

ANNUAL REPORTS
OF THE
GEOLOGICAL SURVEY AND MINES DEPARTMENT
FOR THE YEARS
1969 AND 1970.

1. GENERAL

1.1 Introduction

An acute shortage of staff, combined with a great amount of work arising from rapid development of the country's mineral resources, led to the Annual Reports for 1969 and 1970 being deferred. With the present increase of staff it has become possible (in late 1972) to attempt to make good the deficiency, and to record something of the work which was done in these years, and which has contributed so importantly to the country's new position of economic strength.

In order to reduce the delay, and because nearly all the staff are new and were not familiar with what took place in Botswana in 1969 and 1970, it was decided to issue the two Annual Reports within one cover. When this gap has been filled we shall return to the normal Annual Report appearing each year.

The Geological Survey and Mines Department in the Republic of Botswana is a part of the Ministry of Commerce, Industry and Water Affairs. Its headquarters are at Lobatse in southeastern Botswana, 75km south of the capital at Gaborone.

The fundamental aim of the Geological Survey is the assessment of the mineral and underground water resources of Botswana with the intention of stimulating the realisation of their economic potential. The attainment of these objectives demands a study of the rocks and geological structures over the whole of the country. Regional geological mapping and the publication of maps and reports describing the geology of Botswana is thus the prime function of the Geological Survey. Mineral survey work is carried out and this includes geological and geophysical survey of mineral occurrences supplemented by laboratory work; prospecting for new mineral deposits; rendering assistance to prospecting organisations and operating mines; and wherever possible furthering interest in Botswana's mineral potential.

Another major task of the Geological Survey is the development of underground water supplies and hydrogeological survey. The Geological Survey carries out the siting of water boreholes by means of geological and geophysical investigations, and controls drilling of the selected sites to the stage where productive boreholes can be passed to another Department within the Ministry for equipping the boreholes. Hydrogeological research work is carried out and the Geological Survey is building up a considerable body of information about the nature and occurrence of under-

ground water resources in Botswana. Borehole drilling is carried out by the Drilling Branch section of the Geological Survey and Mines Department, which has its headquarters at Gaborone, under the control of a Drill Superintendent who is directly responsible to the Director of Geological Survey and Mines.

Besides these main activities, the Geological Survey and Mines Department undertakes special investigations where geological advice is required, such as in engineering, and renders assistance to other Government Departments when needed. Geological and geophysical investigations and research are undertaken for a better understanding of the basic geology and geological structure of Botswana.

The Director of Geological Survey and Mines is Mining Commissioner for Botswana. The Department includes a Government Mining Engineer's division. This division is responsible for safe mining practices, the inspection of mines and machinery, and the implementation of explosives regulations. In the exercise of its dual functions as a Geological Survey and Mining Commissioner's office, the Department is responsible to Government for ensuring that company prospecting operations in Botswana are carried out energetically and efficiently with due regard to the provisions of the Mines and Minerals Act in force.

The main costs of running the Geological Survey and Mines Department, and the full costs of the development of underground water supplies in Botswana by drilling during 1969 and 1970 were again borne on normal budget estimates.

1.2 Summary of the Two Years' Work

Recruiting difficulties continued throughout the period under review both in the professional and technical cadres of the Geological Survey and Mines Department. The situation was particularly serious as far as geologists were concerned and five vacancies existed for the greater part of 1969. This affected work in all spheres of Geological Survey activity. The position had improved for this cadre of officer by the end of 1970 when three vacancies existed. The newly established Mines Division had two professional officers in post by April, 1969.

Regional reconnaissance geological mapping was continued during the period under review. In 1969, a total of about 3 000 square miles of previously unmapped country was geologically surveyed on a scale of 1:125 000. This figure was reduced to about 1 000 square miles in 1970 when only one geologist was engaged on this important aspect of Geological Survey activity. Revision mapping was continued in south-eastern Botswana throughout 1969 and 1970. A 25 000 square mile tract of country in eastern Botswana was tackled during

1970 as a special revision project.

The professional staff position limited the amount of work that could be carried out on direct mineral survey projects. The regional survey of the mineral potential of an area in northern Botswana was completed and case history geophysical studies continued as the staff situation allowed. A number of manganese-ore occurrences in southeastern Botswana were investigated.

During the two years currently being described, 23 State Grants were issued conferring special prospecting licences over various areas of Botswana for a variety of minerals. Prospecting activity is reviewed under the sections on Economic Geology. Mining development and legislation falls within the sphere of the Mines Inspectorate Division whose work comes under the heading of 'Mining'.

In underground water development work, geological and geophysical surveys were again undertaken in most District Council areas. Considerable assistance was rendered to mining companies in their search for underground water as a Government counterpart contribution. Ground-water research programmes continued, but at a reduced tempo owing to staff shortages.

During 1969, a total of 68 boreholes were completed for Government and the private sector of which 53 were successful, representing an overall success value of 77,9%. In 1970, a total of 74 boreholes were completed of which 55 were successful, giving a 74,3% success rate.

1.3 Organization and Staff

In the two year period being reviewed there was a considerable turn-over of staff. The more important changes are given below.

C.M.H. Jennings, Deputy Director, retired from the Public Service in December, 1970.

S.P. Malan was appointed to fill the vacant post of Principal Geologist in April, 1969.

G. Stansfield was appointed to one of the vacant posts of Geologist in October, 1969.

C.V. Reeves took up his appointment as Geologist/Geophysicist in January, 1970.

C.M. Thomas, Senior Geologist, resigned on completion of his contract appointment in February, 1970.

B.S. Marengwa who had been appointed Assistant Geologist in September, 1969, resigned in March, 1970.

M. Litherland joined the Geological Survey in December 1970, as a Geologist on secondment terms from the Institute of Geological Sciences in London.

At the end of 1970 the Deputy Director's post was vacant and 4 further vacancies existed for Geologist/Senior Geologist.

Two posts of Government Mining Engineer (later redesignated Chief Government Mining Engineer and Assistant Government Mining Engineer) were both filled in the first quarter of 1969. K.J. Dell was appointed to the former post in January, 1969, and G.A. Jess took up the Assistant Government Mining Engineer's post in March, 1969. K.J. Dell proceeded on leave on 10th December, 1970.

K. Jennings was promoted to the post of Senior Cartographer with effect from April, 1970.

C.E.R. Bruchwalski was appointed to fill the vacant Cartographer's post in December, 1969.

C.A. Candy completed his three year secondment as Cartographer with the Department in October, 1970 and returned to the Directorate of Overseas Surveys in London.

R.J. Hastings, who was promoted to Senior Scientific Assistant during 1969, resigned his appointment on completing his contract period in 1970.

D.J.V. Pretorius was promoted to Senior Scientific Assistant with effect from August, 1970.

J.A.J. de Wet resigned as Scientific Assistant on completion of his contract appointment in 1969.

B.V.J. Brislin, R.E. Cowley and G.C. Hojem were appointed to fill vacant posts as Scientific Assistants in July, 1969.

F. Bicheno resigned as Scientific Assistant in December, 1969, but re-engaged in the same post in December, 1970.

D. Burwood, V.S.O. volunteer, was recruited to the Department as a Scientific Assistant between September 1969 and September 1970.

D.J. Hunt and K. Beesley, also V.S.O. volunteers, joined the Department as Scientific Assistants in September, 1970.

Miss D.V. Turner resigned after completing her contract appointment as Personal Secretary in October, 1970 and Miss J.M. McKie was appointed as the replacement.

H.H. Swart joined the Drilling Branch Staff as Drill Foreman in July, 1969.

W.M. Bond was also appointed as Drill Foreman in September 1969, and C.J. Dorfling was appointed in a similar capacity in October, 1970.

Lists of Availability of Staff at the end of 1969 and 1970 are given in Appendices 3 and 4 respectively.

6. UNDERGROUND WATER DEVELOPMENT, 1969

6.1 Geological Survey Activities

The Geological Survey continued to be responsible for the control of all underground water development work in Botswana, including the siting of boreholes following geological and geophysical work, and the subsequent drilling of selected water borehole sites.

In the course of this work geological and geophysical investigations were undertaken in the Central District; the North East District; Kgatleng District; Ngwaketse District; Ghanzi District; North West District and Lobatse township areas.

During 1969, a total of 80 boreholes were drilled on sites selected after geological and geophysical surveys carried out by officers of the Department. Out of these 80 boreholes, 4 were drilled for brine testing purposes, 1 was abandoned for technical reasons and 7 were uncompleted at the end of the year. Of the 68 completed water boreholes, 53 were successful, representing an overall success value of 77,9%. This figure is slightly lower than that achieved in 1968 (81,5%). The total number of completed boreholes is about 20% lower than the number completed on Geological Survey sites in 1968. This is accounted for by the severe shortage of professional and technical staff, and to the fact that during the latter part of the year 2 drilling rigs were used solely for pump testing purposes near Lobatse.

A tabulated list of boreholes drilled on sites selected by officers of the Geological Survey is given in Appendix '7.

6.2 Drilling Branch Activities

During 1969, a total of 24 338 feet was drilled by the Drilling Section of the Geological Survey and by Contract Drilling (under the direct supervision of the Drill Superintendent) for the development of underground water supplies. This figure amounts to an increase of 711 feet as compared with that for 1968.

During the year 94 boreholes were worked on but this number includes 14 holes that were only cleaned out and re-tested. Of the 80 new boreholes worked on, 1 drilled to a depth of 310 feet was abandoned for technical reasons although it should prove possible to use the hole for observation

purposes, and 4 amounting to 1 132 feet were drilled during brine testing operations. 7 boreholes totalling 2 425 feet remained uncompleted at the end of the year. Of the total footage of 21 195 feet drilled in completed boreholes for underground water development purposes, 16 465 feet were drilled in successful boreholes.

In addition to boreholes drilled by Government drilling machines, 17 boreholes were drilled under contract in the Lobatse area during the last 5 months of the year. This drilling programme was necessary owing to the impending drying up of Nuane Dam. It also meant 2 Government rigs were unavailable for normal drilling operations for the latter part of the year since the contract did not include pump testing and machines had to be deployed to do this work. It should be pointed out, however, that the footages from the contract drilling have been included in the above summary.

During the first quarter of the year assistance was rendered to De Beers Prospecting Botswana (Pty.) Limited at Orapa. 2 boreholes previously drilled on contract were deepened and pump tests were undertaken.

The remainder of the drilling in the non-Governmental/District Council sphere took the form of boreholes drilled on a repayment basis for Bamangwato Concessions Limited in the Selebi-Pikwe area. 14 boreholes were drilled, mainly during the first half of the year, and although yields were on the whole rather disappointing only 2 holes were blank and 3 had yields in excess of 1 800 gallons per hour.

4 successful boreholes were completed in connection with the borehole repayment scheme which will mean revenue amounting to R4 257 accruing to Government.

6.3 General Hydrogeological Research Work

The ground-water research programme was continued though on a limited scale because of lack of staff. A number of new automatic water level recorders were purchased during the year. Recorders are now in operation at such widely separated localities as Ghanzi, Nata, Francistown, Serowe, Pikwe, Orapa and Lobatse. In addition to the automatic recorders more than 80 boreholes are monitored for changes in water level at daily, weekly or monthly intervals.

A comprehensive water sampling programme for both tritium and chemical analysis was commenced in the Serowe and Lobatse areas in collaboration with the Nuclear Physics Research Unit of the Witwatersrand University, aided by a grant from the International Atomic Energy Agency in Vienna. This sampling programme entails the regular sampling of pumped and unused boreholes at different

depths. Results so far have shown that the use of tritium can prove to be an extremely useful hydro-geological tool and has enabled a quantitative estimate of the storage capacity of certain basins to be made. These storage capacities were found to be many times larger than those calculated from conventional hydro-geological data using an assumed aquifer thickness.

In addition, the use of tritium has revealed new sources of recharge hitherto unsuspected in both Lobatse and Serowe; it has confirmed one suspected method of recharge in the Lobatse Estates south basin; the sensitivity of the tritium method to different geohydrological conditions has been clearly demonstrated where markedly different tritium values are found in two adjacent but geologically distinct groundwater basins. Simple age stratification measurements on the standing water column in boreholes have been shown to indicate recharge patterns.

Approval was received during the year for the project to be extended till the end of 1970.

Detailed aquifer evaluation tests were carried out in the Lobatse area to determine coefficients of transmissibility and storage of the dolomite aquifer.

Systematic sampling of ground-water for chemical analysis is being continued.

Following a visit by Dr. J.S.V. van Zyl of the Geophysics Division of the Council for Scientific and Industrial Research, in which the use of the Schlumberger electrode configuration for the electrical resistivity method was demonstrated, together with methods of interpretation of the results, it was decided to commence with this method as soon as practicable. This method gives far more reliable quantitative results than does the empirical interpretation at present in use by the Survey. It is also less subject to errors caused by lateral surface inhomogeneities; the use of copper potential electrodes eliminates the need for carrying large amounts of water with the vehicles and the time for taking a reading is appreciably less, though the interpretation of the results takes longer.

Self-potential, resistivity (both constant separation traverses and depth-probes) and magnetic readings are now undertaken as a matter of routine on all surveys for ground-water.

7. HEADQUARTERS WORK, 1969

7.1 Laboratory Services

Two divisions exist within the scope of Laboratory Services.

In the Petrological and Mineralogical Laboratory section, all geologists undertake work falling within the scope of this more purely geological section.

The Chemical Laboratory provides analytical services for officers of the Department and work is also undertaken for other Government Departments and the public. Analyses of manganese ores, silicate analysis of various rocks together with routine analyses of borehole waters constituted the bulk of the laboratory's work in 1969.

The following is a statistical summary of work carried out in the analytical laboratory during 1969:

	<u>No. of samples</u>	<u>No. of determinations</u>
Water analyses	658	7 896
Ores	68	120
Miscellaneous	67	530

Notes

- (a) The number of water samples analysed during 1969 showed an increase of 112% over the total analysed during 1968.
- (b) Included in the samples under the heading 'Miscellaneous' was a total of 31 samples from Bamangwato Concessions Limited for full rock analysis. These samples made up 70% of the number of determinations in this section.
- (c) Of the samples of ores analysed, a total of 44 samples were of manganese ore from Kgwakgwe for MnO₂ determinations. Other elements analysed for in this section were: copper, nickel, aluminium and iron.

7.2 Drawing Office

The main work carried out in the Drawing Office, over and above normal Departmental routine, was the preparation of quarter degree sheet geological maps for colour printing.

Quarter Degree sheets 2026D and 2126B, Mosetse/Matsitamma,

9. PUBLICATIONS AND REPORTS, 1969

9.1 Publications

R.N. Crockett - Brief explanation of the geology of the Shashi area (accompanying geological map, quarter degree sheet 2127A).

Publication of other material was delayed due to shortage of staff and hence the inability of more senior officers to pay attention to this work in view of their heavy commitments in other fields. Descriptions of all mapped areas are, however, available at Geological Survey headquarters at Lobatse, details of which can be supplied on request.

9.2 Reports

Unless otherwise stated, the following are all unpublished reports of the Geological Survey, Botswana.

J.D. Bennett - Notes on the photogeological interpretation of the Magogaphate area, sheet 2128C.

- Brief explanation of the geology of the Tsessebe area (quarter degree sheet 2027C and part of sheets 2027B and 2027D, compiled from maps and reports by C.A. Laughton 1964-67).

C. Boocock - The Geology and Mineral Development Possibilities in Botswana.

- Review of mineral resources and mining activities in the Republic of Botswana.

- Mining in Botswana.

R.N. Crockett - A note on the possible origin of Bevet's conglomerate, Botswana and South Africa.

- Note on certain sedimentological features of the highest Pretoria Series beds near Lobatse, Botswana.

C.M.H. Jennings - Report on geophysical investigations and drilling for groundwater at Selebi-Pikwe, Central District area.

- Groundwater in Botswana (Prepared for the "Symposium on Groundwater in Southern Africa", Pretoria, 1969).

with
M.T. Jones

- Notes on underground water resources in Botswana (Prepared for S.A.R.C.C.U.S. Symposium at Lorenzo Marques, February, 1970).

- M.T. Jones - The geology of the country around Artesia, southeastern Botswana (Unpublished M.Sc. thesis, University of Wales, 113p.)
- S.P. Malan - Notes on magnetometric traverses over maniferous horizons in the Kanye area.
 - The Sobathwe manganese occurrence, Kanye district.
 - Notes on a manganicrete occurrence, Kanye district.
- D.S. Marengwa - Geology of the Ventersdorp System between Motlhatsa, Lokgwathe and Tsopeng, south of Kanye.
- G. Stansfield - Geology of the Gaborone granite and associated rocks of sheet 2525B(1).
 - Note on the field characteristics of the Gaborone granite and associated rocks near Lobatse.
- C.M. Thomas - The Selebi area (sheet 2227B).
 - A brief description of the geology of south Ngamiland (sheets 2022C, 2022D and 2023C).
 - A note on the geology of the Toteng area (sheet 2022B).
 - Geological notes on the Chobe district.

Geological Survey Activities

In the course of this work geological and geophysical surveys were carried out in the Central District; Ngwatekse District; Kgatleng District; Kweneng District; Kgalagadi District; Ghanzi District; North West District; North East District; South East District and Lobatse township areas.

During 1970, a total of 82 boreholes were drilled on sites selected after geological and geophysical surveys carried out by officers of the Department. Of this number, 6 boreholes were abandoned for technical reasons and 2 were unfinished at the end of the year. 55 out of the remaining 74 completed water boreholes were successful representing an overall success value of 74,3%. The success value for 1969 was marginally higher than this figure and stood at 77,9%.

The total number of completed boreholes was identical with the 1969 figure. It would have been considerably higher had it not been necessary for 2 drillers to undergo training on the Ingersoll Rand air rig during the course of the year.

A tabulated list of boreholes drilled on sites selected by officers of the Geological Survey is given in Appendix 8.

Drilling Branch Activities

During 1970, a total of 20 259 feet was drilled by the Drilling Branch section of the Geological Survey and by Contract Drilling for the development of underground water supplies. This footage is 4 079 less than the footage drilled during 1969.

During the year 95 boreholes (including 17 boreholes cleaned and retested) were worked on. 78 new boreholes were started in 1970 but 7 boreholes totalling 861 feet had to be abandoned for technical reasons and 2 boreholes totalling 594 feet remained uncompleted at the end of the year. Of the total footage of 18 642 feet drilled in completed boreholes for underground water development purposes 14 063 feet were drilled in successful boreholes.

Apart from normal drilling for Government purposes and in various District Council areas (all of which is summarized in Appendix 6), assistance was given to Mineral

Research (Pty.) Limited in the Foley area. Eight boreholes were drilled in this region, where the company are actively engaged in a gypsum evaluation programme, and although only a 50% success value was obtained, 2 high yielding boreholes were developed.

In November a contract drilling programme under the direct supervision of the Geological Survey Department was commenced north of Mosomane (Artesia) in the Kgatleng District to develop water supplies for the realignment of the main north/south road. One very high-yielding borehole had been developed by the end of the year.

Assistance was also rendered during the year to African and European Investment Company Limited in the Morupule coalfield area, west of Palapye. Two very deep boreholes drilled in close proximity to the proposed mining area but with only limited success. A very high-yielding borehole was developed, however, 4 miles southeast of Morupule on the bank of the Lotsane River.

9 boreholes were completed in connection with the borehole repayment scheme for private applicants in the various District Council areas. This will result in revenue amounting to R8 772 accruing to Government. Drilling undertaken for Mineral Research (Pty.) Limited and African and European Investment Company Limited on a repayment basis will result in R2 543 being paid to Government.

15.3 General Hydrogeological Research Work

The tempo of the groundwater research programme was again reduced owing to the staff shortages but it did prove possible to continue detailed investigations at Lobatse, Serowe, Orapa and in the Western Kweneng District. A number of automatic water level recorders were in operation in these areas and a further 80 boreholes throughout the country are monitored for changes in water level at daily, weekly or monthly intervals.

Liaison continued between the Nuclear Physics Research Unit of the Witwatersrand University and the Geological Survey during the year. The collaboration started in 1969 through a grant from the International Atomic Agency in Vienna to carry out work on the effectiveness and application of environmental tritium as a groundwater tracer over detailed selected areas in Botswana. Initially the areas of investigation were confined to Lobatse and Serowe, where tritium proved to be an extremely valuable yardstick in the quantitative assessment of the storage capacities of certain groundwater basins. During 1970, Orapa was added to the tritium sampling programme owing to the importance this area had assumed following the

discovery of diamondiferous kimberlitic pipes there and the short-term reliance that the mining operations would have to place on groundwater. It was too early to assess the usefulness of tritium as a hydrogeological tool in the Orapa area by the end of the year, but updated field observations and increasing records of tritium data at Lobatse and Serowe allowed for new sources of recharge to be postulated for these areas.

The International Atomic Energy Agency gave its approval during the course of the year for the tritium project to continue to the end of 1971.

Systematic sampling of groundwaters for chemical analysis is being continued and a data bank consisting of 2 500 full analyses has been built up at the Geological Survey. Water temperature measurements are being recorded at all Government boreholes drilled throughout the country.

The use of the Schlumberger electrode configuration for the electrical resistivity method of borehole siting was fully implemented during the course of the year. Resistivity sets have been modified successfully for this purpose in the Department. By the end of the year a great deal of benefit had been reaped from the more reliable quantitative results obtained from such surveys, especially with regard to lateral surface inhomogeneities which had led to errors in interpretation when using the Wenner empirical method.

The acquisition of a Gaerhardt-Owen Model X borehole logger during the latter part of the year represents a considerable potential asset to the Geological Survey Department. Work is in hand to modify a Land Rover to transport the logger and its accessories. The logger has a comprehensive range of facilities including single point electrical resistivity log, spontaneous polarisation, natural gamma, caliper, flowmeter (flow/no flow only), temperature and differential temperature, gamma-gamma and neutron logs. It is hoped to utilize the logger in all underground water research schemes planned for 1971.

C.M.H. Jennings - Note on cyclic denudational surfaces in Botswana (Prepared for submission for publication in Trans.geol.Soc. South Africa).

The groundwater storage capacity of the Lobatse area, Botswana. (Prepared for submission for publication in Trans. geol.Soc.South Africa).

Note on geophysical survey at Bushman Mine, Central District.

with

M.T. Jones - Notes on underground water resources in Botswana (Prepared for S.A.R.C.C.U.S. Symposium at Lourenco Marques, February, 1970).

with

S.P. Malan - Brief report on geophysical case-history study of Lentswe copper-nickel prospect.

as

co-author - Contribution of environmental tritium measurements to some geohydrological problems in southern Africa. (Published in "Isotope Hydrology 1970" International Energy Agency, Vienna).

M.T. Jones - Notes on the subdivisions of the Waterberg System as recognised in the southwestern portion of the Waterberg area of the Transvaal and their possible correlations in eastern and southeastern Botswana.

G. Stansfield - Note on a Joint survey of the Gaborone Granite west of Lobatse.
- An interpretation of the depositional environment for part of the Middle Ecca as exposed at Mea Pan.

APPENDIX 5

Statistics of drilling operations carried out by the Drilling Branch of the Geological Survey and by Contract Drilling during 1969

	No. of new boreholes worked on	No. of completed boreholes for underground water development	No. of successful boreholes	No. of abandoned boreholes	No. of uncompleted boreholes	Total footage drilled	Footage drilled in successful boreholes	Footage drilled in unsuccessful boreholes	Footage drilled in abandoned boreholes	Footage drilled in uncompleted boreholes	Water developed in gallons per hour.
Central District	21	15	7	-	1	4 550	2 017	2 233	-	300	4 380
Kgatlang District	6	4	3	-	1	1 324	924	400	-	253	1 260
Ngwaketse District	7	3	3	-	1	1 795	1 251	-	-	544	605
Kgalagadi District	2										
Ghanzi District	6	3	3	-	1	2 354	1 695	-	-	659	4 800
South East District	2	1	1	-	-	172	172	-	-	-	400
Government (including Veterinary, Agriculture, Townships, repayment boreholes other than for Tribal applicants)	50	42*	36	1	3	14 143	10 405	1 627	310	699	119 055
	94	68	53	1	7	24 338	16 464	4 260	310	2 455	130 495

Statistics of drilling operations carried out by the Drilling Branch of the Geological Survey and by Contract Drilling during 1970

	No. of new boreholes worked on	No. of completed boreholes for underground water development	No. of successful boreholes	No. of abandoned boreholes	No. of uncompleted boreholes	Total footage drilled	Footage drilled in successful boreholes	Footage drilled in un-successful boreholes	Footage drilled in abandoned boreholes	Footage drilled in un-completed boreholes	Water developed in gallons per hour
Central District	18	17	12	-	1	5285	3287	1510	-	488	9680
Kgatlang District	3	3	2	-	-	314	267	47	-	-	1420
Kweneng District	10	6	6	4	-	2021	1412	-	609	-	940
Ngwaketse District	4	4	3	-	-	1743	1323	420	-	-	2600
South East District	4	3	3	1	-	1255	1055	-	200	-	2600
North East District	2	2	-	-	-	390	-	-	390	-	-
Kgalagadi District	4	3	2	1	-	1173	870	268	35	-	650
Ghanzi District	2	2	2	-	-	965	965	-	-	-	3000
Government (including Veterinary, Agriculture, Townships, repayment boreholes other than for Tribal applicants)	31	29	21	1	1	6951	4884	1944	17	106	23530
	78	69	51	7	2	20097	14063	4549	861	594	44420

APPENDIX 7

TABLE OF BOREHOLES 1969.

Official Number	Locality District	Depth in Feet	Yield in G.P.H.	Depth Water Struck in feet	Static Water Rest Level in feet	Geology
2153	Orapa, Central District	1 066	3 600	374	63	Basalt(374'), Cave Sandstone to 670'(Stormberg Series) and Eccca Series mudstone, shale and sandstone.
2199	Orapa, Central District	484	3 600	(borehole deepened from 432 feet)		Basalt (280') & Cave Sandstone (Stormberg Series, Karroo System).
2203	Bushman Mine, Central District	265	Blank (5 g.p.h.)	210	180	Basement Complex gneiss, metaquartzite and amphibolite.
2206	Orapa, Central District	406	7 200	75,138,154, 174,194	22'6"	Basalt(138') & Cave Sandstone(Stormberg Series, Karroo System).
2207	Dintswane Ngwaketse District	272	250	81-186'	26'	Kalahari Beds(80') & shale, siltstone & sandstone (Waterberg System).
2208	Motale(Selibe), Central District	200	600	78	32	Basement Complex granite & biotite schist.
2209	Phikwe, Central District	165	100	64	34	Basement Complex biotite schist (130') & granite.
2210	Phikwe, Central District	- 480	+3 000	-461 164	41	No samples received 0-346'. 346' to 480' Basement Complex granite.
2211	Maitlo a Fhuduhudu, Ghanzi District	613	900	538	514	Kalahari Beds (150') & Cave Sandstone (Stormberg Series, Karroo System).
2212	Chadibe, Central District	227	Blank	-	-	Gravel(20') & Basement Complex gneiss, decomposed to 100 ft.
2213	Letlhakane(Phikwe), Central District	307	400	260	42	Shale, siltstone & sandstone to 260' (Ecca Series, Karroo System & Basement Complex gneiss, schist & granite).
2214	Mosetse, Central District	200	900	125	95	Basement Complex granite-gneiss & amphibolite, decomposed to 120'.
2215	Phikwe, Central District	180	500	96-116	42	Basement Complex granite-gneiss with bands of amphibolite.
2216	Letlhakane(Phikwe), Central District	491	1 800	390,453 488	50	Basement Complex metavolcanics, mylonite & flinty-crush rocks.
2217	Phikwe, Central District	195	600	126,137,172	40	Basement Complex granite-gneiss with bands of amphibolite.
2218	Nata, Central District	40	180	28	14	Kalahari Beds.
2219	Orapa, Central District	200	3 600	374	63	Basalt(374'), Cave Sandstone to 670'(Stormberg Series) and Eccca Series mudstone, shale and sandstone.

Reference Number	Locality District	Depth in Feet	Width in G.P.H.	Depth Water Struck in feet	Depth Water Next Level in feet	Description
2220	Ramakoala, Ngwaketse District	485	275	460-470 330-340	240	Cherty rubble & sand(40'), dolomite (300') chert (330') and dolomite (Dolomite Series, Transvaal System).
2221	Khale, Gaborone Block, S.E. District	172	380-400	42 & Onwards	22	Felsitic lava, decomposed to 80 ft. (Kanye Volcanic Group).
2222	East of Nojane, Ghanzi District	790	3 000+	605,736 755,780	418	Kalahari Beds(+380'), Cave Sandstone(450'), mudstone & shale(590'), dolerite(730'), shale & sandstone (Ecca Series, Karroo System).
2223	Selotso(Lebung), Central District	322	60	220	182	Cave Sandstone(Stormberg Series, Karroo System).
2224	Maapi, Central District	285	Saline (300 g.p.h.)	130-270	51	Gravel(40'), Waterberg System shale & sandstone (200'), then Basement Complex granite.
2225	Lepane Spruit(Phikwe), Central District	310	Blank	-	-	Basement Complex schist & granite-gneiss.
2226	Lepane Spruit(Phikwe), Central District	200	300	53- 73	52	Basement Complex granite-gneiss.
2227	Sikwane, Kgatleng District	261	600	47-228	32	Basic lavas, decomposed to 120' (Swaziland System?).
2228	Maapi, Central District	213	Saline (5 g.p.h.)	130	95	Waterberg System sandstone & arkose(150') & Basement Complex granite.
2229	Selotso(Lebung), Central District	645	Blank	-	-	Basalt(110') Cave sandstone to 470' (Stormberg Series) then alternations of red shale, siltstone & sandstone (Ecca Series & Red beds, Karroo System).
2230	Letlhakane(Phikwe), Central District	465	2 500	+355,425 462	36	Basement Complex granitic gneiss.
2231	Mabalane, Kgatleng District	263	240	41-132	51	Basement Complex granite & amphibolite.
2232	Pilikwe, Central District	351	Blank (30-50 g.p.h.)	200,215	182	Gravel (40') & Basement Complex granite-gneiss.
2233	Pilikwe, Central District	238	220	207	121	Decomposed dolerite(150') & Basement Complex granite & minor schist.
2234	Gootau, Central District	250	Blank	-	-	Basement Complex granite, decomposed to 125'
2235	MacCloutsi River(Phikwe), Central District	560	300	345	60	Basement Complex granitic gneiss with minor metavolcanics.
2236	Jwana, Ngwaketse District	605	80	220	140	Sand & cherty gravel (60'), vari-coloured gritty quartzitic sandstone (Waterberg System).

Official Number	Locality District	Depth in Feet	Yield in G.P.H.	Depth Water Struck in feet	Static Water Rest Level in feet	Geology
2237	Takane, Central District	331	1 100	234	230	Kalahari Beds(40'), basalt (230') and Cave Sandstone (Karoo System, Stormberg Series).
2238	Mabalane, Kgatleng District	400	Blank (20 g.p.h.)	125	41	Gravel(30') and indurated acid lavas (Age uncertain but possibly Swaziland System).
2239	Lobatse Township	242	+7 000	120,202 230	93	Purplish & grey shale, siltstone & sandstone (Pretoria Series, Transvaal System).
2240	Maitlo a Phuduhudu/cattle route, Nojane, Ghanzi District	550	900	455,476	367	Kalahari Beds (330'), conglomerate, coaly shale, mudstone & sandstone (Beca Series, Karoo System).
2241	Sua Pan, Central District	265	Drilled for brine testing			No samples received.
2242	Lobatse Township	485	+200	194	-	Reddish-brown shales with diabase(90' to 100') (Dospoort Stage, Pretoria Series, Transvaal System).
2243	Lobatse Township	205	4 500	196	+135	Red shale (50') & grey quartzite (Magaliesberg Stage, Pretoria Series, Transvaal System).
2244	Macloutsi River (Phikwe), Central District	550	Blank	-	-	Alluvium(40') & Basement Complex grey gneissic granite.
2245	Foley, Central District	320	In Progress			Gravel(30') & Basement Complex granite-gneiss.
2246	Lobatse Township	150	Blank	-	-	No samples received.
2247	Lobatse Township	90	In Progress			Coarse, cherty overburden & wad(110') & dolomite (Dolomite Series, Transvaal System).
2248	Sikwane, Kgatleng District	400	300	125	105	Micaceous granite-gneiss partly decomposed to 220' (Basement Complex).
2249	Lobatse Township	450	1 600	190	-?	Khaki & grey siltstone & sandstone (Magaliesberg Stage, Pretoria Series, Transvaal System).
2250	Lobatse Township	240	+7 000	175	126	Brown siltstone & shale (150'), then quartzitic sandstone (Magaliesberg Stage, Pretoria Series, Transvaal System).
2251	Lobatse Township	310	Abandoned for Technical Reasons To be used as observation hole 285			No samples received.
2252	Lobatse Township	500	+300	270	?	Magaliesberg Stage quartzitic sandstone, shale & dolomite (Pretoria Series, Transvaal System).
2253	Lobatse Township	430	1 600	335	?	Shale, siltstone & quartzitic sandstone (Magaliesberg Stage, Pretoria Series, Transvaal System).
2254	Lobatse Township	361	15 000	175,340	?+137	Mudstone, siltstone & pyritic sandstone with diabase at 230', 240' and 280', (Magaliesberg Stage, Pretoria Series, Transvaal System).

Number	Location	Area (ha)	Drilling Status	Depth (m)	Core Length (m)	Geological Description	
2257	Macloutsi River(Phikwe), Central District	530		100	120	48	Karoo siltstone & sandstone (180'), then Basement Complex granite.
2258	Maitlo a Phuduhudu/cattle route Nojane, Ghanzi District	659	Drilling in progress				Kalahari Beds (310'), dolerite (465'), mudstone, shale & sandstone, (Ecca Series, Karroo System); gneiss.
2259	Sua Pan, Central District	267	Drilled for Brine Testing				No samples received.
2260	Macloutsi River(Phikwe), Central District	583		200	190 & 200	31	Karroo System sandstones (180') and Basement Complex granite-gneiss.
2261	Lobatse Township	110		3 000	?	40	Dolomite (Dolomite Series, Transvaal System).
2262	Lobatse Township	335		4 000	220, 300	156	Magaliesberg Stage mudstone & quartzitic sandstone (Pretoria Series, Transvaal System).
2263	Lobatse Township	396		800	210	?	Magaliesberg Stage shale, mudstone and quartzitic sandstone; diabase at 320'.
2264	Lobatse Township	350		4 000	225, 340	+99	Smelterskop & Magaliesberg Stage mudstone, shale & quartzitic sandstone (Pretoria Series, Transvaal System).
2265	Lobatse Township	248	+18 000		170, 202	127	Mudstone & shale (150'), then grey, quartzitic sandstone (Magaliesberg Stage, Pretoria, Series, Transvaal System).
2266	Sua Pan, Central District	300	Drilled for Brine Testing				No samples received.
2267	Lobatse Township	110		-	60	60	Cherty gravel and Wad (Dolomite Series, Transvaal System).
2268	Lobatse Township	200		2 000	90, 178	90	Cherty gravel & Wad (100'), then dolomite (Dolomite Series, Transvaal System).
2269	Lobatse Township	200		675	123	97	Cherty gravel (120') and dolomite (Dolomite Series, Transvaal System).
2270	Lobatse Township	260	+4 000		246	+169	Mudstone, shale & quartzitic sandstone (Magaliesberg Stage, Pretoria Series, Transvaal System).
2271	Lobatse Township	220	+15 000		170, 202	-	Brownish grey shale & sugary sandstone (Magaliesberg Stage, Pretoria Series, Transvaal System).
2272	Gweta, Central District	30		1 400	18	12	Kalahari Beds.
2273	Tamasane, Central District	266		1 200	70	60	Gravel & Calcrete(40'), feldspathic sandstone (Middle Ecca Stage, Ecca Series, Karroo System).
2274	10 miles S. of Tamasane, Central District	200		300	110	104	Basement Complex amphibolite, partly decomposed to 120'.
2275	Pandamatenga, Central District	207	Blank		-	-	Basalt (Stormberg Series, Karroo System).
2276	Foley, Central District	400	Blank		-	-	Basement Complex granite-gneiss & minor schist & amphibolite.

Official Number	Locality District	Depth in Feet	Yield in G.P.H.	Depth Water Struck in feet	Static Water Rest Level in feet	Geology
2277	S.of Tamasane, Central District	300	Drilling in Progress			Basement Complex granite.
2278	Lobatse Township	200	+4 500	118	90	Cherty gravel and Wad(110'), then dolomite (Dolomite Series, Transvaal System).
2279	Lobatse Township	253	200	160-170	?	Cherty gravel (110') & dolomite(Dolomite Series, Transvaal System).
2281	Jwana Area, Ngwaketse District	544	Drilling in Progress			Waterberg System sandstone & conglomerate.
2282	Dikwadidi, Kgatleng District	253	Drilling in Progress			Basement Complex granite.
2285	Lobatse Township	259	Drilling in Progress			Cherty gravel, boulders and wad.

Official Number	Locality District	Depth in Feet	Field in G.P.H.	Depth Water Struck in feet	Static Water Rest Level in feet	Geology
2245	Foley, Central District	320	80	40	11	
2247	Lobatse Township	201	BLANK	-	-	
2258	Nojane, Ghanzi District	710	75	621	374	
2277	S. of Tamasane, Central District	300	600	124,276	105	Basement Complex Granite, decomposed to 120'.
2281	Jwana Area, Ngwaketse District	642	600	210,410,482	170	Waterberg System Sandstone & Conglomerate.
2282	Dikwadidi, Kgatleng District	300	BLANK (10 g.p.h.)	265	230	Basement Complex Granite, decomposed dolomite.
2285	Lobatse Township	270	2 400+	120,225		Cherty Gravel, boulders, wad & decomposed dolomite. (Dolomite Series, Transvaal System).
2286	Foley, Central District	280	290	185	36	Decomposed pink gneiss(40'), then spotted lavas, quartzite & schist (Basement Complex).
2287	Molepolole, Kweneng District	57	ABANDONED			Waterberg System quartzitic sandstone.
2288	Chinka Pan, Ngwaketse District	583	1 200	320,550		Kalahari beds (50'), shale, siltstone & quartzitic sandstone to 450'(Waterberg System), then chert & limestone (Dolomite Series, Transvaal System).
2289	Foley, Central District	270	BLANK			Basement Complex granitic gneiss, decomposed to 60'.
2290	Molepolele, Kweneng District	200	360	35- 37	12	Waterberg System ferruginous, quartzitic sandstone.
2291	Foley, Central District	280	BLANK			Granite-gneiss to 110 feet, amphibolite & mafic schist with dolerite(210'), grey gneiss(250'), then mainly biotite schist (Basement Complex).
2292	Foley, Central District	300	BLANK			Basement Complex quartz-biotite-muscovite gneiss & biotite schist.
2293	Foley, Central District	280	BLANK			Basement Complex mica schist with intercalations of gneiss.
2294	Seswe River, Central District	420	220	182,414	54	Decomposed dolerite(90'), pink gneiss(110'), then mafic schist, amphibolite.
2295	Makoba, Central District	350	900	320,332	193	Kalahari Beds(120'), basalt(320') & Cave Sandstone (Stormberg Series, Karroo System).
2296	Thamaga, Kweneng District	252	50	77	23	Gaborone-type granite, decomposed to 90 feet.
2297	Mogudu wa Puti, Ngwaketse District	420	BLANK (5 g.p.h.)	190		Kalahari Beds(117'), Gaborone-type granite (320'), then dolerite & granite.

Official Number	Locality District	Depth in Feet	Yield in G.P.H.	Depth Water Struck in feet	Static Water Rest Level in feet	Geology
2298	Rhikwe, Central District	147	1 200	40&72	35	Basement Complex gneiss, decomposed to 90 feet.
2300	Kanye, Ngwaketse District	642	800	90,362,385 390,408,430	46	Waterberg System quartzitic sandstone (450') and felsite(Kanye Volcanic Group).
2301	Nyamakatse, Central District	450	600	377	225	Kalahari Beds(150'), basalt(370') & Cave Sandstone (Stormberg Series, Karroo System).
2302	Lobatse Township	230	3 600+	176	160	Cherty gravel,(140'), wad & chert (220'), then chert & decomposed dolomite (Dolomite Series, Transvaal System).
2303	Mmopane, Kweneng District	73	ABANDONED			Gaborone-type granite, decomposed to 60 feet.
2304	Modipane, Bakgatla District	187	70	70	46	No samples received.
2305	Seswe River, Central District	175	2 100+	50, 90,115	35	Decomposed dolerite(70'), then Basement Complex mafic schist & amphibolite.
2306	Mmopane, Kweneng District	190	50	81	73	Gaborone-type granite decomposed to 80 feet.
2307	Tsabong, Kgalagadi District	35	ABANDONED			No samples received.
2308	Nojane, Ghanzi District	502	1 200	248,273,365	202	Basalt(100'), Cave sandstone(140'), basalt (200'), Cave Sandstone(280')(Stormberg Series, Karroo System), then carbonaceous mudstone, shale & sandstone(Ecca Series, Karroo System).
2309	Seswe, Central District	250	600	60, 85	40	Recent deposits(30'), then quartz-biotite schist, talc schist, limestone and minor quartzitic sandstone (Basement Complex).
2310	Thamaga, Kweneng District	170	250	96	70	No samples received.
2311	Leselepole, Central District	531	SALINE (60 g.p.h.)	100		Recent Beds(30') & micaceous shale, siltstone & fine-grained sandstone.
2312	Dikwane, Kgalagadi District	350	600	309	270	Kalahari Beds(300'), then Waterberg System quartzitic sandstone.
2313	Odiakwe, Central District	50	1 200	36	26	Kalahari Beds.
2314	Odiakwe, Central District	50	1 200	32- 38	33	Kalahari Beds.
2315	Moshaweng, Kweneng District	105	ABANDONED			No samples.
2316	Moshaweng, Kweneng District	300	40-50	181	110	Gaborone-type granite, decomposed to 130 feet.
2317	Odiakwe, Central District	50	1 200	36	34	Kalahari Beds.

Official Number	Locality District	Depth in Feet	Weight in G.P.H.	Depth in Feet	Weight in Feet	Description
2320	Bushman's Pits, North West District	48	120	27	25	Kalahari Beds.
2321	Bushman's Pits, North West District	38	BLANK(5 g.p.h.)			Kalahari Beds.
2322	Makoba, Central District	550	2 000*	494	201	Kalahari Beds(100'), basalt(494') & Cave Sandstone (Stormberg Series, Karroo System).
2323	Leselepole, Central District	186	600	165	92	Basement Complex granite, decomposed to 150 feet.
2324	Forest Hill, South East District	523	500	80,140, 190,510	57	Gaborone-type granite & granophyre.
2325	Bushman's Pits, North West District	44	240	37	26	Kalahari Beds.
2326	Odiakwe, Central District	40	600	32	27	Kalahari Beds.
2327	Western Nata Ranches, Central District	50	1 200*	36	25	Kalahari Beds.
2328	Western Nata Ranches, Central District	64	BLANK			Kalahari Beds.
2329	Western Nata Ranches, Central District	45	400	36-40	33	Kalahari Beds.
2330	Oodi, Kgatleng District	80	1 350			No samples received.
2331	Tamasane, Central District	260	600	110,219	96	
2332	Merupule, Central District	840	360	180	163	Kalahari Beds(40'), Upper Ecca shales, mudstone & coal(420'), Middle Ecca gritty sandstone, dark shale & siltstone (640'), Dwyka tillite(750'), then Waterberg System quartzitic sandstone.
2333	Mmamoagi, Kweneng District	300	180	209-220 258	145	Waterberg System quartzitic sandstone.
2334	Kolokwaneng, Kgalagadi District	520	50	390	380	
2335	Monametsane, W. Kgatleng District	?	Good	?	?	No samples received.
2336	Merupule, Central District	725	600	150,328	105	Kalahari Beds(50'), Upper Ecca mudstone, shale & coal(510'), Middle Ecca siltstone & sandstone(550'), then Waterberg System quartzitic sandstone.
2337	Metshegaletau, Central District	661	1 800	220,480, 500	265	Kalahari Beds(30'), Cave Sandstone Stage marl & Sandstone(232'), then Middle Ecca Stage, Ecca Series, Karroo System sandstone, shale, mudstone & shaly coal.

Official Number	Locality District	Depth in Feet	Yield in G.P.H.	Depth Water Struck in feet	Static Water Rest Level in feet	Geology
2338	Mosetse River, Central District	340	180	198	134	Recent Beds(30'), decomposed schist(90') & pink gneiss (Basement Complex).
2339	Lepasha, Central District	305	BLANK			Recent Beds (20'), mafic schist(260'), limestone(280') & gneissic granite (Basement Complex).
2340	Kule, Ghanzi District	463	1 800	365	282	Kalahari Beds(70'), sandstone, siltstone, shale & mudstone (Ecca Series, Karroo System).
2341	Lepasha, Central District	280	BLANK(5 g.p.h.)	122	96	Recent Beds(20') & Basement Complex gneissic granite decomposed to 130'.
2342	Bojang Babua Kweneng District (MONWANE)	374	BLANK (10-20 g.p.h.)			Kalahari Beds(70'), gritty sandstone(Middle Ecca Stage, Ecca Series, Karroo System) & diabase.
2343	Mookane, Central District	200	600	?	30	Diabase(190') decomposed to 140' and Waterberg System quartzitic sandstone.
2344	Palapye, Central District	397	2 000	166,328,339 390	50	Recent Beds(30'), Dwyka Series shale & tillite(10') & Waterberg System quartzitic sandstone.
2345	Phudulooga, Central District	330	BLANK			Basement Complex gneissic granite, decomposed to 70'.
2346	Mahalapye, Central District	93	300	65, 85	41	
2348	Tlokweg, S.E. District	186	900	120,141	59	
2349	Makaleng, Central District	195	200	100	85	Basement Complex gneiss & Schist, decomposed to 60'.
2350	Pitsane, Southern District	234	900	78	60	Kanye Volcanic Group felsite, decomposed to 100'.
2351	South East District(Batlokwa)	200	ABANDONED FOR TECHNICAL REASONS			Gaborone-type granite decomposed to 100'.
2352	Mahalapye, Central District	114	SALINE	110	110	No samples received.
2353	Farm 61, Trekkers' End, N.E. District	205	NO WATER			Dolerite(131') and Basement Complex granite.
2354	Kolokwaneng, Kgalagadi District	268	NO WATER			No samples received.
2356	Lentswe, Kgatleng District	550	2 000	485	150	Kalahari Beds(80'), basalt(500') & Cave Sandstone (Stormberg Series, Karroo System).
2357	Masama, Kgatleng District	600	100		550	Basalt(100'), Cave Sandstone(480') & Marly beds (Stormberg Series, Karroo System).
2362	Pitsane, Southern District	200	1 200	170,180	190	Gaborone-type granite, decomposed to 200 feet.

Official Number	Locality District	Depth in Feet	Yield in G.P.H.	Depth Water Struck in feet	Static Water Rest Level in feet	Geology
2365	Trekkers' End, Central District	185	BLANK			Basement Complex granite with dolerite at 80'.
2368	Hildavale, Southern District	106	IN PROGRESS			Broken & decomposed felsite(Kanye Volcanic Group).
2369	Rameutsa, South East District	126	1 200	30-105	20	No samples.