 000 l/h	
		O	P	O	P	O	P
MAR/ES	9,0 (I)	60	90	25	59	3	12
	7,M (V)	68	89	31	61	14	36

In fact, the figures for Class V region 7,M are on the whole better than those for region 9,0, and are second only to those of the Early PreCambrian rocks in region 9,0. The impression given is that Class V rocks constitute fairly good aquifers.

It is desirable to note if there is any difference in the depths to which most of the observed boreholes were drilled. Previous investigation has so far shown that the optimum depth range is much the same in most rocks, with the exception of sands and sandstones. Table 4.11.2 gives the depth/yield distribution.

Table 4.11.2 Lithological Class V. MAR/ES Region 7,M.

Depth x Yield Distribution

DEPTH INTERVAL (M)	YIELD CLASS ± 1 5000 l/h		+5 000 l/h		+15 000 l/h	
	No. of B/Hs	% of Total	No.	%	No.	%
0 - 7,6	0	0	0	0	0	0
7,6 - 15,2	1	0,4	1	0,4	0	0
15,2 - 22,9	4	1,5	0	0	0	0
22,9 - 30,5	14	5,3	3	1,1	1	0,4
30,5 - 38,1	23	8,6	6	2,3	0	0
38,1 - 45,7	36	13,5	17	6,4	5	1,9
45,7 - 53,4	91	34,2	43	16,2	18	6,8
53,4 - 61,0	64	24,1	32	12,0	17	6,4
61,0 - 68,6	33	12,4	19	7,1	11	4,1
No. of Boreholes Yielding ± 1 500 l/h in Region (Those Analysed only) = 266						
These as Percentage of Total in Sub-Region (290) = 68%						

The upper limit for the first two yield classes is between 38,1 and 45,7 whilst that for the high yield class is between 45,7 and 53,4 m. The overall decline in the numbers of boreholes beyond 61,0 is not very pronounced, especially in the higher yield classes. This, together with the fact that in limestone and dolomite for example, water is often able to percolate to great depths, indicates that considerable yields may be obtained in particular locations if wells are drilled beyond 68,6 m. However, it is known that these formations have low permeabilities. Water could only percolate along solution channels. Boreholes would have to penetrate such cavernous rocks below the general water level of the area to produce large amounts of water.

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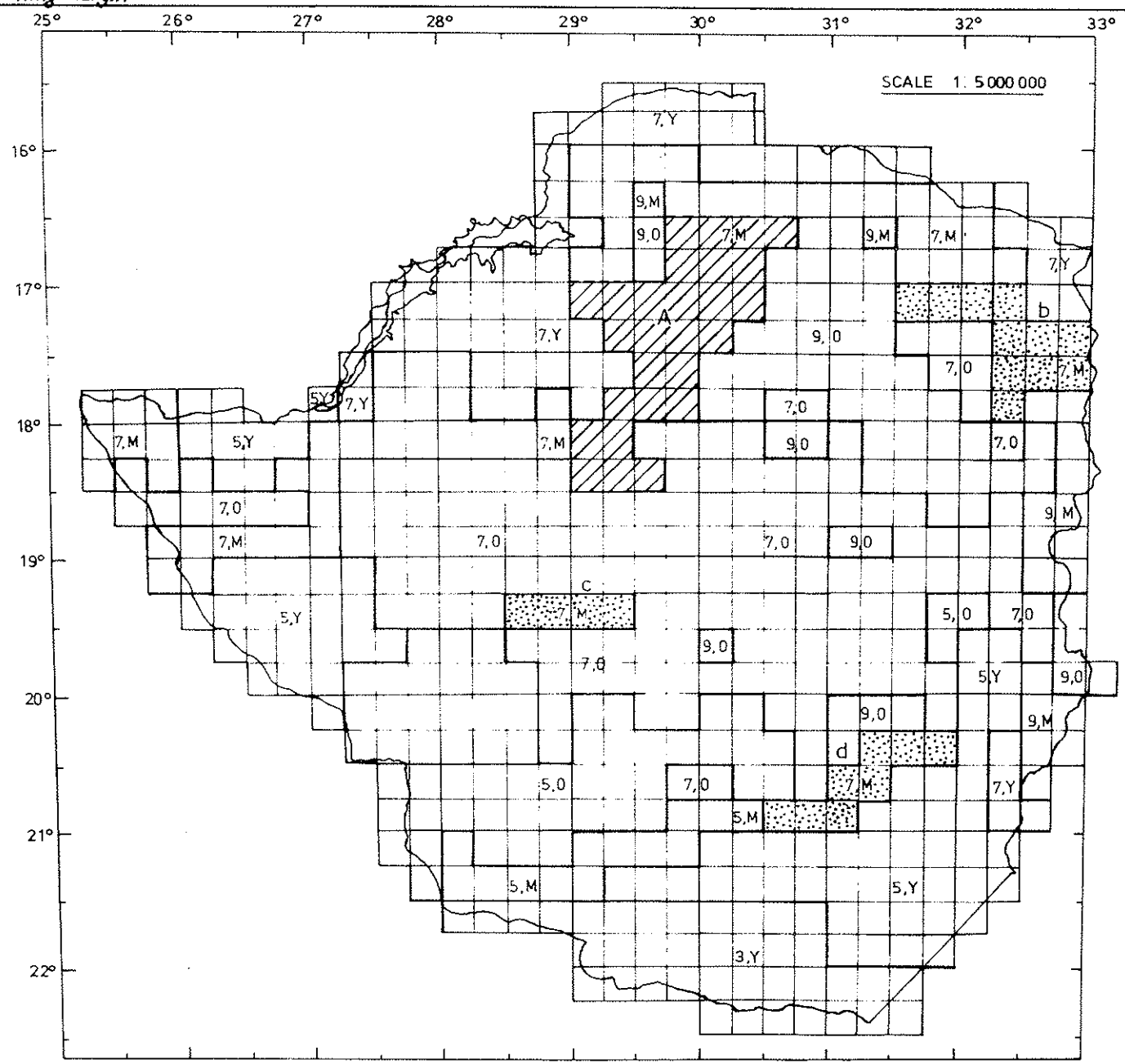

NOTES

CLASS VI MAR/ES REGION 7,M SUB-REGIONS

Mean Annual Rainfall (mm)	Erosion Surfaces: Post African and Older (0)	Mixed O and Y (M)	Pliocene and Younger (Y)
Over 800 = 9	9,0	9,M	-
600 - 800 = 7	7,0	7,M	7,Y
400 - 600 = 5	5,0	5,M	5,Y
Under 400 = 3	-	-	3,Y

Constructed from Diagrams 1 and 2

(N.B. Those sub-regions for which a depth x yield analysis has been made are shaded.)

Combined Mean Annual Rainfall And Erosion Surfaces (MAR/ES)	P 47

Manner of Occurence of Groundwater in Rhodesia

Diagram 4.12

M.O.W.D. HYDRO SK 385/9

TABLE 4.12.1 DEPTH X YIELD ANALYSIS

CLASS VI, MAR/ES 7,M					RATES OF SUCCESS %					
SUB-REGION	LOCATION	AREA KM^2	NO. OF B/H's		+ = 1 500 l/h		+5 000 l/h		+ 15 000 l/h	
			TOTAL	ANALYSED	O	P	O	P	O	P
A	Doma, Karoi, Angwa N & S; Eldorado-Maquadzi, Umsweswe I.C.A's. Sanyati T.T.L.	198	224	213	65	90	23	43	2	3
TOTAL: 1	TOTAL AREA COVERED (KM^2) (APPROX.)	198	224	213	Mean 65	90	23	43	2	3

4.12 Class VI. (Early PreCambrian Rocks). MAR/ES Region 7,M.

4.12.1 Introduction

Although there are four sub-regions in this Class in region 7,M, all widely separated, only one, A, has over 200 boreholes. (See Diagram 4.12). The sub-region covers some 198 km^2 and is mainly comprised of the Karoi, Angwa and Umsweswe I.C.A's. There are 224 boreholes, 213 of which constitute the sample for the analysis (Table 4.12.1).

4.12.2 Depth x Yield Distribution and Analysis.

It has been noted that in regions 9,0 and 7,0, Class VI rocks are better yielders than Class I rocks. This trend is not repeated in region 7,M, where the reverse is true.

Another point is that in region 7,M, the proportions of boreholes attaining 1 500 l/h or more in Class VI are lower than those in Class V rocks, indicating that, given the same conditions, the latter are better yielding.

Table 4.12.2 gives the depth x yield distribution for the observed boreholes.

Table 4.12.2 Lithological Class VI. MAR/ES Region 7,M

Depth x Yield Distribution

DEPTH INTERVAL (M)	YIELD CLASS					
	± 1 500 l/h		+5 000 l/h		+ 15 000 l/h	
	No.of B/Hs	% of Total	No.	%	No.	%
0 - 7,6	0	0	0	0	0	0
7,6 - 15,2	0	0	0	0	0	0
15,2 - 22,9	1	0,7	1	0,7	1	0,7
22,9 - 30,5	10	7,1	4	2,9	1	0,7
30,5 - 38,1	36	25,7	11	7,9	1	0,7
38,1 - 43,7	35	25,0	13	9,3	1	0,7
45,7 - 53,4	32	22,9	12	8,6	1	0,7
53,4 - 61,0	15	10,7	6	4,3	0	0
61,0 - 68,6	11	7,9	2	1,4	0	0
No. of Boreholes Yielding ± 1 500 l/h (Those Analysed only) in Region = 140 These as Percentage of Total Commenced (213) = 66%						

The depth range is similar to that of boreholes in other classes and regions. There is one borehole in each interval from 15,2 to 53,4m. in the high yield class, and there is a decline in all yield classes between 53,4 and 61,0 m. which decline is characteristic of this rock type in the other regions so far examined.

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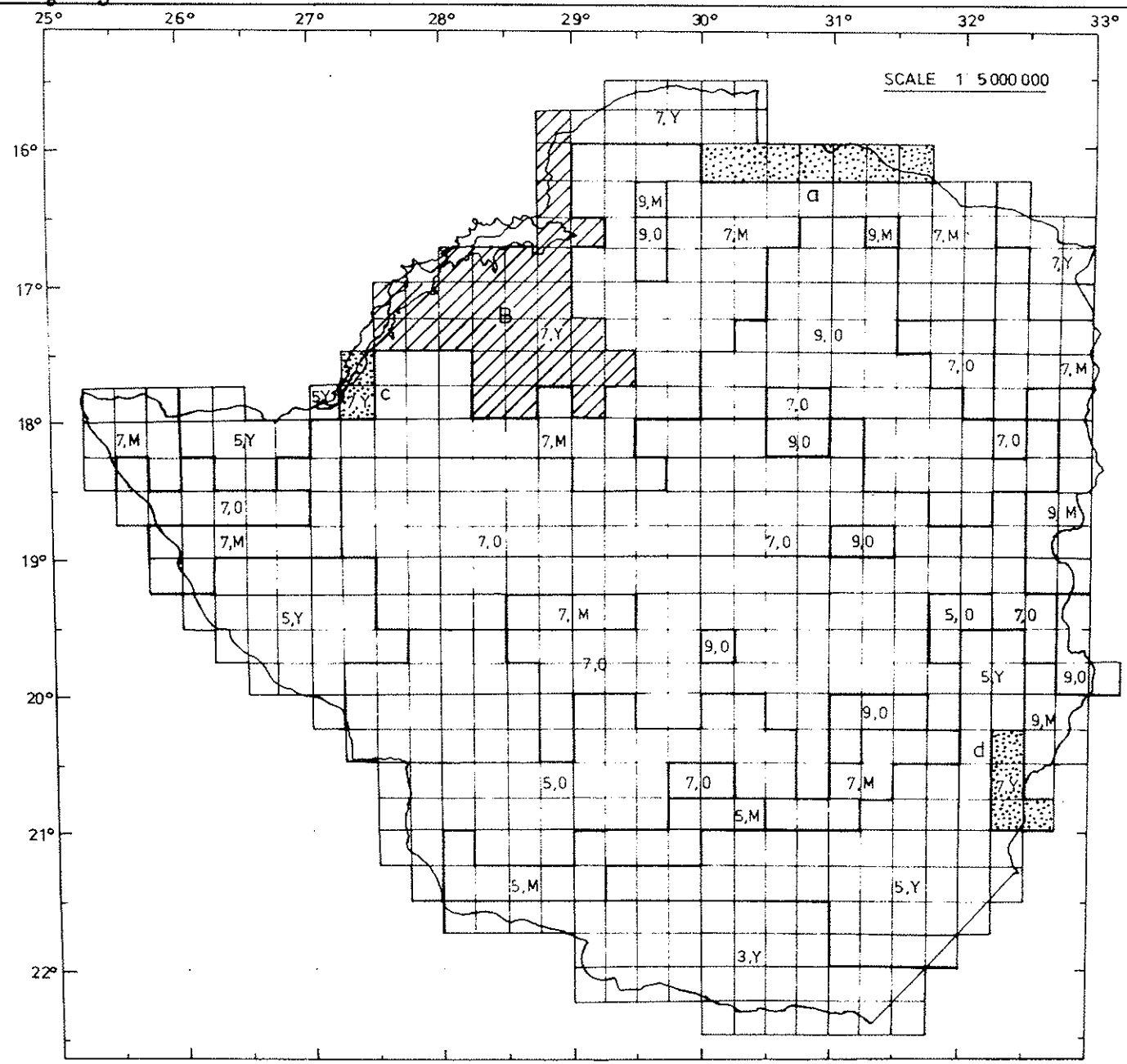

NOTES

CLASS III MAR/ES REGION 7,Y SUB-REGIONS

Mean Annual Rainfall (mm)	Erosion Surfaces: Post African and Older	Mixed O and Y	Pliocene and Younger
	O	M	Y
Over 800 = 9	9,0	9,M	-
600 - 800 = 7	7,0	7,M	7,Y
400 - 600 = 5	5,0	5,M	5,Y
Under 400 = 3	-	-	3,Y

Constructed from Diagrams 1 and 2

(N.B. Those sub-regions for which a depth × yield analysis has been made are shaded.)

Combined Mean Annual Rainfall And Erosion Surfaces (MAR/ES)	SD

Manner of Occurence of Groundwater in Rhodesia Diagram 4.13

M.O.W.D. HYDRO SK 385/10

TABLE 4.13.1 DEPTH X YIELD ANALYSIS.

CLASS III, MAR/ES 7,Y					RATES OF SUCCESS %					
SUB-REGION	LOCATION	AREA KM^2	NO. OF B/HOLES		+ = 1 500 l/h		+ 5 000 l/h		+15 000 l/h	
			TOTAL	ANALYSED	O	P	O	P	O	P
B	Sebungwe, Gokwe T.T.L's	221	190	134	75	85	25	42	0	0
TOTAL: 1	TOTAL AREA COVERED (KM^2) (APPROX.)	221	190	134	Mean 75	85	25	42	0	0

4.13 Class III. (Sands and Sandstone). MAR/ES Region, 7,Y.

4.13.1 Introduction.

MAR/ES Region 7,Y consists of one main section stretching East-West along the Northern border, and two minor areas, one in the extreme North-east part of the country and the other in the South-east. Erosion surface region 7,Y is relatively young, consisting of surfaces of Pliocene and younger age.

The region has boreholes in all Classes, but only in Class III are there enough listed to warrant study. This Class has four sub-regions and of these, only B has been examined. Although it has only 190 boreholes (134 analysed) scattered over an area of 221 km^2 (see relevant map and table), it has been studied because it is the only sample available for this region.

4.13.2 Depth x Yield Distribution and Analysis

Since only one sub-region in one Class has been analysed, and it has a relatively low number of boreholes, the reliability of the analysis cannot be clearly established.

Table 4.13.1 shows that the observed and potential figures are fairly high in the low yield class but low in the next class, although in both classes they are higher than those for the same lithological Class in region 7,M and 7,0. No boreholes exceeded 15 000 l/h.

The following table gives the depth/yield distribution for boreholes down to 68,6 m and can be compared with Table 4.10.2.

Table 4.13.2 Lithological Class III MAR/ES Region 7,M.

Depth x Yield Distribution

DEPTH INTERVAL (M)	YIELD CLASS					
	± 1 500 l/h		+ 5 000 l/h		+ 15 000 l/h	
	No. of B/Hs	% of Total	No.	%	No.	%
0 - 7,6	0	0	0	0	0	0
7,6 - 15,2	0	0	0	0	0	0
15,2 - 22,9	2	2,0	1	1,0	0	0
22,9 - 30,5	8	8,0	2	2,0	0	0
30,5 - 38,1	17	17,0	9	9,0	0	0
38,1 - 45,7	22	22,0	5	5,0	0	0
45,7 - 53,4	22	22,0	8	8,0	0	0
53,4 - 61,0	17	17,0	5	5,0	0	0
61,0 - 68,6	12	12,0	4	4,0	0	0
No. of Boreholes Yielding ± 1 500 l/h in Region (Those analysed only) = 100						
These as Percentage of Total in Sub-Region (134) = 75%						

The optimum depth range for the two yield classes is similar to that in region 7,0, i.e. 30,5 to 61,0 m. The proportion of observed boreholes in these yield classes to the total commenced is better in 7,Y (75%) than in 7,M (64%), but the significance of this difference is not clear.

In order to ascertain whether or not the depth/yield pattern produced in these rocks in region 7,M is characteristic, the distribution of boreholes more than 68,6 m. deep in region 7,Y was examined and the following is a summary of the results. Out of the 56 boreholes:-

(i) 29 failed to attain 1 500 l/h
(ii) 23 produced between 1 500 and 5 000 l/h
(iii) Four bettered 5 000 l/h
(iv) None attained a yield better than 15 000 l/h.

The results show a a pattern similar to that displayed by these rocks in MAR/ES region 7,M.

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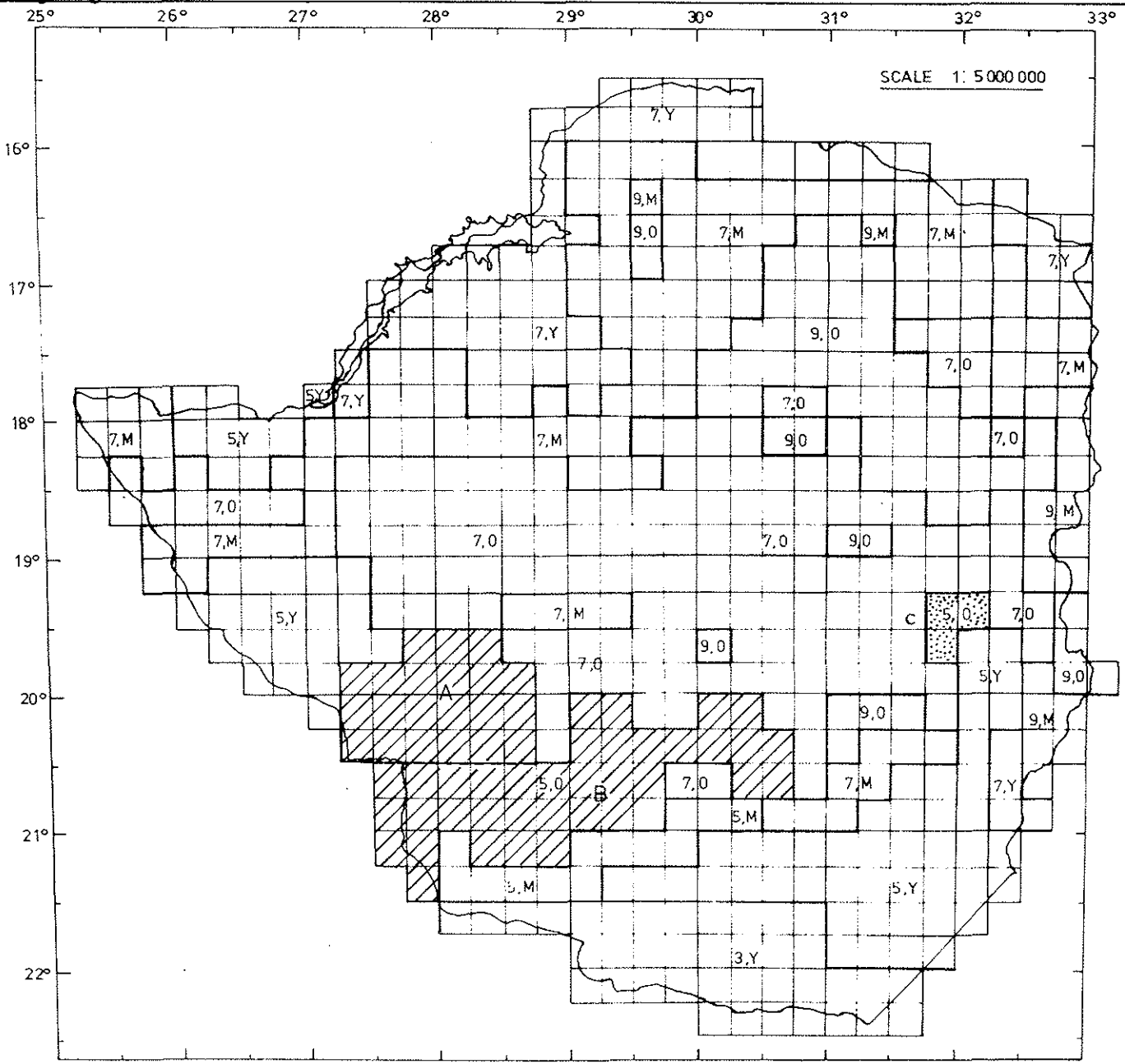

NOTES

CLASS I MAR/ES REGION 5,0 SUB-REGIONS

Mean Annual Rainfall (mm)	Erosion Surfaces: Post African and Older (O)	Mixed O and Y (M)	Pliocene and Younger (Y)
Over 800 = 9	9,0	9,M	-
600 - 800 = 7	7,0	7,M	7,Y
400 - 600 = 5	5,0	5,M	5,Y
Under 400 = 3	-	-	3,Y

Constructed from Diagrams 1 and 2

(N.B. Those sub-regions for which a depth × yield analysis has been made are shaded.)

Combined Mean Annual Rainfall And Erosion Surfaces (MAR/ES)	Fig. 5

Manner of Occurence of Groundwater in Rhodesia Diagram 4.14

M.O.W.D. HYDRO SK 385/11

TABLE 4.14.1 DEPTH X YIELD ANALYSIS

CLASS I, MAR/ES 5,0					RATES OF SUCCESS %					
SUB-REGION	LOCATION	AREA KM^2	NO. OF B/H'S		± 1 500 l/h		+ 5 000 l/h		+ 15 000 l/h	
			TOTAL	ANALYSED	O	P	O	P	O	P
A	Nyamandhlovu/Umgusa, Khami L & U; Inyati, Figtree, Matopos N. I.C.A's. Nata, Maitengwe T.T.L's. Samenani A.P.A.	154	324	295	39	69	11	22	0	1
B	Gwanda, Matopos S; Umshandige I.C.A's. Insiza A.P.A./T.T.L., Raditladi, Mphoengs, Shashani etc. T.T.L's.	272	287	275	34	60	11	29	1	4
TOTAL: 2	TOTAL AREA COVERED (KM^2) (APPROX.)	426	611	570	Mean 37	65	11	26	1	3

4.14 Class I. (Granitic Rocks). MAR/ES Region 5.0.

4.14.1 Introduction

The main portion of region 5,0 lies in the South-western part of the country and a smaller part is to the East of it. The Erosion surfaces are Post African and older and the mean annual rainfall is between 400 and 600 mm.

There are boreholes in all Classes except Class IV. Class I has three sub-regions and two, A and B, have been investigated. These consist of the Nyamandhlovu, Gwanda, Matopos and other I.C.A's. (See Table 4.14.1). They cover an area of some 426 km^2 and contain 611 boreholes, of which 570 have been analysed.

4.14.2 Depth x Yield Distribution and Analysis

Table 4.14.1 shows that the percentages of boreholes giving the specified yields in this Class in region 5,0 are comparatively low. Nevertheless, there are boreholes in all the yield classes.

A study of the depth/yield distribution as given in Table 4.14.2 shows that most of the boreholes lie between 22,9 and 53,4 m. which range is similar to that for most rocks in the various regions.

Table 4.14.2 Lithological Class I. MAR/ES Region 5.0

Depth x Yield Distribution

DEPTH INTERVAL	YIELD CLASS					
	± 1 500 l/h		+ 5 000 l/h		+ 15 000 l/h	
	No. of B/Hs	% of Total	No.	%	No.	%
0 - 7,6	0	0	0	0	0	0
7,6 - 15,2	0	0	0	0	0	0
15,2 - 22,6	8	3,8	2	1,0	0	0
22,9 - 30,5	41	19,7	16	7,7	0	0
30,5 - 38,1	64	30,8	16	7,7	1	0,5
38,1 - 45,7	45	21,6	13	6,3	2	1,0
45,7 - 53,5	31	14,9	7	3,4	0	0
53,4 - 61,0	13	6,3	7	3,4	1	0,5
61,0 - 68,6	6	2,9	1	0,5	0	0
No. of Boreholes Yielding ± 1 500 l/h in Region (or sub-region) = 208						
These as Percentage of Total in Sub-Region (570) = 36%						

A point to note is that the percentage of the observed boreholes to the total number commenced is low (36%); most of the boreholes drilled were either completely dry or failed to strike sufficient water. This is confirmed on maps of boreholes drilled in the area. (See work in the Nyamandhlovu area). An unusual feature revealed on such maps is that in some cases, boreholes giving fairly high yields were sited quite near dry boreholes.

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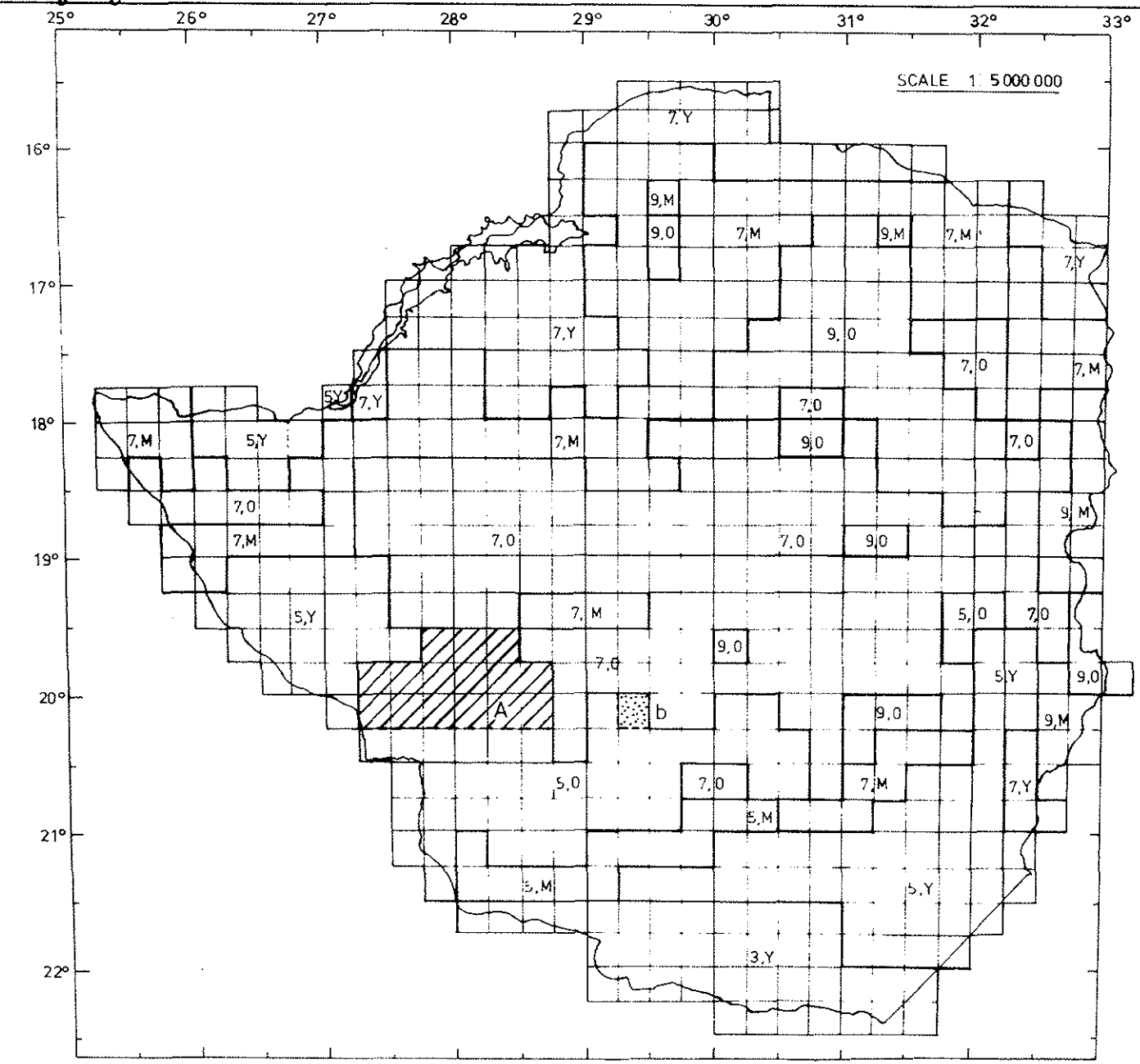

NOTES

CLASS III MAR/ES REGION 5,0 SUB-REGIONS

Mean Annual Rainfall (mm)	Erosion Surfaces: Post African and Older 0	Mixed 0 and Y M	Pliocene and Younger Y
Over 800 = 9	9,0	9,M	-
600 - 800 = 7	7,0	7,M	7,Y
400 - 600 = 5	5,0	5,M	5,Y
Under 400 = 3	-	-	3,Y

Constructed from Diagrams 1 and 2

(N.B. Those sub-regions for which a depth × yield analysis has been made are shaded.)

Combined Mean Annual Rainfall And Erosion Surfaces (MAR/ES)	D 57

Manner of Occurence of Groundwater in Rhodesia — Diagram 4.15

M.O.W.D. HYDRO SK 385/12

TABLE 4.15.1 DEPTH X YIELD ANALYSIS.

CLASS III,	MAR/ES 5,0				RATES OF SUCCESS %					
SUB-REGION	LOCATION	AREA KM^2	NO. OF B/H's		+ = 1 500 l/s		+ 5 000 l/h		+ 15 000 l/h	
			TOTAL	ANALYSED	O	P	O	P	O	P
A	Khami L. & U; Nyamandhlovu/Umgusa, Umgusa U; I.C.'s. Maitengwe, Nata, Gwaai T.T.L's/APA	110	218	156	55	80	10	23	2	5
TOTAL: 1	TOTAL AREA COVERED (KM^2) (APPROX.)	110	218	156	Mean 55	80	10	23	2	5

4.15 Class III. (Sands and Sandstone). MAR/ES Region 5.0.

4.15.1 Introduction

There are only two sub-regions in this Class and only A is considered. It contains 218 boreholes, 156 of which have been analysed. The sub-region covers an area of 110 km^2 and is comprised of a number of I.C.A's (notably Nyamandhlovu and Umgusa) and nearby T.T.L's. Diagram 4.15. and the related Table give the relevant information on the sub-region.

4.15.2 Depth x Yield Distribution and Analysis

Table 4.15.1 shows that 55% of the analysed boreholes attained yields of 1 500 l/h or more. According to the analytical sheets, this figure could be raised to 80% if the boreholes which failed to attain 1 500 l/h were deepened until they did.

The corresponding figures in the next yield class are 10 and 23% whilst those for the + 15 000 l/h yield class are 2 and 5%. These compare favourably with those for Class I rocks. Previous observations in the MAR/ES regions with higher rainfall showed that granitic rocks gave better results than sands and sandstone, but this is not repeated in MAR/ES 5,0.

An examination of the depth/yield distribution reveals a pattern similar to that for these rocks in other regions (See Table 4.15.2). In the high yield class the three boreholes are between 45,7 and 61,0 m. deep.

Table 5.15.2 Lithological Class III, MAR/ES Region 5.0

Depth x Yield Distribution.

DEPTH INTERVAL (M)	YIELD CLASS					
	± 1 500 l/h		+ 5 000 l/h		+ 15 000 l/h	
	No. of B/Hs	% of Total	No.	%	No.	%
0 - 7,6	0	0	0	0	0	0
7,6 - 15,2	0	0	0	0	0	0
15,2 - 22,9	1	1,2	0	0	0	0
22,9 - 30,5	10	11,6	2	2,3	0	0
30,5 - 38,1	14	16,3	1	1,2	0	0
38,1 - 45,7	16	18,6	1	1,2	0	0
45,7 - 53,4	23	25,6	4	4,7	1	1,2
53,4 - 61,0	19	19,8	8	9,3	2	2,3
61,0 - 68,6	6	7,0	0	0	0	0
No. of Boreholes Yielding ± 1 500 l/h (Those Analysed only) = 86						
These as Percentage of Total Commenced (158) = 55%						

A point to note is the low number of boreholes in the high yield class. A comparison of this and three other tables shows that only in regions 7,0 and 5,0 are there boreholes which have yields greater than 15 000 l/h.

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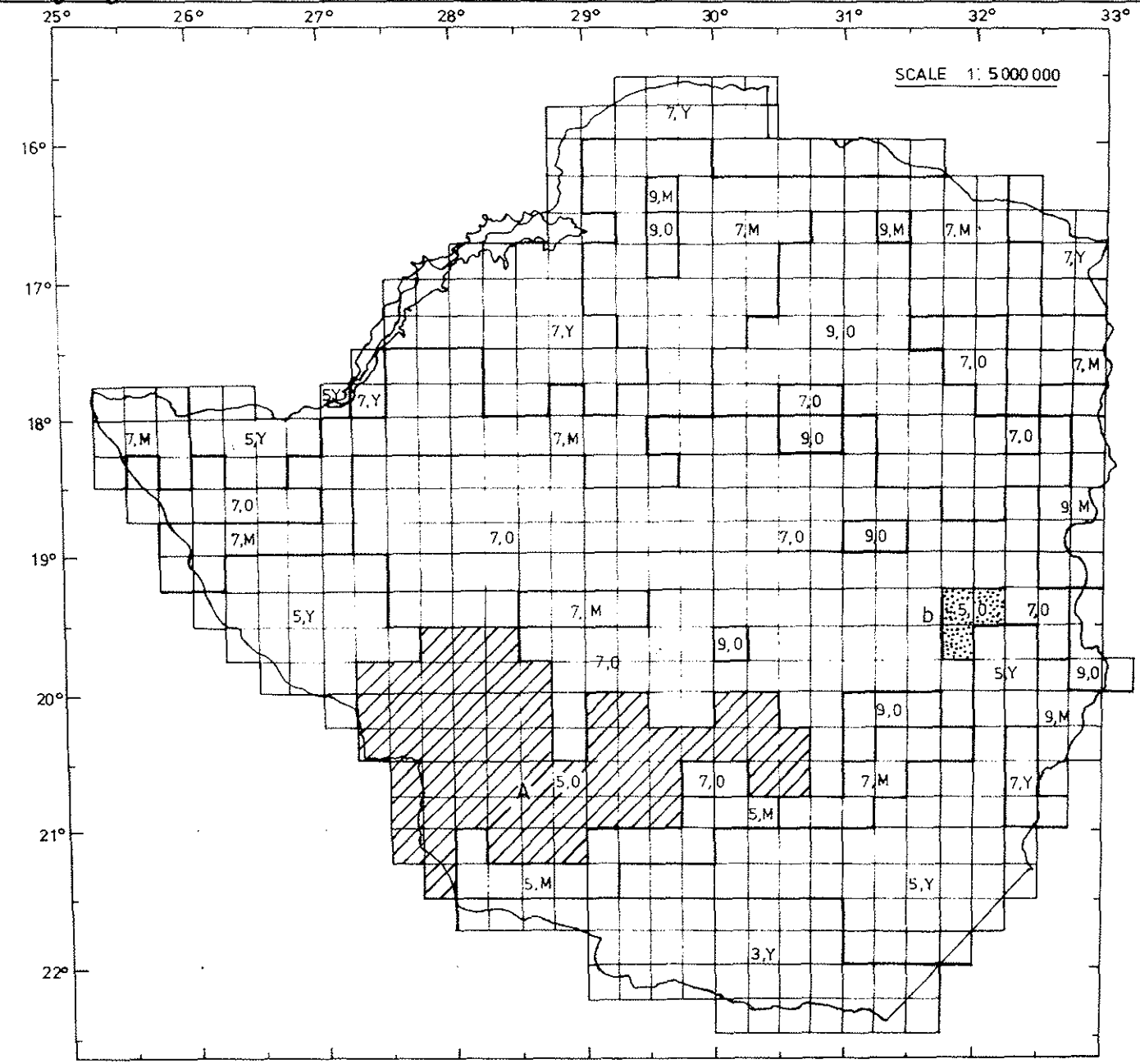

NOTES

CLASS VI MAR/ES REGION 5,0 SUB-REGIONS

Mean Annual Rainfall (mm)	Erosion Surfaces: Post African and Older (0)	Mixed O and Y (M)	Pliocene and Younger (Y)
Over 800 = 9	9,0	9,M	-
600 - 800 = 7	7,0	7,M	7,Y
400 - 600 = 5	5,0	5,M	5,Y
Under 400 = 3	-	-	3,Y

Constructed from Diagrams 1 and 2

(N.B. Those sub-regions for which a depth × yield analysis has been made are shaded.)

Combined Mean Annual Rainfall And Erosion Surfaces (MAR/ES)	p 60

TABLE 4.16.1 DEPTH X YIELD ANALYSIS

CLASS VI, M/R/ES 5,0					RATES OF SUCCESS %					
SUB-REGION	LOCATION	AREA KM^2	NO. OF B/H's		+ = 1 500 l/h		+ 5 000 l/h		+ 15 000 l/h	
			TOTAL	ANALYSED	O	P	O	P	O	P
A	Nyamandhlovu/Umgusa U; Khami U; Figtree, Matopos N & S; Umshandige etc. I.C.A's Semokwe etc. T.T.L's	426	258	230	64	93	34	66	5	24
TOTAL: 1	TOTAL AREA COVERED (KM^2) (APPROX.)	426	258	230	Mean 64	93	34	66	5	24

4.16 Class VI. (Early PreCambrian Rocks). MAR/ES Region 5,0.

4.16.1 Introduction

This class of rocks is found in parts of the Nyamandhlovu/Umgusa, Matopos and other I.C.A's and T.T.L's in the western part of the country. As shown on Diagram 4.16. and Table 4.16.1, there are two sub-regions but only the larger one, A, covering an area of approximately 426 km^2 and containing 258 boreholes (230 analysed) has been investigated.

4.16.2 Depth x Yield Distribution and Analysis.

As illustrated in the table below, Class VI rocks, under the same rainfall and erosion/surface conditions, give comparatively better yields than other rocks. The figures given here represent the observed results for boreholes in the three yield classes for three types of rocks in region 5,0.

Table 4.16.2. Ratios for Boreholes attaining Various Yields for Three Rock Types in Region 5,0.

LITHOLOGICAL CLASS	YIELD CLASS		
	± 1 500 l/h	+ 5 000 l/h	+ 15 000 l/h
I	37%	11%	1%
III	55%	10%	2%
VI	64%	34%	5%

The pattern shown above is similar to that found in the higher rainfall regions 9,0, 7,0, 7,M and 7,Y.

Table 4.16.3. Lithological Class VI. MAR/ES Region 5,0

Depth x Yield Distribution

DEPTH INTERVAL (M)	YIELD CLASS					
	± 1 500 l/h		+ 5 000 l/h		+ 15 000 l/h	
	No.of B/Hs	% of Total	No.	%	No.	%
0 - 7,6	0	0	0	0	0	0
7,6 - 15,2	2	1,3	1	0,7	0	0
15,2 - 22,9	4	2,7	3	2,0	2	1,3
22,9 - 30,5	18	12,1	11	7,4	0	0
30,5 - 38,1	24	16,1	17	11,4	3	2,0
38,1 - 45,7	27	18,1	12	8,1	1	0,7
45,7 - 53,4	31	20,8	13	8,7	0	0
53,4 - 60,1	35	23,5	17	11,4	3	2,0
61,0 0 68,6	8	5,4	4	2,7	2	1,3
No. of Boreholes Yielding ± 1 500 l/h (Those Analysed only) = 149						
These as Percentage of Total Commenced (230) = 65%						

The depth range for most boreholes in the first two yield classes is from 22,9 to 61,0 m. whilst that for the high yield class is from around 15,2 m. to 68,6 m. These limits are quite similar to those for these rocks in the other MAR/ES regions.

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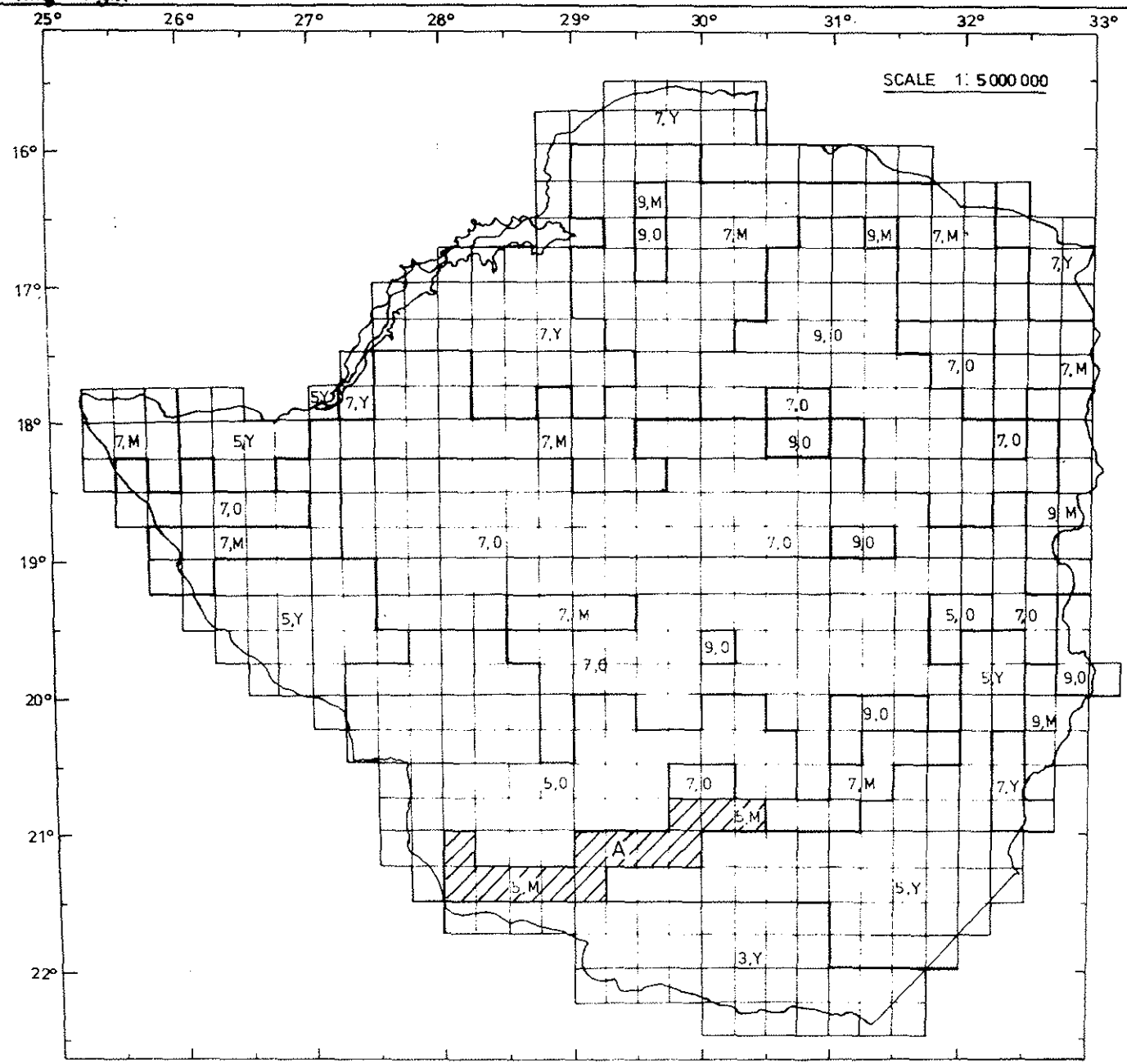

NOTES

CLASS I MAR/ES REGION 5,M SUB-REGIONS

Mean Annual Rainfall (mm)	Erosion Surfaces: Post African and Older (0)	Mixed O and Y (M)	Pliocene and Younger (Y)
Over 800 = 9	9,0	9,M	-
600 - 800 = 7	7,0	7,M	7,Y
400 - 600 = 5	5,0	5,M	5,Y
Under 400 = 3	-	-	3,Y

Constructed from Diagrams 1 and 2

(N.B. Those sub-regions for which a depth × yield analysis has been made are shaded.)

Combined Mean Annual Rainfall And Erosion Surfaces (MAR/ES)	Diagram 63

Manner of Occurence of Groundwater in Rhodesia — Diagram 4.17

M.O.W.D. HYDRO SK 385/14

TABLE 4.17.1 DEPTH X YIELD ANALYSIS

CLASS I, MAR/ES 5,M					RATES OF SUCCESS %					
SUB-REGION	LOCATION	AREA KM^2	NO. OF B/H's		+ = 1 500 l/h		+ 5 000 l/h		+ 15 000 l/h	
			TOTAL	ANALYSED	O	P	O	P	O	P
A	Gwanda I.C.A. Semokwe, Mombale, Prospect, Gwanda T.T.L/A.F.A; Belingwe T.T.L.'s	96	200	187	41	60	11	19	0	0
TOTAL: 1	TOTAL AREA COVERED (KM^2) (APPROX.)	96	200	187	Mean 41	60	11	19	0	0

4.17 Class I. (Granitic Rocks) MAR/ES 5.M.

4.17.1 Introduction

Region 5,M consists of a single narrow area in the south-western part of the country (Gwanda District). Its total area is only about 96 km^2, and it has not been split into sub-regions but treated as a whole. The designation of 'A' to the region on the diagram and tables is in anticipation of other sub-regions being added as more boreholes are drilled in the area.

There are some boreholes drilled in Classes I, V, VI and VII, but only in Class I was there an adequate number of boreholes listed to allow an analysis to be made. This class contains 200 boreholes, of which 187 have been analysed.

4.17.2 Depth x Yield Distribution and Analysis

Table 4.17.1 gives the results of the analysis. Of the 187 boreholes analysed, 41% attained yields of 1 500 l/h and higher and 11% yielded amounts greater than 5 000 l/h. No boreholes exceeded 15 000 l/h. The observed and potential figures are the lowest recorded for granitic rocks in all the MAR/ES regions.

An examination of the depth distribution reveals that the depth range for most of those boreholes which equalled or exceeded 1 500 l/h is between 22,9 and 53,4 m. The range is narrower in the higher yield class (22,9 to 45,7 m.)

Table 4.17.2 Lithological Class I. MAR/ES Region 5.M

Depth x Yield Distribution

DEPTH INTERVAL (M)	YIELD CLASS					
	± 1 500 l/h		+ 5 000 l/h		+ 15 000 l/h	
	No. of B/H's	% of Totals	O	P	O	P
0 - 7,6	0	0	0	0	0	0
7,6 - 15,2	1	1,3	1	1,3	0	0
15,2 - 22,9	10	13,2	3	3,9	0	0
22,9 - 30,5	18	23,7	4	5,3	0	0
30,5 - 38,1	19	25,0	6	7,9	0	0
38,1 - 45,7	14	18,4	5	6,6	0	0
45,7 - 53,4	12	15,8	0	0	0	0
53,4 - 61,0	2	2,6	1	1,3	0	0
61,0 - 68,6	0	0	0	0	0	0
No. of Boreholes Yielding ± 1 500 l/h (Those Analysed only) = 76						
These as Percentage of Total Commenced (187) = 41%						

One borehole which yielded over 5 000 l/h was drilled to a depth of 15,2 m,, a comparatively shallow level for most rocks. No holes exceeded 15 000 l/h and this includes the 13 which were drilled to depths greater than 68,6 m.

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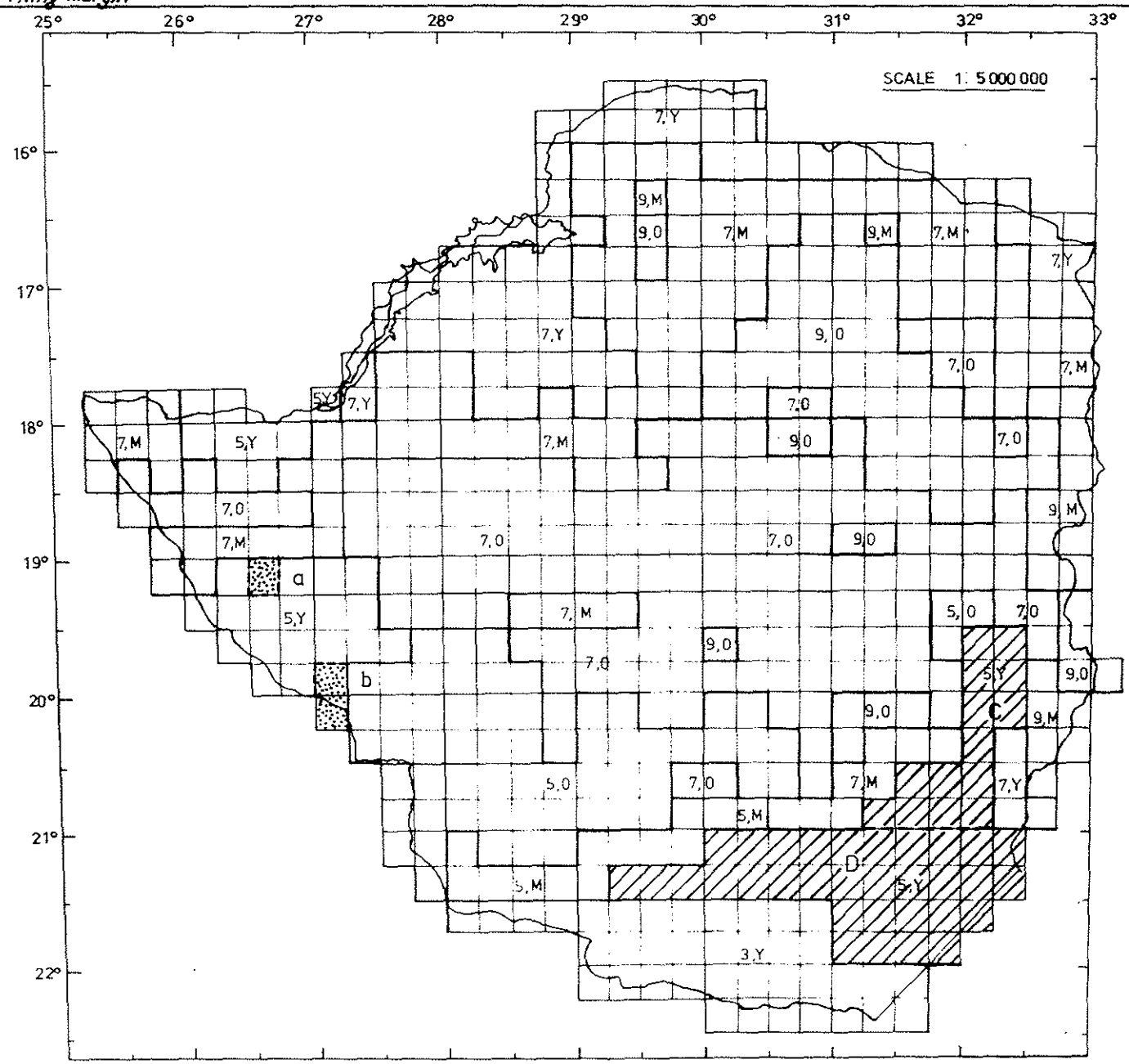


NOTES

CLASS I MAR/ES REGION 5,Y SUB-REGIONS

Mean Annual Rainfall (mm)	Erosion Surfaces: Post African and Older (0)	Mixed 0 and Y (M)	Pliocene and Younger (Y)
Over 800 = 9	9,0	9,M	-
600 - 800 = 7	7,0	7,M	7,Y
400 - 600 = 5	5,0	5,M	5,Y
Under 400 = 3	-	-	3,Y

Constructed from Diagrams 1 and 2

(N.B. Those sub-regions for which a depth × yield analysis has been made are shaded.)

Combined Mean Annual Rainfall And Erosion Surfaces (MAR/ES)	P 66

Manner of Occurence of Groundwater in Rhodesia Diagram 4.18

M.O.W.D. HYDRO SK 385/15

TABLE 4.18.1 DEPTH X YIELD ANALYSIS

CLASS I,	MAR/ES 5,Y				RATES OF SUCCESS %					
SUB-REGION	LOCATION	AREA KM^2	NO. OF B/H's		+ = 1 500 l/h		+ 5 000 l/h		+ 15 000 l/h	
			TOTAL	ANALYSED	O	P	O	P	O	P
C	Sabi Valley, Mid-Sabi etc. I.C.A's Ndanga T.T.L.	103	239	222	42	84	10	16	1	2
D	Chiredzi, Nuanetsi I.C.A's	235	231	168	33	65	11	22	2	2
TOTAL: 2	TOTAL AREA COVERED (KM^2) (APPROX.)	338	470	390	Mean 38	75	11	19	2	2

4.18 Class I. (Granitic Rocks) MAR/ES Region 5,Y.

4.18.1 Introduction

Region 5,Y consists of three separate areas. The main portion is in the South-east and the smaller ones are in the North-west. There are boreholes in all lithological classes, including "Class VIII". (Alluvium and Dwyka tillite) which is not included in the analysis. Only in Classes I and III were there enough boreholes listed to permit analysis.

Class I has four sub-regions but only C and D, which cover an area of about 338 km^2 and have 470 boreholes (390 analysed) are dealt with in this section.

4.18.2 Depth x Yield Distribution, and Analysis

Table 4.18.1 gives the relevant percentage figures for observed and potential yields. 38% of the boreholes analysed attained yields of 1 500 l/h or better whilst 11% bettered 5 000 l/h and 2% exceeded 15 000 l/h. The calculated potential success rates are 75, 19 and 2% for the three yield classes. These figures compare with those for Class I rocks in regions 5,0 and 5,M. For example the observed rates for the ± 1 500 l/h yield class are: 5,0 - 37%; 5,M - 41% and 5,Y - 38%.

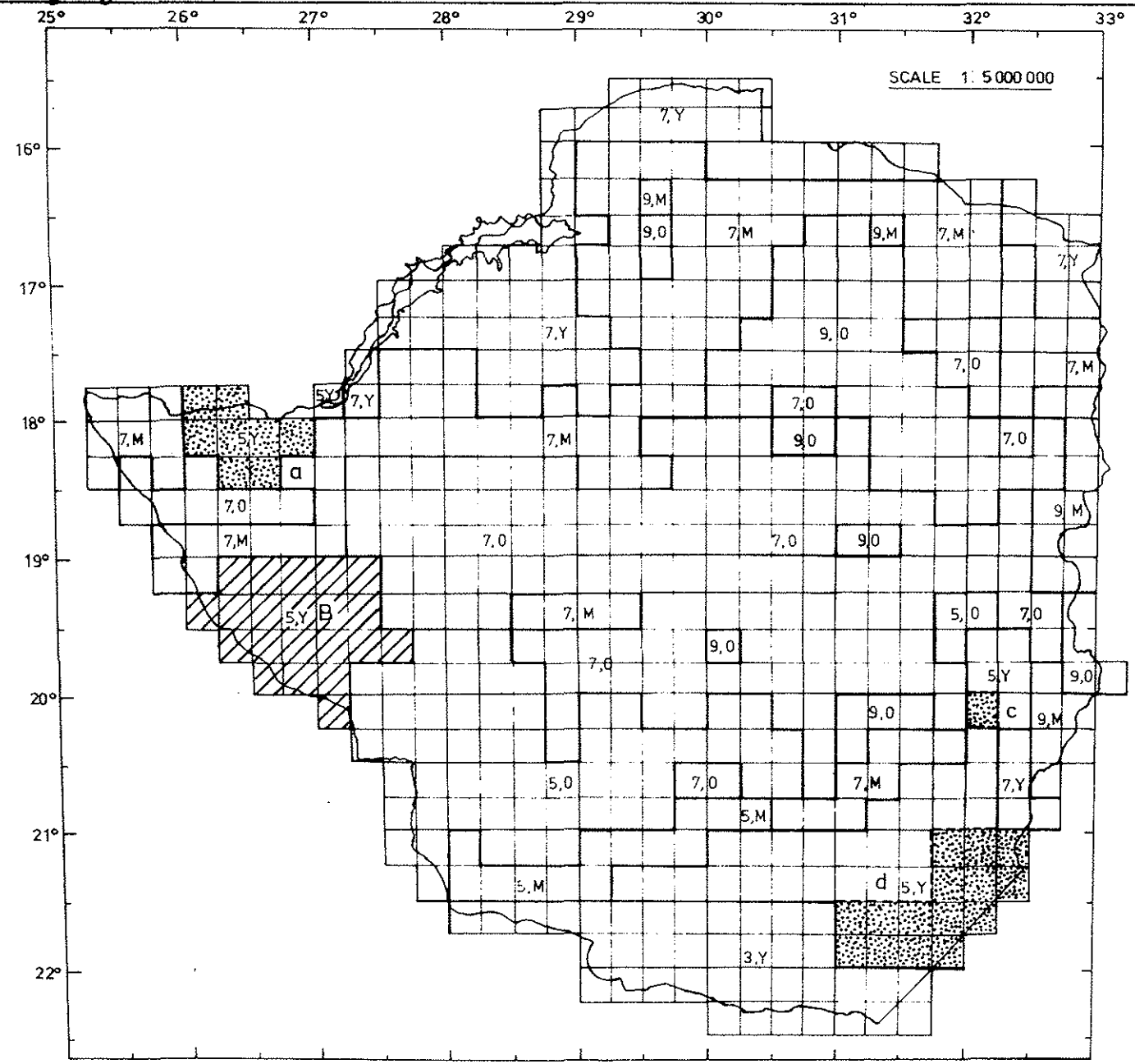
Table 4.18.2 shows that the depth range for most of the boreholes in the first yield class lie between 22,9 and 53,4 m, which is the range common in most other rock types in the various MAR/ES regions.

Table 4.18.2 Lithological Class I, MAR/ES Region 5,Y

Depth x Yield Distribution

DEPTH INTERVAL	YIELD CLASS					
	± 1 500 l/h		+ 5 000 l/h		+ 15 000 l/h	
	No.of B/Hs	% of Total	No.	%	No.	%
0 - 7,6	0	0	0	0	0	0
7,6 - 15,2	4	2,7	0	0	0	0
15,2 - 22,9	7	4,7	2	1,3	0	0
22,9 - 30,5	20	13,4	9	6,0	1	0,7
30,5 - 38,1	48	32,2	11	7,4	2	1,3
38,1 - 45,7	21	14,1	5	3,4	0	0
45,7 - 53,4	25	16,8	11	7,4	2	1,3
53,4 - 61,0	13	8,7	2	1,3	0	0
61,0 - 68,6	11	7,4	1	0,7	0	0

Filing Margin



NOTES

CLASS III MAR/ES REGION 5,Y SUB-REGIONS

Mean Annual Rainfall (mm)	Erosion Surfaces: Post African and Older (O)	Mixed O and Y (M)	Pliocene and Younger (Y)
Over 800 = 9	9,0	9,M	-
600 - 800 = 7	7,0	7,M	7,Y
400 - 600 = 5	5,0	5,M	5,Y
Under 400 = 3	-	-	3,Y

Constructed from Diagrams 1 and 2

(N.B. Those sub-regions for which a depth × yield analysis has been made are shaded.)

Combined Mean Annual Rainfall And Erosion Surfaces (MAR/ES)	69 d

Manner of Occurence of Groundwater in Rhodesia Diagram 4.19

M.O.W.D. HYDRO SK 385/16

TABLE 4.19.1 DEPTH X YIELD ANALYSIS

CLASS III, MAR/ES 5,Y					RATES OF SUCCESS %					
SUB-REGION	LOCATION	AREA KM^2	NO. OF B/H's		+ ± 1 500 l/h		+ 5 000 l/h		+ 15 000 l/h	
			TOTAL	ANALYSED	O	P	O	P	O	P
B	Wankie G.R., Gwaai T.T.L/APA., Maitengwe T.T.L.	154	210	143	62	81	6	8	0	0
TOTAL: 1	TOTAL AREA COVERED (KM^2) (APPROX.)	154	210	143	Mean 62	81	6	8	0	0

4.19 Class III. (Sands and Sandstone). MAR/ES Region 5,Y.

4.19.1 Introduction

There are four areas of Class III rocks where boreholes have been drilled. These areas are shown on diagram 4.19. They are widely scattered, A being in the extreme North-west and D being in the extreme South-east of the country. Sub-region B comprises parts of the Wankie Game Reserve and the Gwaai and Maitengwe T.T.L's, an area of some 154 km^2. Out of the 210 boreholes listed in this sub-region, 143 were analysed.

4.19.2 Depth x Yield Distribution and Analysis

Although there is a slight difference in the amounts of rainfall between the South-eastern and the North-western parts of region 5,Y, the results derived from B should reflect those which might be obtained in the other parts of the region, if there were enough boreholes listed for those parts.

As shown in Table 4.19.1, 62% of the boreholes drilled gave yields of 1 500 l/h or better. This could be raised to 81%, according to calculations made. These figures are higher than those for Class III rocks in region 5,0 (55 and 80%), and are not much lower than those for the same rocks in the higher rainfall regions 7,M and 7,Y; in fact, the observed figure in region 5,Y is slightly higher than that for the rocks in region 7,Q. There is a substantial drop in the percentage of boreholes with yields greater than 5 000 l/h and, as is the case in these rocks in other regions, few or no boreholes attained yields greater than 15 000 l/h.

The depth/yield distribution in the ±1 500 l/h yield class is somewhat different from those previously encountered in Class III rocks in other regions in that the boreholes are evenly spread in the intervals between 22,9 and 68,6 m. whereas in other rocks most boreholes were found in a narrower depth range.

Table 4.19.2 Lithological Class III. MAR/ES Region 5,Y

Depth x Yield Distribution

DEPTH INTERVAL (M)	YIELD CLASS					
	± 1 500 l/h		+ 5 000 l/h		+15 000 l/h	
	No.of B/H's	% of Total	No.	%	No.	%
0 - 7,6	0	0	0	0	0	0
7,6 - 15,2	1	1,1	1	1,1	0	0
15,2 - 22,9	2	2,2	0	0	0	0
22,9 - 30,5	17	15,7	3	3,4	0	0
30,5 - 38,1	15	16,9	1	1,1	0	0
38,1 - 45,7	12	13,5	2	2,2	0	0
45,7 - 53,4	15	16,9	2	2,2	0	0
53,4 - 61,0	11	12,4	0	0	0	0
61,0 - 68,6	16	18,0	0	0	0	0

No. of Boreholes Yielding ± 1 500 l/h (Those Analysed only)	= 89
These as Percentage of Total Commenced (143)	- 62%

An examination of the distribution tables of boreholes which exceeded 68,6 m. reveals that out of the 67 boreholes listed, 37 attained yields equal to or greaterthan 1 500 l/h and 30 had less than this figure. As was also the case with the sands and standstone in other regions, no boreholes attained yields greater than 15 000 l/h.

4.20 Conclusion : Some Points Arising from the Analysis.

A number of topics require further study before their effects on groundwater supplies are fully understood. Certain inferences may be drawn from the information in foregoing sections and some of these are presented in this section. An investigation into the water bearing qualities of the various rocks has been avoided here since the topic is dealt with in some detail in Chapter 5.

Considerable scope exists for the development of groundwaters in the country and this applies to all the MAR/ES regions and lithological classes considered in the text. Practically all rocks will yield some water, but the capacities and percentages of boreholes yielding "satisfactory" yields vary greatly as can be seen from tables in the chapter.

Generally, the Early PreCambrian rocks show a higher yield potential than the younger rocks with the exception perhaps of the more recent sedimentary rocks such as alluvia sands, Sabi alluvium and certain sandstones. This may be a reflection of the longer periods over which the older rocks have been subjected to earth movements and weathering processes. A study of core samples and test drilling in specific areas should to a large extent clarify the issue.

The higher mean annual rainfall in region 9,0 favours higher yield levels but it is of course the proportion of the effective rainfall that enters the level of permanent saturation that is important. Differences in the degree of fissuring are also important, especially in the harder rocks such as schists.

Rocks in the greater part of region 7,0 give fairly consistent yields. Although the mean annual rainfall is less than that in region 9,0, there is not much difference in the observed percentages of boreholes striking satisfactory yields. The fact that the Erosion surfaces are of the same age might partly account for the small difference.

The fairly uniform yields in granitic rocks within the regions suggest that the rocks have reacted to various processes in much the same way, although there are often great differences in permeability from one place to another. Rates of surface water infiltration, in addition to being affected by the extent of rock fracturing, rock type, topography and vegetation cover, are also affected by human activities.

The lower yield capacities observed in most rocks in regions 5,0, 5,M and 5,Y may be partly a result of the lower rainfall received, but the case of sands and sandstones in 5,0 giving somewhat better results in the high yield class than those in regions 7,0, 7,M and 7,Y points to other factors besides rainfall being involved. The highest yielding boreholes are probably sited in areas with favourable features of the lithology or relief such as contact zones, fault lines or nearby streams. As can be seen from the analytical tables sands and sandstones gave comparatively low results even when holes were drilled to great depths. Reasons for this are not completely clear.

A point to note is that in most rocks in the various MAR/ES regions, the depths of the majority of boreholes which struck yeidls above a cetain level lie within a similar range, and this shows that there are depths above and below which supplies decline.

So far a depth versus yield has been done in all MAR/ES regions except 9,M and 3,Y, where not enough boreholes were listed to constitute a reasonable sample. The regions shown in the tables which follow contain a total of 14 513 boreholes, of which 10 270, or 70,8% of the total were used in the analysis. The updated list of borehole totals from the 1976 and 1952 schedules gives a total of 14 694 boreholes (see "Reference Work I - Groundwater Bulleting I"). This figure is constantly changing as more boreholes are drilled. The effect of this increase will be the development of a more quantitative approach to the study of the country's groundwaters. Samples for various analyses will become larger and the addition of more sub-regions will permit studies in areas which have at present few or no boreholes.

Finally, the decision to deepen existing holes or develop new ones in an area will depend on a number of factors, including the quantity and quality of field data available, the use to which the water is to be put and the costs involved. Some of the types of data required are outlined in foregoing paragraphs and in following chapters in the main Bulletin.

4.21. TABLES SUMMARISING INFORMATION AVAILABLE ON REGIONS, SUB-REGIONS AND LITHOLOGICAL CLASSES, SOME OF WHICH APPEAR IN THIS CHAPTER.

N.B. (a) Sub-Regions represented by capital letters have been analysed, whilst those in small letters are included in order to show the grand totals of boreholes in each Class.

(b) More detailed information on all Classes in all MAR/ES regions is available from the Hydrological Branch.

TABLE 4.21.1 MAR/ES REGION 9,0

MAR/ES REGION	LITHOLOGICAL CLASS	SUB-REGION	NO. OF B/H'S IN SUB-REGION	NO. OF B/H'S IN SUB-REGION ANALYSED
9,0	I	A	156	118
		B	229	260
		C	262	293
		D	301	297
		E	371	362
		F	304	297
		G	225	223
		H	200	200
		I	239	233
		J	238	237
		K	298	287
		l	17	0
		m	3	0
		n	2	0
		o	61	0
Total in Class = 2976 Total Analysed (94%) = 2807				
9,0	III-	a	1	0
		B	4	0
Total in Class = 5 Total Analysed = Nil				
9,0	V	a	22	0
		b	18	0
		c	2	0
Total in Class = 42 Total Analysed = Nil				
9,0	VI	a	26	0
		B	294	283
		C	313	310
		D	266	259
		E	564	561
		f	14	0
Total in Class = 1477 Total Analysed (96%) = 1413				
9,0	VII	a	35	0
		b	3	0
Total in Class = 38 Total Analysed = Nil				

SUMMARY
Grand Total of Boreholes in Region = 4538 Total Analysed (93%) = 4220

TABLE 4.21.2 MAR/ES REGION 9,M

MAR/ES REGION	LITHOLOGICAL CLASS	SUB-REGION	NO. OF B/H'S IN SUB-REGION	NO. OF B/H'S IN SUB-REGION ANALYSED
9,M	I	a	31	0
		b	57	0
		c	117	0
		d	16	0
Total in Class = 221 Total Analysed = Nil				
9,M	II	a	1	0
Total in Class = 1 Total Analysed = Nil				
9,M	V	a	14	0
		b	33	0
Total in Class = 47 Total Analysed = Nil				
9,M	VI	a	30	0
		b	5	0
Total in Class = 35 Total Analysed = Nil				
9,M	VII	a	6	0
Total in Class = 6 Total Analysed = Nil				

SUMMARY
Grant Total of Boreholes in Region = 310 Total Analysed = Nil

TABLE 4.21.3 MAR/ES REGION 7.0

MAR/ES REGION	LITHOLOGICAL CLASS	SUB-REGION	NO. OF B/H'S IN SUB-REGION	NO. OF B/H'S IN SUB-REGION ANALYSED
7,0	I	A	297	293
		B	186	180
		c	13	0
		d	2	0
		E	215	202
		F	261	240
		G	391	384
		h	19	0
		I	237	230
		J	210	195
		K	308	292
		L	232	224
		f	4	0
Total in Class				=2375
Total Analysed (94%)				=2240
7,0	II	a	17	0
		b	27	0
		c	3	0
		d	1	0
Total in Class				= 47
Total Analysed				= Nil
7,0	III	a	17	0
		B	260	175
		C	279	194
		D	333	274
		e	1	0
		f	1	0
		g	2	0
Total No. of Boreholes				= 893
Total Analysed (72%)				= 643
7,0	IV	a	3	0
		b	1	0
Total in Class				= 4
Total Analysed				= Nil
7,0	V	a	6	0
		b	1	0
		c	94	0
		d	3	0
		e	1	0
		f	1	0
Total in Class				= 106
Total Analysed				= Nil
		a	22	0
		b	131	0
		C	287	272
		D	354	355
		e	120	0
Total in Class				= 914
Total Analysed (66%)				= 607
7,0	VII	a	1	0
		b	64	0
		c	9	0
Total in Class				= 74
Total Analysed				= Nil
7,0	VIII	a	1	0
Total in Class				= 1
Total Analysed				= Nil

SUMMARY

Grand Total of Boreholes in Region	= 4414
Total Analysed (79%)	= 3490

TABLE 4.21.4. MAR/ES REGION 7,M

MAR/ES REGION	LITHOLOGICAL CLASS	SUB-REGION	NO. OF B/H'S IN SUB-REGION	NO. OF B/H'S IN SUB-REGION ANALYSED
7,M	I	A	370	326
		B	331	301
		c	13	0
		d	61	0
		e	91	0
Total in Class = 866 Total Analysed (72%) = 627				
7,M	II	a	5	0
		b	21	0
		c	14	0
Total in Class = 40 Total Analysed = Nil				
7,M	III	a	4	0
		b	60	0
		c	4	0
		D	229	142
Total in Class = 331 Total Analysed (43%) = 142				
7,M	IV	a	3	0
		b	11	0
		c	2	0
Total in Class = 16 Total Analysed = Nil				

MAR/ES REGION	LITHOLOGICAL CLASS	SUB-REGION	NO. OF B/H'S IN SUB-REGION	NO. OF B/H'S IN SUB-REGION ANALYSED
7,M	V	A	273	212
		b	5	0
		C	225	178
		d	3	0
		e	1	0
		f	1	0
Total in Class = 528 Total Analysed = 390				
7,M	VI	A	224	213
		b	15	0
		c	19	0
		d	3	0
Total in Class = 261 Total Analysed (82%) = 213				
7,M	VII	a	10	0
		b	2	0
Total in Class = 12 Total Analysed = Nil				
7,M	*	a	2	0
Total in Class = 2 Total Analysed = Nil				

SUMMARY
Grand Total of Boreholes in Region = 2036 Total Analysed (67%) = 1372

TABLE 4.21.5 MAR/ES REGION 7,Y

MAR/ES REGION	LITHOLOGICAL CLASS	SUB-REGION	NO. OF B/H'S IN SUB-REGION	NO. OF B/H'S IN SUB-REGION ANALYSED
7,Y	I	a	5	0
		B	72	0
Total in Class = 77 Total Analysed = Nil				
7,Y	II	a	5	0
Total in Class = 5 Total Analysed = 0				
7,Y	III	a	33	0
		B	190	134
		c	32	0
		d	20	0
Total in Class = 275 Total Analysed (49%) = 134				
7,Y	IV	a	4	0
		b	16	0
Total in Class = 20 Total Analysed = Nil				
7,Y	V	a	7	0
		b	3	0
		c	51	0
		d	1	0
Total in Class = 62 Total Analysed = Nil				
7,Y	VI	a	2	0
Total in Class = 2 Total Analysed = Nil				
7,Y	*	a	1	0
		b	4	0
		c	46	0
Total in Class = 51 Total Analysed = Nil				

SUMMARY	
Grand Total of Boreholes in Region	= 492
Total Analysed (27%)	= 134

TABLE 4.21.6 MAR/ES REGION 5.0

MAR/ES REGION	LITHOLOGICAL CLASS	SUB-REGION	NO. OF B/H'S IN SUB-REGION	NO. OF B/H'S IN SUB-REGION ANALYSED
5,0	I	A	324	295
		B	287	275
		c	40	0
Total in Class = 651 Total Analysed (88%) = 570				
5,0	II	a	73	0
		b	5,0	0
Total in Class = 78 Total Analysed = Nil				
5,0	III	A	218	156
		b	1	0
Total in Class = 219 Total Analysed (71%) = 156				
5,0	V	a	5	0
		b	1	0
		c	2	0
Total in Class = 8 Total Analysed = Nil				
5,0	VI	A	258	230
		b	8	0
Total in Class = 266 Total Analysed (86%) = 230				
5,0	VII	a	1	0
		b	4	0
		c	1	0
Total in Class = 6 Total Analysed = Nil				
5,0	*	a	1	0
Total in Class = 1 Total Analysed = Nil				

SUMMARY	
Grand Total of Boreholes in Region	=1231
Total Analysed (45%)	= 556

TABLE 4.21.7 MAR/ES REGION 5,M

MAR/ES REGION	LITHOLOGICAL CLASS	SUB-REGION	NO. OF B/H'S IN SUB-REGION	NO. OF B/H'S IN SUB-REGION ANALYSED
5,M	I	A	200	187
Total in Class = 200 Total Analysed (94%) = 187				
5,M	V	a	3	0
Total in Class = 3 Total Analysed = Nil				
5,M	VI	a	23	0
Total in Class = 28 Total Analysed = Nil				
5,M	VII	a	4	0
Total in Class = 4 Total Analysed = Nil				

SUMMARY	
Grand Total of Boreholes in Region	= 235
Total Analysed (80%)	= 187

TABLE 4.21.8 MAR/ES REGION 5,Y

MAR/ES REGION	LITHOLOGICAL CLASS	SUB-REGION	NO. OF B/H'S IN SUB-REGION	NO. OF B/H'S IN SUB-REGION ANALYSED
5,Y	I	a	3	0
		b	4	0
		C	239	222
		D	231	168
Total in Class = 477 Total Analysed (82%) = 390				
5,Y	II	a	14	0
		b	22	0
		c	1	0
		d	130	0
Total in Class = 167 Total Analysed = Nil				
5,Y	III	a	17	0
		B	210	143
		c	3	0
		d	32	0
Total in Class = 262 Total Analysed (55%) = 143				
5,Y	IV	a	1	0
Total in Class = 1 Total Analysed = Nil				

MAR/ES REGION	LITHOLOGICAL CLASS	SUB-REGION	NO. OF B/H'S IN SUB-REGION	NO. OF B/H'S IN SUB-REGION ANALYSED
5,Y	V	a	20	0
		b	2	0
		c	1	0
		d	4	0
Total in Class = 27 Total Analysed = Nil				
5,Y	VI	a	16	0
		b	2	0
		c	1	0
Total in Class = 19 Total Analysed = Nil				
5,Y	VII	a	4	0
Total in Class = 4 Total Analysed = Nil				
5,Y	*	a	23	0
		b	2	0
Total in Class = 25 Total Analysed = Nil				

SUMMARY
Grand Total of Boreholes in Region = 979 Total Analysed (32%) = 311

TABLE 4.21.9 MAR/ES REGION 3,Y

MAR/ES REGION	LITHOLOGICAL CLASS	SUB-REGION	NO. OF B/H'S IN SUB-REGION	NO. OF B/H'S IN SUB-REGION ANALYSED
3,Y	I	a	158	0
Total in Class = 158 Total Analysed = Nil				
3,Y	II	a	94	0
Total in Class = 94 Total Analysed = Nil				
3,Y	III	a	24	0
Total in Class = 24 Total Analysed = Nil				
3,Y	IV	a	2	0
Total in Class = 2 Total Analysed = Nil				

SUMMARY	
Grand Total of Boreholes in Region	= 278
Total Analysed (0%)	= Nil