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Record No. 1971/24

First-Order Regional Magnetic Survey of Eastern Australia, 1968

by

D. M. Finlayson

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SUMMARY

The Bureau of Mineral Resources Geology & Geophysics (BMR) has established a network of 72 first-order regional magnetic stations throughout Australia and its Territories. Regular observations at the stations every few years will allow the geomagnetic field and its secular variation to be obtained with greater precision than before.

The first-order survey was initiated in 1968 when 24 stations in southeastern Australia and on Lord Howe Island and Norfolk Island were occupied. A portable variograph was used for the first time, and extended recording allowed first-order precision to be obtained at 21 stations; at the other three, geomagnetic disturbance affected the results.

This survey has proved the practicability of transporting and operating the BMR variograph, and results approaching observatory standards can now be obtained in the field.

1. INTRODUCTION

Land magnetic observations can be categorized into:

First-order observations - the most accurate type of regional magnetic observations outside magnetic observatories, involving the making of variograph recordings for a few days to take into account diurnal and transient variations in the geomagnetic field. The variograph recordings are rigidly controlled using magnetometers calibrated against some national or international standard.

Second-order observations - 6 to 8 sets of magnetic observations are made with magnetometers over a period of about two days but without variograph control. Reference is made to magnetic observatory records up to several thousand kilometres away to allow for diurnal variation.

Third-order observations - a single set of magnetic observations is made at a temporary station.

Most field observations made previously in Australia were second-order observations (van der Linden, 1961, 1965a, 1965b, 1968, 1969).

During 1965 the requirements for regional magnetic mapping were rationalized and it was decided that more accurate geomagnetic secular variation data were required and that a survey method should be designed which would enable the larger regional magnetic anomalies to be mapped. The secular variation of the geomagnetic field is of the order of five gammas per year in intensity and one minute per year in angular measurements, so it was decided that a survey should aim to make observations within the limits $\pm$ 5 gammas in intensity and $\pm$ 1 minute in angular measurement, which could not be achieved with second-order observations. It was then decided to undertake first and third-order surveys to meet these various requirements, with effective uniform station spacings of 500 km and 80 km respectively.

The survey described in this Record was the first of a series of first-order surveys to establish the station network and provide data for the proposed 1970.0 series of isomagnetic maps. Twenty-four stations in Queensland, New South Wales, Victoria, South Australia, and Norfolk Island were occupied during 1968. The stations, all in eastern Australia, are given in Table 1 and indicated in Plate 1. All but four stations had been occupied in previous second-order surveys (van der Linden, 1961, 1965a, 1965b, 1969). The four new stations are Canberra, Parafield, Tibooburra, and Norfolk Island. The bulk of the survey work (22 stations) was carried out by the author during the period 3 April to 8 August 1968, and the work at Lord Howe Island and Norfolk Island was carried out respectively by J. van der Linden during October and by the author in December 1968.

2. METHODS AND EQUIPMENT

Logistics

The survey party that occupied the stations on the mainland and Tasmania travelled in two vehicles, a Holden station sedan and a Holden panel van. The geophysicist was assisted by a field hand. The vehicles were adequate for the survey but wet weather produced bad road conditions in a number of places; this necessitated changes of routes and timetables. Only one station (Etadunna) was omitted from the original schedule because of bad road conditions.

The stations at Lord Howe Island and Norfolk Island were occupied using commercial airline services.

At each site, efforts were made to make the station permanent for the foreseeable future. The sites were cleared of undergrowth and marked with a Bureau of Mineral Resources (BMR) station marker with a white post beside it. The presence of the station was brought to the attention of local authorities and Department of Civil Aviation (DCA) officials, many of whom were not aware of the nature of the work carried out.

Throughout the survey, information was gathered from air photographs, DCA airport plans, etc. to check the latitudes and longitudes of the various stations.

Table 1 summarizes the work carried out at each station.

Variograph

First order magnetic survey observations require variograph control to correct the observations for diurnal and other transient variations in the geomagnetic field. BMR designed and built a three-component fluxgate variograph especially for field use (Seers, in prep.) and the 1968 first-order survey was the first time it was fully operational. For this survey it was decided to record for approximately 48 hours at each station (this was increased to 60 hours for later surveys).

Variograph detectors. The 3 fluxgate detector heads were rigidly mounted mutually at right angles. In the setting-up procedure two detectors were set horizontal and thus the third was vertical. One of the horizontal detectors was orientated in azimuth at right angles to the magnetic meridian at the time of setting up, by obtaining a null signal on the recorder. Thus recordings were obtained of the variation in horizontal intensity (H) and vertical intensity (Z), and also the horizontal intensity variation at right angles to the initial magnetic meridian. This last component was converted to the equivalent variation in declination (D).

Variograph records and timing. The variograph records were produced on three Rustrak recorders operating at a chart speed of approximately 25 mm per hour. Time marks placed on the record were derived from Mercer chronometer No. 19090 which gave a contact closure for 25 seconds each hour.

Variograph scale values. Scale values on the variographs were determined using a BMR fluxgate calibrating unit (Type MCR1). This provided a calibrated d.c. current derived from a zener diode bridge network through a series of standard resistors. The current was fed into the backing-off coils of the individual detectors and the recorder deflections were scaled to give the sensitivity of each component.

The fluxgate detector coil constants were determined in the BMR Design and Development workshops and are given below.

Detector	H	D	Z
Coil constant	2.40	2.41	2.37 gammas per microamp

Scale value tests were made three times every day.

Variograph temperature effects. The variograph exhibited temperature effects, which were reduced by insulating the detecting heads from diurnal temperature variations. This was done with an insulated box so that there was about 20 cm of polystyrene between the detectors and the outside atmosphere. A check was kept of the temperature inside the insulation by reading a thermometer inserted through the insulation. During the first 12 hours (approximately) of recording, the baseline values were found to vary with temperature as it settled down to an optimum value inside the insulation and from these observations temperature coefficients were calculated for the three individual detectors. However, during the remainder of the recording period the temperature inside the insulation remained stable and no corrections to the baseline values were needed to reduce them to a common temperature.

Variograph operation. The electronics and recorders of the three-component fluxgate system were installed in a panel van, and only the detectors with their insulated cover were set up outside the van at each station. The detectors were operated under a tent to reduce solar heating.

Power for the system was derived from two 85 amp-hour lead acid accumulators and these were sufficient for approximately 72 hours' recording. Four batteries were carried so that two could be charged while the other two were in use at the station.

At each site the variograph was set up near the magnetic station marker and allowed to settle down for a period of about an hour. This enabled the electronic components to reach optimum operating conditions. After the settling-down period, magnetic control observations were started.

Since this was the first time the variograph had been used on a survey, an attempt was made to gauge the performance of the equipment. Resultant comments and suggestions are outlined in Appendix 1.

Magnetometers

The instruments used for variograph control were the same at all sites and are listed below together with their corrections. The magnetic elements measured were H, D, and F; vertical intensity (Z) was derived from F and H. Corrections were derived from van der Waal (1966).

Horizontal intensity (H). Instrument - QHM 306. Correction adopted after inter-comparisons with BMR standard = -65 gammas/gauss.

Total intensity (F). Instrument - Elsec proton magnetometer No. 329. No correction applied. An instrument crystal correction measured in 1970 would increase F readings by an average of 4 gammas.

Declination (D). Instrument - Askania declinometer No. 509320. Correction adopted from BMR standard instruments = + 0.3 minutes. Three sets of control observations were made each day at the BMR permanent concrete marker for each station.

For the determination of D, the azimuth of a chosen fixed mark was determined by measuring the hour angle of the sun. Two sets of observations were usually made before and after noon giving a total of four independent determinations. Not infrequently bad weather affected observations so that some were rejected. For the determination of azimuth by this method, good latitude and longitude values are required. The majority of stations were on airfields controlled by DCA, and these usually had an Airfield Reference (ARP) which had been accurately positioned and from which the position of the magnetic station could be measured. At stations where there was no nearby reference point, a good position could usually be determined using aerial photographs and mosaics. Latitudes and longitudes were determined to 0.1 minute, which is sufficiently accurate for the purposes of magnetic surveys.

The number of sets of control observations made at each station is listed in Table 1.

3. RESULTS

Derivation

The following procedure was adopted in obtaining the mean values for the geomagnetic field at the various stations.

(a) All absolute values of H, D, and F were computed, and instrument corrections were applied.

(b) All scale values were computed and a mean was adopted for each station; adopted values are given in Table 2 together with the mean standard deviation of the observed scale values from adopted means.

(c) Baseline values for the variograph records were computed for H and D. The D baselines were computed from the control observations by converting the horizontal-intensity variations normal to the magnetic meridian to an equivalent angular displacement. Baseline values for Z were computed using the measured F value and the value for H derived from the corresponding set of absolute observations, taking into account H field changes as measured on the variograph record.

(d) During the first overnight run of the variograph at each station, the temperature in the detector enclosure settled down to an optimum value which varied very little throughout the remainder of the recording period. Baseline measurements made during the settling-down period enabled the temperature coefficients for the various detectors to be measured. These are given below:-

Component	H	D	Z
Temperature coefficient	-2.6 gammas/^{o}C	-0.19 minutes/^{o}C	-4.4 gammas/^{o}C

After the overnight settling-down period, the temperature inside the outer detector enclosure had a mean range of 1.2 ± 0.5C^{o}. Because the detectors had yet further insulation immediately surrounding them, it is estimated that the range of temperature experienced by the detectors at any station was approximately 1.0^{o}. This would lead to an approximate uncertainty in H, D, and Z of ± 2 gammas, ± 0.1 minutes, and ± 2 gammas respectively.

Because the accuracy to which the survey aspired was ± 5 gammas or ± 1 minute, it is felt that the measures taken to reduce the temperature effects to negligible proportions were successful.

(e) A 24-hour period was adopted at each station which had (a) stabilized temperature in the detector enclosure, (b) the minimum amount of magnetic disturbance, and (c) a sufficient number of baseline values. This 24-hour record was scaled to give hourly mean values of H, D, and Z.

The adopted baseline values for H, D, and Z are given in Table 3 together with standard deviation of the observed values from the adopted values. The mean values of H, D, and Z for the adopted 24-hour observation period are given in Table 4. The mean hourly values are graphed in Plates 2-5.

At six stations it was necessary to obtain site differences between the present site and the sites used in the most recent surveys done in previous years. This involved making a full set of magnetic observations at the old site and tying them to the present site through the variograph baseline values. The resultant corrections to H, D, and Z observations at the old sites in order to tie them to the 1968 sites are given in Table 5.

The station at Lord Howe Island was occupied by J. van der Linden during the last week in October while he was carrying out the third-order regional magnetic survey of northern New South Wales. The fluxgate magnetometer was not used at this station but observations were made at intervals during the daylight hours. The listed results from Lord Howe Island were obtained by taking the mean of 15 sets of absolute observations made during the daylight hours.

The results from Norfolk Island were obtained from the newly established first-order station on the airfield. However, because of the volcanic origin of the island, spot readings were made at three subsidiary stations in order to obtain an estimate of the variability of the magnetic components throughout the island. These results are listed in Table 6. In addition, total-intensity surveys were carried out in the vicinity of the first-order station on the airport and on a road traverse across the island. These results are presented in Plates 6 and 7.

Precision

The accuracy of the results can be assessed by considering (a) errors resulting from the observing and recording systems, and (b) errors introduced by magnetic disturbances and phenomena.

Observational errors. The standard deviations of the observed scales values from the adopted mean values are given in Table 2. The error in scale value determination would lead to a maximum error in H, D, and Z of ± 1 gamma, ± 0.3 minutes and ± 2 gammas respectively at the limits of the recording chart. However, because the recordings were always made as close to the centreline (baseline) of the chart as possible the errors introduced into the measured field values due to scale value uncertainty are not significant for H and are of the order of ± 0.1 minutes and ± 1 gamma for D and Z respectively.

The standard deviations of the observed baseline values from the adopted values are given in Table 3. These give a measure of the accuracy of the methods of carrying out absolute observations, the stability of the electrical components of fluxgate variographs, and the stability of the temperature inside the detector insulation after it has settled down to an optimum value.

The standard error of the azimuth determinations from the adopted values is ± 0.8 minutes, and this is the main source of error in the determination of D.

A combination of the errors in the methods of determining the geomagnetic field values indicate errors in H, D, and Z of ± 3 gammas, ± 0.9 minute and ± 4 gammas respectively, which are within the ± 5 gammas, ± 1 minute and ± 5 gammas accuracy to which the survey aspired.

Errors caused by geomagnetic disturbance. Magnetic disturbance during the period of recording may influence the mean values of H, D, and Z so that they are not representative of the undisturbed values.

A measure of the level of magnetic disturbance is given by the K-index, and Table 7 gives the sum of the K-indices, the C-index, and reported phenomena at Toolangi Observatory on the days when field observations were made. However, the K- and C-indices do not give an immediate numerical measure of the field disturbance or an indication of the post-perturbation effects of magnetic storms and effects of other phenomena. A measure of this is given in Table 8, which lists the difference between the monthly mean for the 5 International Quiet Days and the daily mean at Toolangi Observatory on the days when field observations were made.

It will be seen from Table 8 that H is affected most by magnetic disturbance. If an arbitrary value of 15 gammas is taken as the limit above which the disturbance seriously distorts the mean values, the observations at Grafton, Roma, and Hobart must be regarded as untypical, and an effort should be made to re-occupy the stations.

4. CONCLUSIONS

First-order magnetic survey observations of H, D, and Z were made at 24 stations throughout eastern Australia during 1968, but the results from three stations are doubtful because of magnetic disturbance during the observation period. The observing method achieved the ± 5 gammas accuracy in H and Z and ± 1 minute accuracy in D to which it aspired, and with some alterations it should be used to make observations at the other first-order stations in the Australian network to provide data for the compilation of the 1970.0 series of isomagnetic charts.

5. ACKNOWLEDGEMENTS

The author would like to express his appreciation of the assistance rendered by the staff of the Department of Civil Aviation, the Weapons Research Establishment (Woomera), and the Ionospheric Prediction Service Division of the Bureau of Meteorology (Norfolk Island) during the course of the survey.

6. REFERENCES

SEERS, K.J., - Handbook for three-component fluxgate magnetometer, MFR1. Bur. Min. Resour. Aust. Rec. (in prep.).

SERSON, P.H., and HANNAFORD, W.L.W., 1956 - A portable electrical magnetometer. Can. J. of Tech. 34, 232.

VAN DER LINDEN, J., 1961 - Regional magnetic survey of Queensland and NSW, 1960. Bur. Min. Resour. Aust. Rec. 1961/10 (unpubl.).

VAN DER LINDEN, J., 1965a - Regional magnetic surveys in Australia, Australian Antarctica, and the Territory of Papua & New Guinea, 1962. Bur. Min. Resour. Aust. Rec. 1965/20 (unpubl.).

VAN DER LINDEN, J., 1965b - Regional magnetic surveys in Australia, Australian Antarctica and the Territory of Papua & New Guinea during 1963. Bur. Min. Resour. Aust. Rec. 1965/218 (unpubl.).

VAN DER LINDEN, J., 1968 - Regional magnetic surveys in Australia, Australian Antarctica, and on some islands in the Pacific and Indian Oceans during 1964. Bur. Min. Res. Aust. Rec. 1968/2 (unpubl.).

VAN DER LINDEN, J., 1969 - Regional magnetic surveys in Australia, 1965 and 1966. Bur. Min. Resour. Aust. Rec. 1969/5 (unpubl.).

VAN DER WAAL, C.A., 1966 - Corrections for absolute and semi-absolute magnetic instruments. Bur. Miner. Resour. Aust. Rec. 1966/207 (unpubl.).

APPENDIX 1

PERFORMANCE OF BMR THREE-COMPONENT FLUXGATE VARIOGRAPH SYSTEM

The BMR three-component fluxgate variograph system MFR1 was used on a field survey for the first time during the 1968 first-order survey, and what follows is an account of its suitability for field work and how it might be improved.

Summary of development work

The instrument was designed from the work in Canada of Serson and Hannaford (1956). A description of the instrument is given in the handbook (Seers, in prep.). The main difficulties experienced during development were connected with (a) mutual interference of detector heads, (b) movement of the fluxgate detectors in their mountings, and (c) temperature effects in the detector heads and electronics. The mutual interference effects were deemed to be tolerable since the instrument was going to be used only as a variograph and not as an absolute magnetic standard. The movement of the heads was eliminated by altering the mountings so that the detectors were held in rigid instead of in spring mountings.

Temperature effects

The effect of temperatures likely to be experienced during field work on the electronic components was found to be negligible but the effect on the detector heads was quite significant and proved difficult to eliminate. Eventually an insulated cover was constructed which reduced the diurnal range in temperature to approximately one degree centigrade, as mentioned earlier in this report. A fly-sheet was erected over the insulated cover at each site to reduce solar heating, but during strong winds the cooling/heating rate increased greatly. The temperature coefficients found during the survey (see RESULTS) will be used to design an electronic compensation circuit for use in future surveys.

Fluxgate electronics

The fluxgate electronics performed well throughout the survey but at Hobart the backing-off current was not sufficient for Z. The whole range of backing-off currents for H and Z will have to be extended if the instrument is to be used in the Antarctic or equatorial regions. Setting-up of the instrument was normally easy but an oscilloscope had to be used on a number of occasions for fault finding.

Recorders

The Rustrak recorders consumed about 1.5 amps at 12 volts and necessitated the carrying of four accumulators. It was felt that with a single three-pen recorder the power consumption could be reduced and thus a smaller power pack could be used. The power consumption of the electronics amounted to only 300 milliamps at 12 volts.

Some difficulty was experienced with the recording paper in that the Australian manufactured paper had a tendency to absorb moisture and tear at the sprocket holes in humid climates.

Scale value unit

The Fluxgate Magnetometer Calibrating unit MCR1 performed well during the survey but with further development this unit could be incorporated in the main electronic units. The meter could be eliminated since it is liable to damage during rough field conditions.

Chronometer

The Mercer chronometer used to impress hour marks on the records was not reliable and had a considerable rate under the conditions in which it operated. A Bulova watch with contacts is more suitable for this type of field work.

Cables and connexions

Because of the 3-chassis construction and external connexion of all units, a large number of plugs and sockets had to be maintained, and those were always a source of worry because of the dusty conditions and hard wear imposed on the equipment. Faults developed in the connectors on a number of occasions.

The main cable to the detector heads was only 7 metres long and thus the detector could be located only about 5 metres from the panel van. This meant that after the instrument was set up, none of the doors in the van could be opened without disturbing the magnetic field 'seen' by the detectors. The cable should be about 50 metres long to eliminate vehicle disturbance, but unfortunately no suitable cable was available in Canberra before the survey commenced.

TABLE 1

SUMMARY OF WORK CARRIED OUT AT SITES

Station	Date, 1968	No. of hours	No.of control observations	Remarks
Canberra	30/4-1/5	31	4	New site at BMR test hut, Kowen Forest. Battery fault.
Newcastle	4-5/5	49	5	Williamtown RAAF Station.
Grafton	7-8/5	35	3	Airport. Wet weather and battery failure.
Maryborough	17-18/5	48	6	1955 Airport site used. Site difference for 1965 site determined. Not a good site. Scale-value calibrator fault.
Roma	20-22/5	47	5	Airport. New site established approx. 100 metres from old site. Site differences determined.
Moree	24-26/5	48	6	Airport. Recommend establishment of new site farther from airport buildings.
Condobolin	28-29/5	45	4	Race-track. New track has been laid but managed to find old site.
Hobart	11-13/6	66	7	Airport. Magnetic disturbance during recording. (No Z trace because fluxgate backing-off current not large enough).
Portland	17-19/6	48	5	New site established at airport. Site differences measured from old site.
Warracknabeal	20-22/6	48	7	Race-track.
Mildura	23-25/6	48	6	Airport.
Parafield	26-28/6	48	6	New site on airport.
Port Lincoln	4-5/7	30	5	Airport. Site differences measured from old site in town.
Ceduna	6-8/7	48	5	New site on airport. Site differences measured from old site on golf course.
Woomera	11-13/7	48	6	E152 site.
Tibooburra	16-18/7	48	6	New site on airport.
Wilcannia	20-22/7	45	6	Airport.
Bourke	23-25/7	46	6	Airport.

TABLE 1 (Continued)

SUMMARY OF WORK CARRIED OUT AT SITES

Station	Date, 1968	No. of hours	No. of control observations	Remarks
Quilpie	26-27/7	47	6	Airport.
Winton	30/7/-1/8	49	7	Race-track.
Boulia	2-4/8	48	6	New site on airport. Site differences measured from old site in town.
Birdsville	6-9/8	45	5	Airport.
Lord Howe Island	24-30/10	XXX		Re-occupation of site near jetty.
Norfolk Island	11-16/12	75	6	New site on airfield.

XXX indicates no variograph record.

TABLE 2

ADOPTED SCALE VALUES

Station	H gammas/div.	D gammas/div.	D mins./div.	Z gammas/div.
Canberra	4.48	3.77	0.54	4.53
Newcastle	4.61	3.79	0.50	4.54
Grafton	4.69	5.51	0.68	4.58
Maryborough	4.57	5.27	0.60	4.57
Roma	4.56	5.31	0.62	4.52
Moree	4.69	5.39	0.67	4.48
Condobolin	4.67	5.26	0.71	4.47
Hobart	4.98	6.04	1.09	XXXX
Portland	4.85	5.56	0.88	4.39
Warracknabeal	4.67	5.40	0.80	4.32
Mildura	4.74	4.97	0.70	4.39
Parafield	4.75	4.88	0.71	4.70
Port Lincoln	4.77	4.82	0.70	4.85
Ceduna	4.76	4.81	0.65	4.82
Woomera	4.74	4.82	0.64	4.81
Tibooburra	4.70	4.85	0.61	4.89
Wilcannia	4.73	4.89	0.64	4.74
Bourke	5.02	4.92	0.62	4.71
Quilpie	4.41	4.84	0.57	4.32
Winton	4.37	4.83	0.53	4.63
Boulia	4.39	4.84	0.53	4.67
Birdsville	4.53	4.84	0.56	4.59
Lord Howe Island	XXXX	XXXX	XXXX	XXXX
Norfolk Island	4.62	4.66	0.55	4.84
SD of scale values from adopted values	±0.04	±0.05	±0.01	±0.06

1 div. = 1 mm in centre of recording chart

XXXX indicates no variograph record

TABLE 3

ADOPTED BASELINE VALUES

Station	H gammas	D ° '	Z gammas
Canberra	24206	11 35.2	53872
Newcastle	25964	11 28.2	51387
Grafton	27782	11 00.0	47918
Maryborough	30278	9 58.7	43600
Roma	29579	9 05.1	45336
Moree	27617	10 03.4	48599
Condobolin	25468	9 42.3	52354
Hobart	19101	13 29.2	XXX
Portland	21588	8 36.8	57665
Warracknabeal	23064	9 16.1	55764
Mildura	24380	8 27.6	54082
Parafield	23624	7 33.5	55214
Port Lincoln	23802	5 02.7	55586
Ceduna	25222	4 54.5	53115
Woomera	25961	6 07.3	51775
Tibooburra	27422	7 52.0	49610
Wilcannia	26148	8 31.5	51371
Bourke	27188	9 02.9	49531
Quilpie	29249	7 50.3	46168
Winton	31447	6 57.2	41327
Boulia	31187	6 30.9	42217
Birdsville	29530	6 13.6	46000
Lord Howe Island	XXX	XXX	XXX
Norfolk Island	29122	14 27.4	43769
SD of baseline values from adopted values	± 3	±0.4	±4

XXX indicates no variograph record

TABLE 4

MEAN VALUES OF H, D, AND Z

Station	Lat. S °	'	Long. E °	'	Date 1968	D °	'	H gammas	Z gammas
Canberra	37	17.3	149	18.0	1/5	11	38.1	24198	53881
Newcastle	32	47.8	151	50.0	5/5	11	26.8	25965	51404
Grafton	29	46.0	153	01.2	8/5	10	51.4	27799	47924
Maryborough	25	31.3	152	43.7	18/5	9	58.4	30264	43631
Roma	26	33.7	148	46.8	21/5	8	59.0	29565	45337
Moree	29	30.0	149	53.0	25/5	10	02.7	27631	48608
Condobolin	33	06.0	147	08.1	29/5	9	42.4	25468	52352
Hobart	42	49.7	147	30.2	13/6	13	24.3	19057	60120
Portland	38	23.1	141	37.4	18/6	8	34.2	21603	57645
Warracknabeal	36	15.1	142	24.3	21/6	9	15.9	23083	55773
Mildura	34	14.3	142	05.1	24/6	8	29.2	24389	54089
Parafield	34	47.5	138	38.6	27/6	7	31.9	23618	55204
Port Lincoln	34	36.5	135	52.4	4/7	5	03.6	23779	55596
Ceduna	32	07.8	133	42.8	7/7	4	53.0	25222	53103
Woomera	31	06.1	136	46.9	12/7	6	05.7	25976	51766
Tibooburra	29	26.9	142	03.2	17/7	7	52.1	27442	49607
Wilcannia	31	30.9	143	22.7	21/7	8	33.3	26170	51370
Bourke	30	03.1	145	57.1	24/7	9	03.5	27184	49528
Quilpie	26	36.5	144	15.2	27/7	7	44.1	29229	46168
Winton	22	23.9	143	03.5	31/7	7	00.7	31446	41333
Boulia	22	54.8	139	53.5	3/8	6	29.7	31174	42220
Birdsville	25	54.6	139	21.1	7/8	6	15.3	29500	46020
Lord Howe Island	31	31.4	159	03.9	27/10	14	28.7	27534	48607
Norfolk Island	29	02.5	167	56.2	13/12	14	31.4	29134	43769

TABLE 5

CORRECTIONS TO BE APPLIED TO OLD SITE OBSERVATIONS

Station	H gammas	D minutes	Z gammas
Maryborough	+105	-16.3	+181
Roma	0	- 0.1	- 5
Portland	+183	-18.8	- 97
Port Lincoln	+179	- 3.3	+372
Ceduna	-146	-18.3	+103
Boulia	+ 24	+ 4.2	+ 40

TABLE 6

MAGNETIC OBSERVATIONS AT NORFOLK ISLAND SUBSIDIARY SITES

	H gammas	D ° '	Z gammas
First-order station	29134	14 31.4	43769
Site 2	28954	15 28.4	43721
Site 3	28715	15 48.4	43947
Site 4	28852	13 17.0	44912

Note: 1) The results from the first-order station are given for reference.

2) The results from the subsidiary sites 2, 3, and 4 should not be given the same weight as those from the first-order station.

3) The locations of the subsidiary sites are given in Plate 7.

TABLE 7

MAGNETIC DISTURBANCE PARAMETERS

Station	Date 1968	K-index Sum (Toolangi)	C-index (Toolangi)	Reported magnetic phenomena (Toolangi)	UT	
Canberra	1/5	19	1	1/5/68	1429	bps
Newcastle	5/5	05	0	-		
Grafton	8/5	12	0	7/5/68	0032	storm (ssc) Kmax=6
					1157	bps
Maryborough	18/5	16	0	18/5/68	1441	bp
Roma	21/5	22	1	20/5/68	1118	bp
Moree	25/5	11	0	-		
Condobolin	29/5	15	0	-		
Hobart	13/6	32	1	10/6/68	2153	storm(ssc) Kmax=6
Portland	18/6	20	1	16/6/68	10..	storm Kmax=5
Warracknabeal	21/6	05	0	-		
Mildura	24/6	04	0	-		
Parafield	27/6	18	0	27/6/68	1154	bp
Port Lincoln	4/7	15	0	3/7/68	0755	bp
Ceduna	7/7	12	0	7/7/68	0650	bp
Woomera	12/7	06	0	9/7/68	20..	storm Kmax=5
Tibooburra	17/7	09	0	17/7/68	1203	bp
Wilcannia	21/7	08	0	-		
Bourke	24/7	02	0	23/7/68	0735	bp
				23/7/68	1507	bp
Quilpie	27/7	16	0	-		
Winton	31/7	07	0	-		
Boulia	3/8	18	1	-		
Birdsville	7/8	22	1	6/8/68	1416	bp
				7/8/68	1119	bps
Lord Howe Island	27/10	12	0	26/10/68	1832	ssc
Norfolk Island	13/12	13	0	11/12/68	1509	si

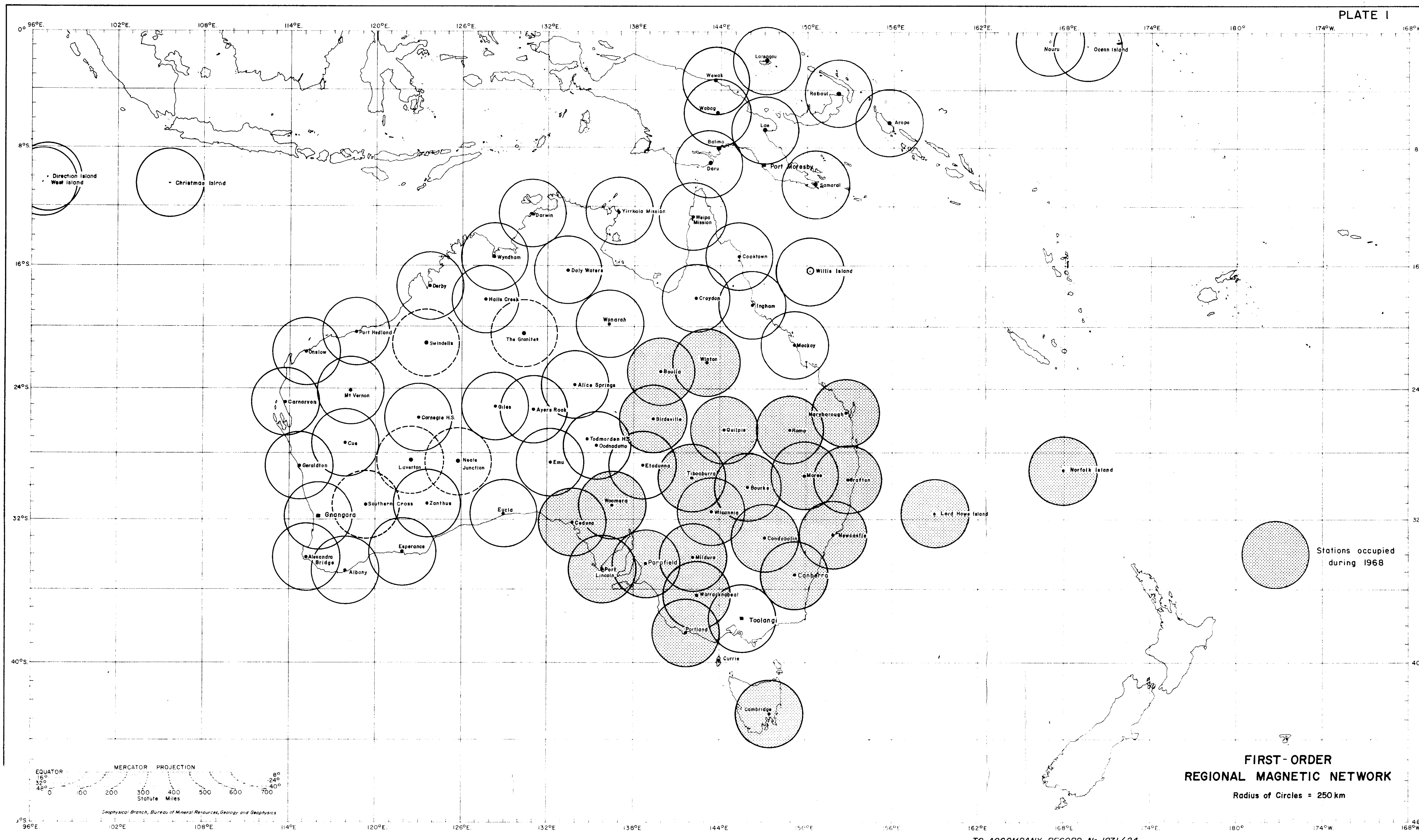
TABLE 8

DISTORTION OF H, D, AND Z AT TOOLANGI

	Date 1968	dH gammas	dD minutes	dZ gammas
Canberra	1/5	6	-0.4	-1
Newcastle	5/5	-1	0.1	-1
Grafton	8/5	24	0.1	-9
Maryborough	18/5	12	0.7	-1
Roma	21/5	26	0.4	-3
Moree	25/5	14	0.0	-4
Condobolin	29/5	12	-0.4	-4
Hobart	13/6	57	0.9	-17
Portland	18/6	15	0.2	-5
Warracknabeal	21/6	2	0.2	0
Mildura	24/6	0	0.2	-2
Parafield	27/6	-2	0.2	1
Port Lincoln	4/7	8	-0.6	-5
Ceduna	7/7	2	-0.1	-4
Woomera	12/7	9	0.2	-2
Tibooburra	17/7	5	-0.1	-2
Wilcannia	21/7	-1	0.3	1
Bourke	24/7	4	0.3	-1
Quilpie	27/7	9	0.3	-2
Winton	31/7	0	0.2	3
Boulia	3/8	-1	-1.1	1
Birdsville	7/8	11	-0.2	-1
Lord Howe Island	27/10	1	0.0	2
Norfolk Island	13/12	0	-0.5	-4

d = (Numerical Monthly Mean for 5 Quiet Days) - (Numerical Daily Mean)

PLATE I



FIRST-ORDER REGIONAL MAGNETIC NETWORK

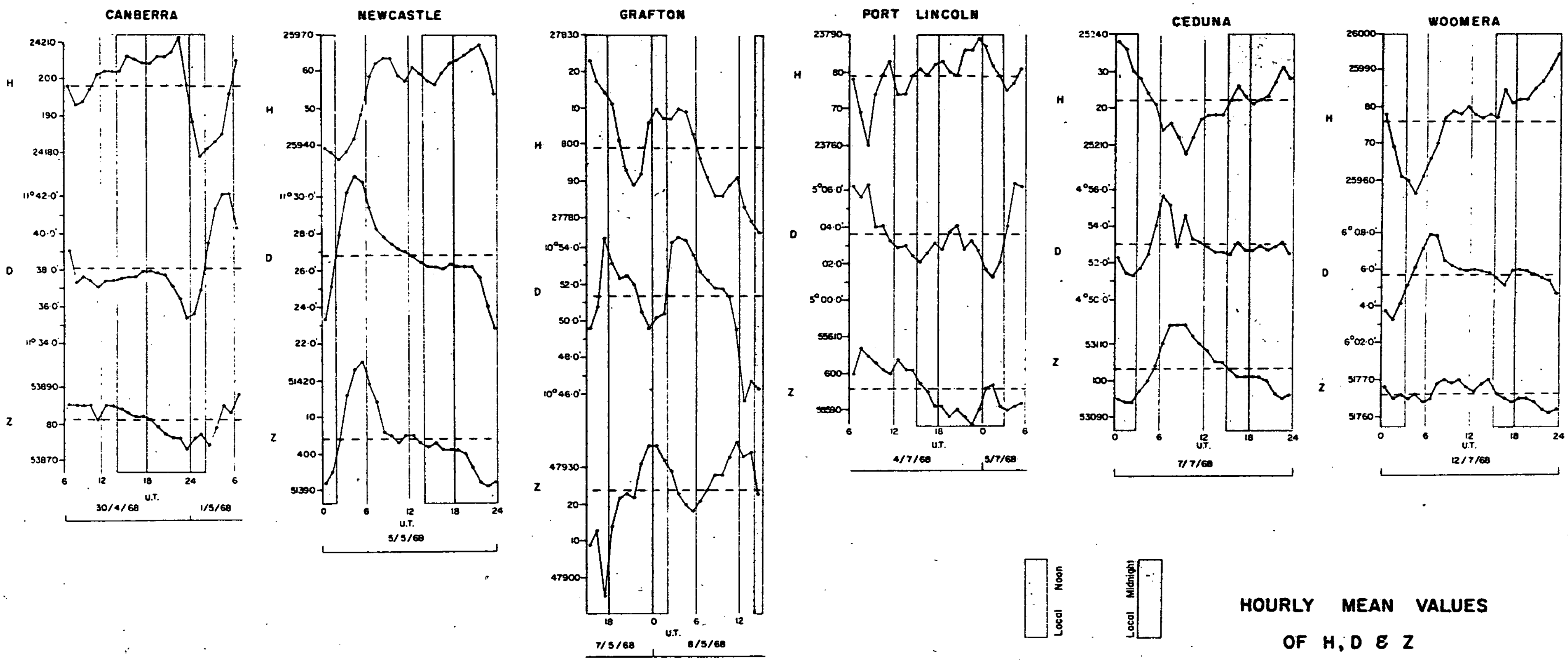
Radius of Circles = 250 km

TO ACCOMPANY RECORD No 1971/24

(Based on G20-14)

G96-315

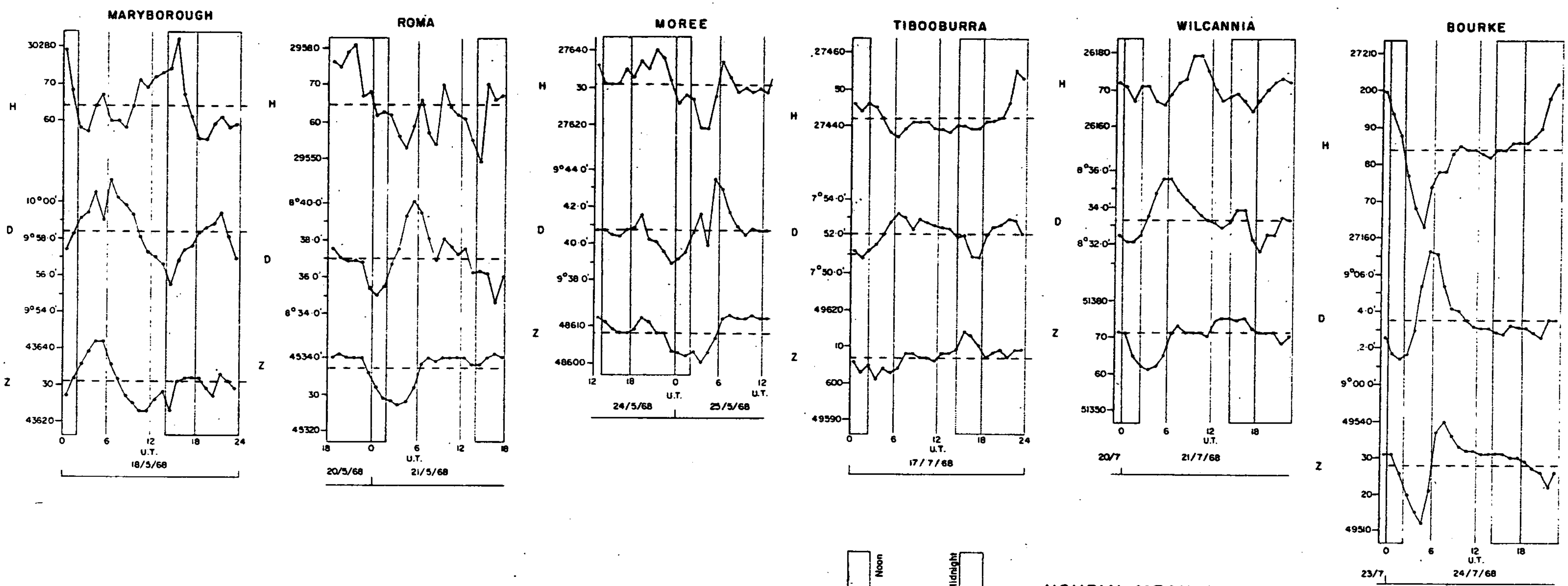
PLATE 2



HOURLY MEAN VALUES OF H, D & Z

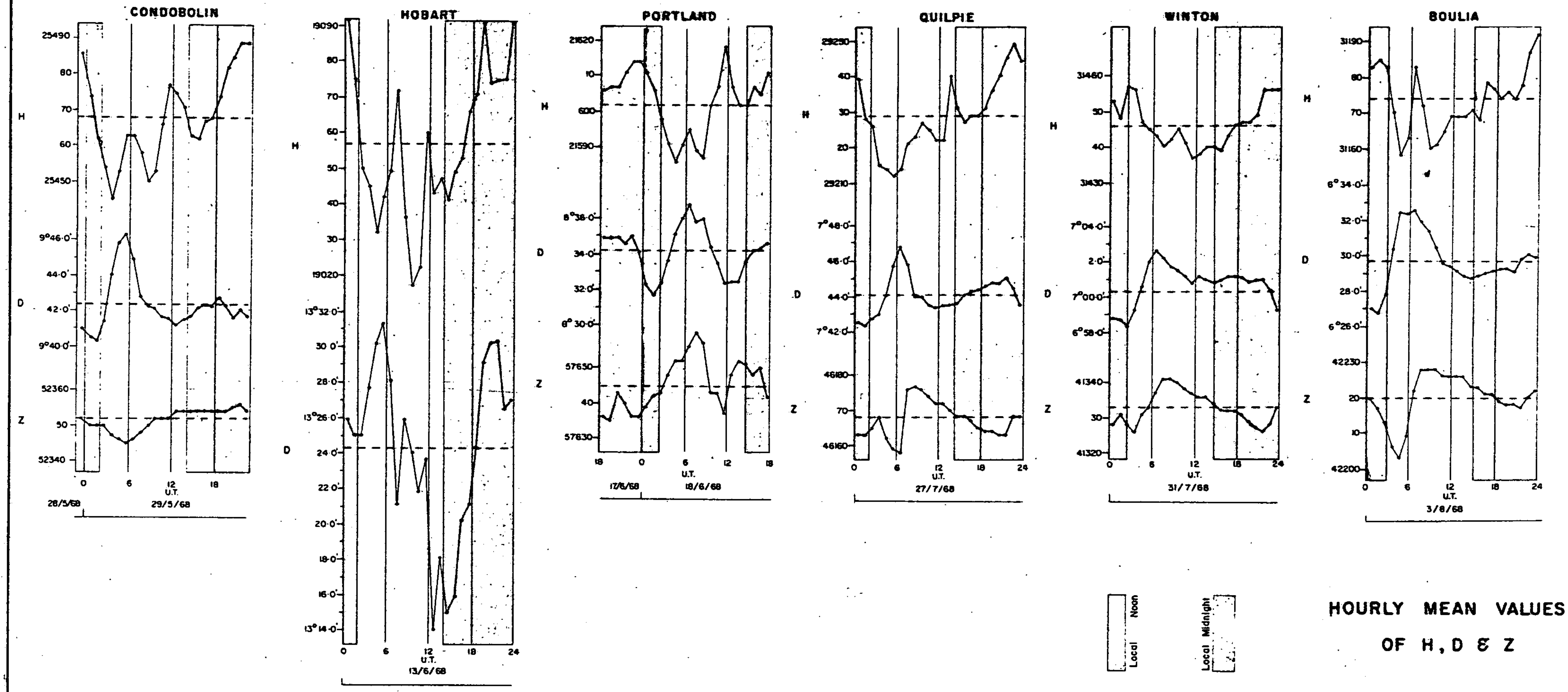
TO ACCOMPANY RECORD No.1971/24

G96-317



HOURLY MEAN VALUES OF H, D & Z

PLATE 4

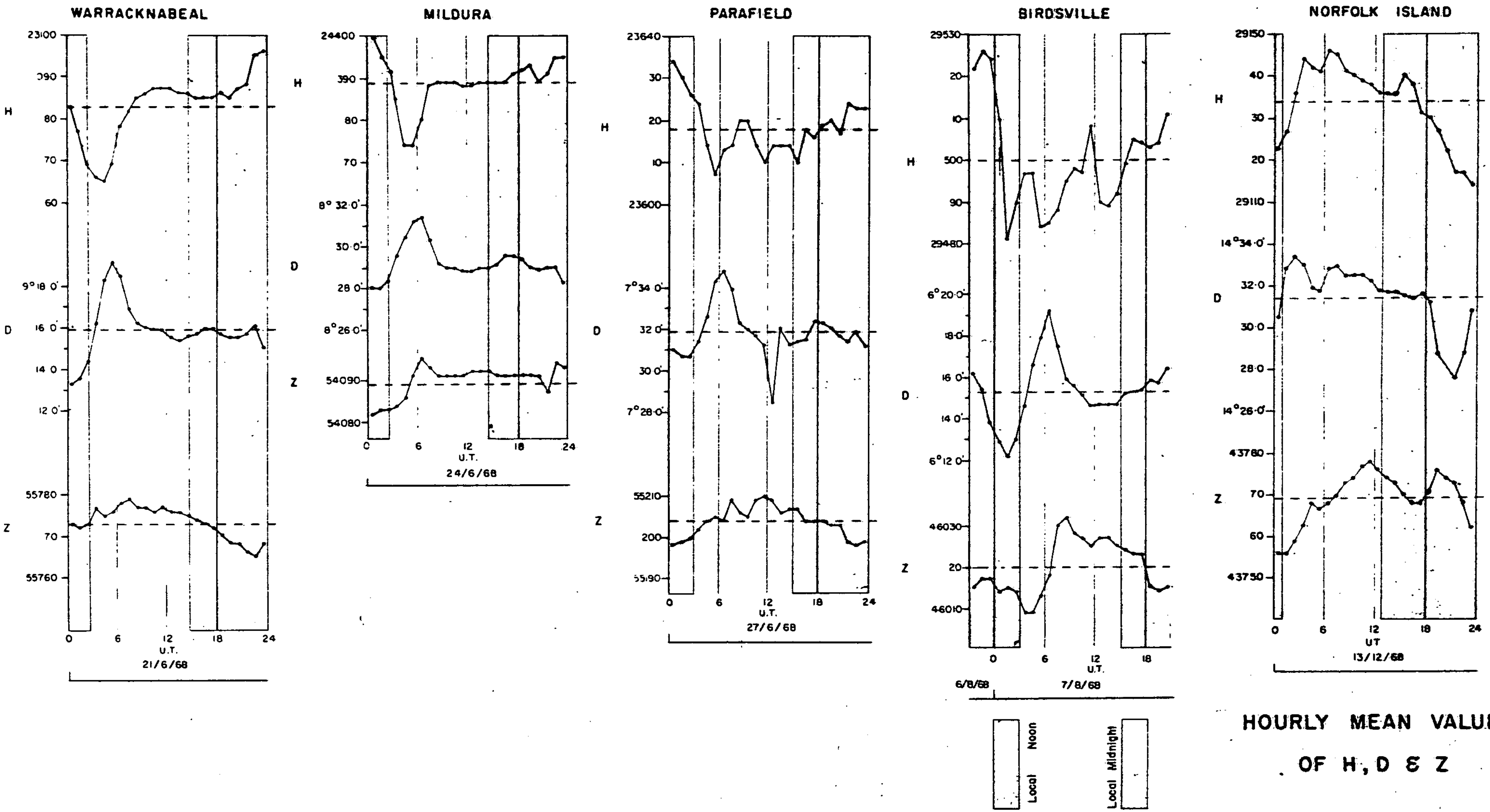


HOURLY MEAN VALUES OF H, D & Z

TO ACCOMPANY RECORD No. 1971/24

G96-319

PLATE 5



HOURLY MEAN VALUES OF H, D & Z

TO ACCOMPANY RECORD No.1971/24

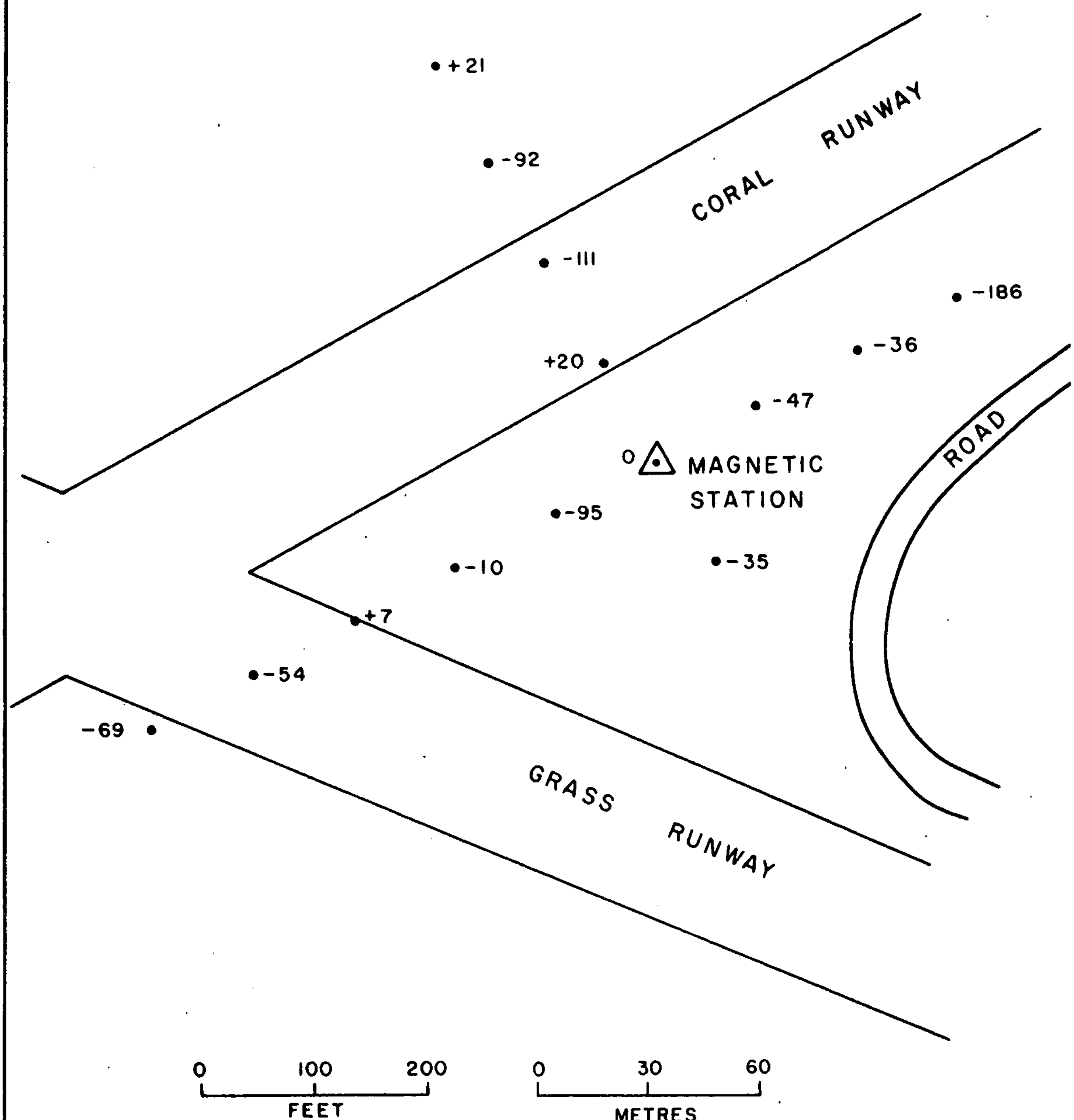
G96-320

PLATE 6

NORFOLK ISLAND

MAGNETIC STATION RECONNAISSANCE SURVEY

AIRFIELD AREA



Total Intensity Difference Indicated: *H* • +24 (gamma)

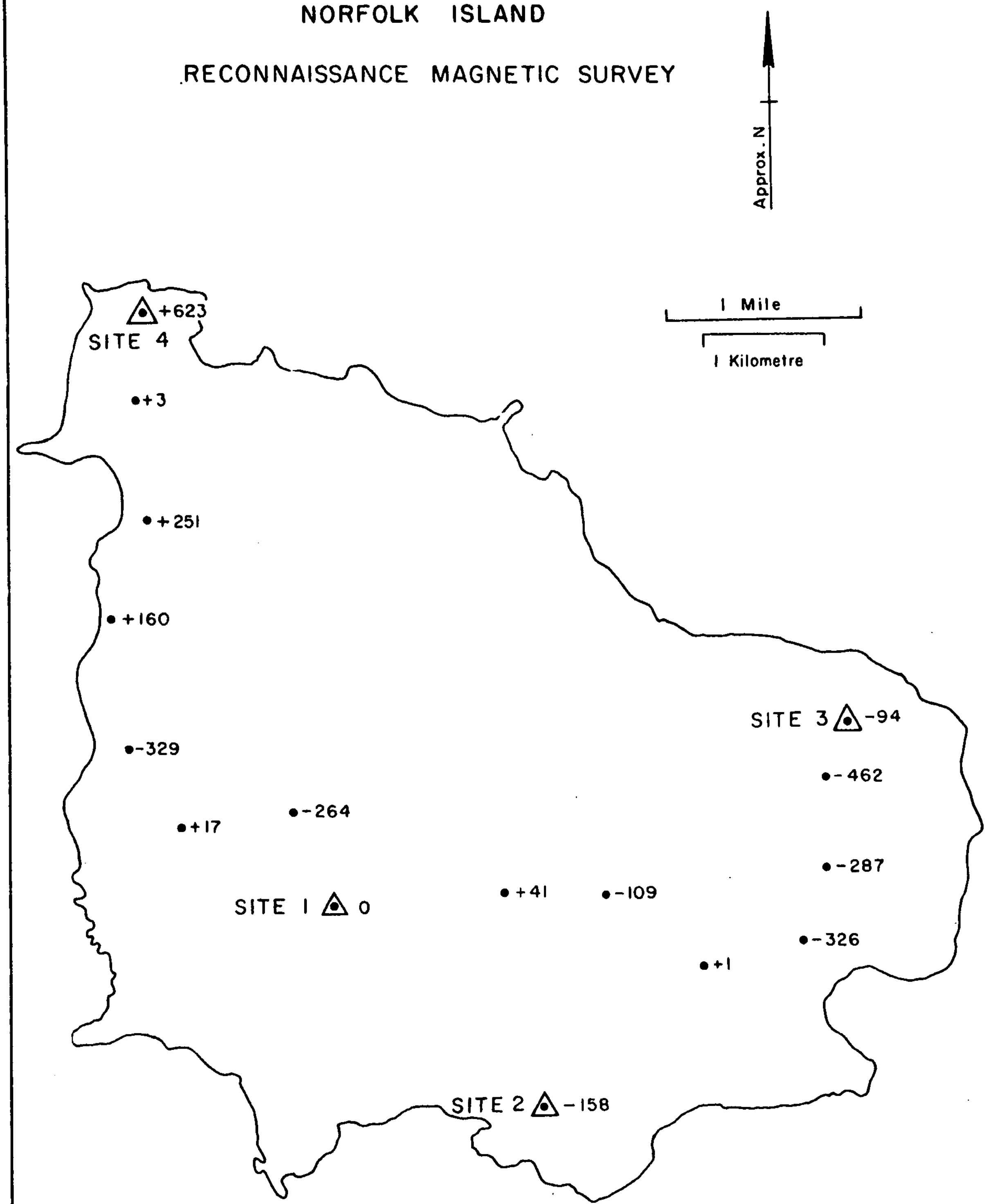
TO ACCOMPANY RECORD No.1971/24

G96-323A

PLATE 7

NORFOLK ISLAND

RECONNAISSANCE MAGNETIC SURVEY



Total Intensity Difference Indicated : + 251 (gamma)

Site 1 is the First-Order Station on Airfield

TO ACCOMPANY RECORD No. 1971/24

G96-322A