Bureau of Mineral Resources, Geology & Geophysics

R E C O R D

BMR RECORD 1991/76

FIRST-ORDER REGIONAL MAGNETIC SURVEY OF PAPUA NEW GUINEA, APRIL - MAY 1989

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S.D. Dennis, A.P. Hitchman and A.J. McEwin

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Department of Primary Industries and Energy
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Geophysical Observatories and Mapping Branch

BMR

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SUMMARY

During April and May 1989 six magnetic repeat stations in Papua New Guinea were visited to collect data on the rate of change and strength of the magnetic field of the Earth in the region, for use in production of charts and the Australian Geomagnetic Reference Field model for 1990.0.

The survey was organized in cooperation with the Port Moresby Geophysical Observatory of the PNG Geological Survey. The survey team consisted of a geophysicist from the observatory and S Dennis from the Geomagnetism Section, BMR Canberra.

The stations at Gurney, Daru, Aropa, Kavieng, Momote and Wewak are part of a network of stations throughout Australia and the southwest Pacific which are visited approximately every five years for this purpose. At each station variations of the magnetic field were recorded for three or four days. During this time frequent absolute observations of the field were made to calibrate the recorded variations. From these data values, representative of the long term quiet field at the station were determined.

The observed field values and preliminary mean hourly values for declination, horizontal, vertical and total intensity are reported, together with adopted quiet field values for each station at the epoch of occupation. Plots of the secular variation of declination, inclination, total and horizontal intensity since 1980 are presented as well as adoptions of the field extrapolated to 1990.0.

Station residuals are derived against the United States Geologic Survey candidate model (USGS90) for the International Geomagnetic Reference Field model (IGRF90).

CONTENTS

1. INTRODUCTION

As part of its role in monitoring and developing an understanding of the natural environment the BMR operates a network of magnetic stations throughout Australia, Papua New Guinea and some southwest Pacific nations (Figure 1). These stations are visited at approximately five year intervals to collect data on the rate of change of the strength and direction of the magnetic field of the Earth. These data augment that which is obtained by continuously monitoring the field at the five well separated magnetic observatories in the region.

The stations are occupied to 'first-order' standards. Variations of the field (in declination and horizontal, vertical and total intensities) are measured on location for a period which preferably includes at least two nights of little magnetic activity. During the occupation frequent absolute measurements are made at known times to calibrate the recorded variations over the whole occupation. After correcting for any magnetic storm effects by comparing the morphology and magnitude of these variations with data from the nearest observatory, values of the strength and direction of the long term quiet magnetic field are adopted for each station. These data form part of the set of first-order and observatory data from the Australian region used to produce a numerical model of the geomagnetic field (the Australian Geomagnetic Reference Field) and epoch charts of the seven elements of the vector magnetic field every five years. The data are also sent to the World Data Center in Colorado for use in global models.

During April and May 1989 six of the magnetic stations in Papua New Guinea were occupied to upgrade field values to epoch 1990.0. They had been previously visited by BMR in 1985 (Hitchman and Bibot, 1987). Occupation of the Australian stations for epoch 1990.0 was completed in 1988 (Hitchman 1990a) and the Pacific stations in 1989 (Hitchman 1990b).

The six PNG stations were visited using domestic commercial flights. At each station vehicles were hired to transport the observers and equipment. Data were collected at Gurney, Daru, Aropa, Kavieng, Momote and Wewak.

Staff from the Port Moresby Geophysical Observatory assisted BMR's Stewart Dennis with the survey; Ian Ripper, the Officer in Charge, with organisational aspects in PNG, and geophysicists Luke Bibot (Gurney), Marburu Burom (Daru), Lawrence Anton (Aropa, Kavieng) and Mathew Moihoi (Kavieng, Momote, Wewak) with the re-occupations at the stations indicated.

2. PREPARATION

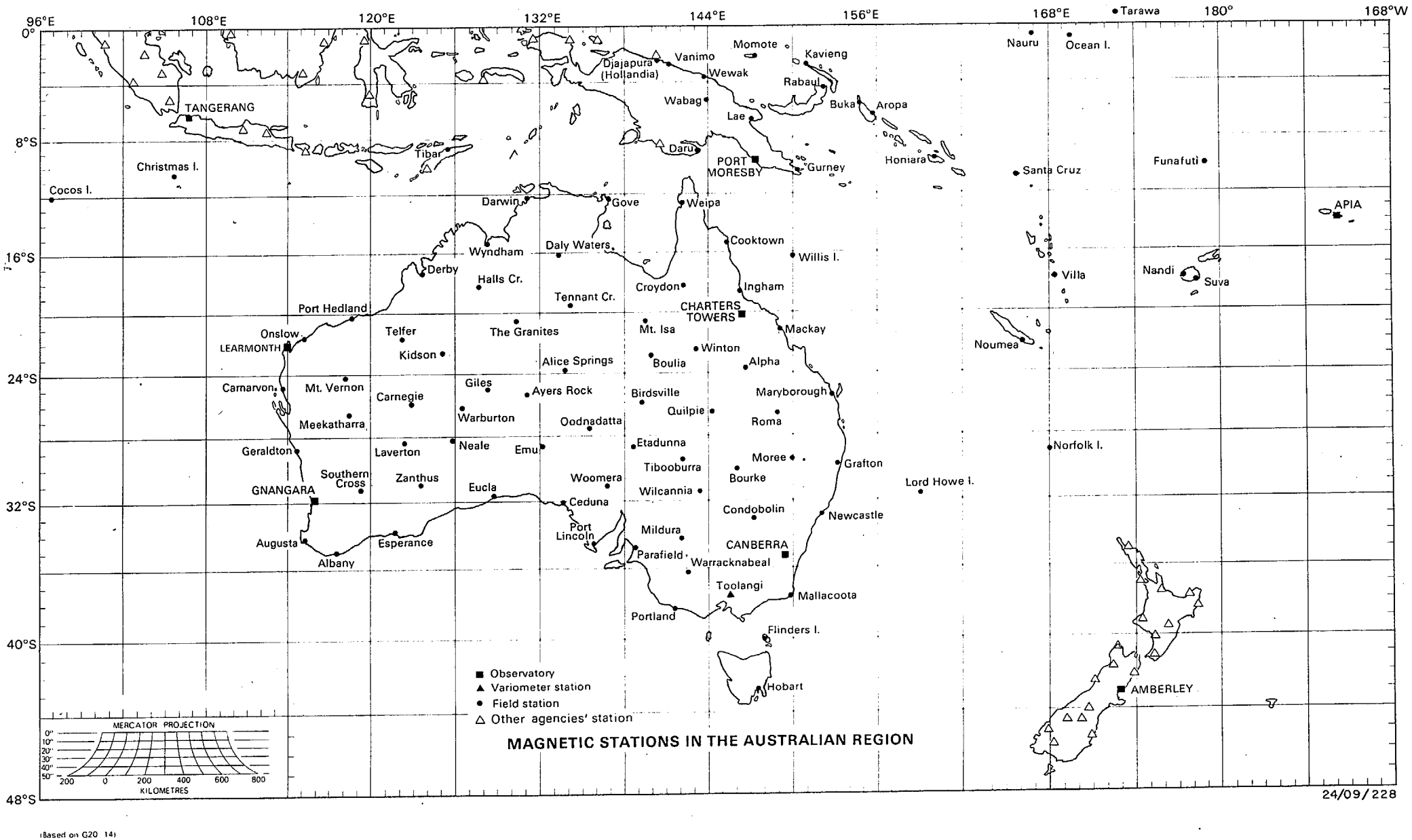
Preliminary arrangements for the visit were begun in Canberra. The subsequent, more detailed local arrangements were more economically and conveniently made through the Observer-in-Charge of the geophysical observatory in Port Moresby.

The initial preparations for the survey included

- PNG Government. Approval was sought from the Secretary, PNG Department of Minerals and Energy, to carry out the survey in cooperation with the Port Moresby Geophysical Observatory.

- Port Moresby Geophysical Observatory. Subsequent liaison was with the Observer-in-Charge PMGO.

- BMR approval. The approval of the Director, BMR was sought for an official overseas visit to PNG.



(Based on G20 14)

Figure 1. Australian and Pacific first-order magnetic repeat stations operated by BMR

. DFAT. The Assistant Secretary, New Zealand, Papua New Guinea Branch, South Pacific, Africa, Middle East,and South Asia (SAMS) Division, Department of Foreign Affairs and Trade was advised of the proposed visit. It is useful to inform DFAT of such visits in case any form of assistance is ever required, whether logistical (see below) or emergency.

. international flights. Book international flights through the BMR travel agent.

. finances. Payment for the excess baggage and vehicle hire costs is best arranged with the assistance of the Australian High Commission in Port Moresby. Rather than having the party leader carry large sums of money to cover these costs they can be more efficiently dealt with by transferring funds to the High Commission. This is done by raising an 'OA1' form through the BMR Finance Section. On receipt of the request the High Commission can issue purchase orders to pay for each of the hired vehicles and one to cover the cost of the Miscellaneous Charges Orders used by the airline as payment for the excess baggage. Since the orders are issued in PNG they have the advantage of being in the local currency, a far more convenient arrangement than dealing in Australian dollars.

. health. A course of antimalarial drugs should be arranged through the Commonwealth Medical Officer.

. passport. An official passport and visa are necessary prerequisites for entry to PNG.

. equipment. The equipment for the survey should be checked to ensure that it is in good working order, and with sufficient spares. Conditions in PNG will be among the most extreme under which the equipment will operate. The absolute instruments must be compared with standard instruments held at the Canberra Magnetic Observatory before and after the survey.

The remaining arrangements were made through the OIC PMGO, they included

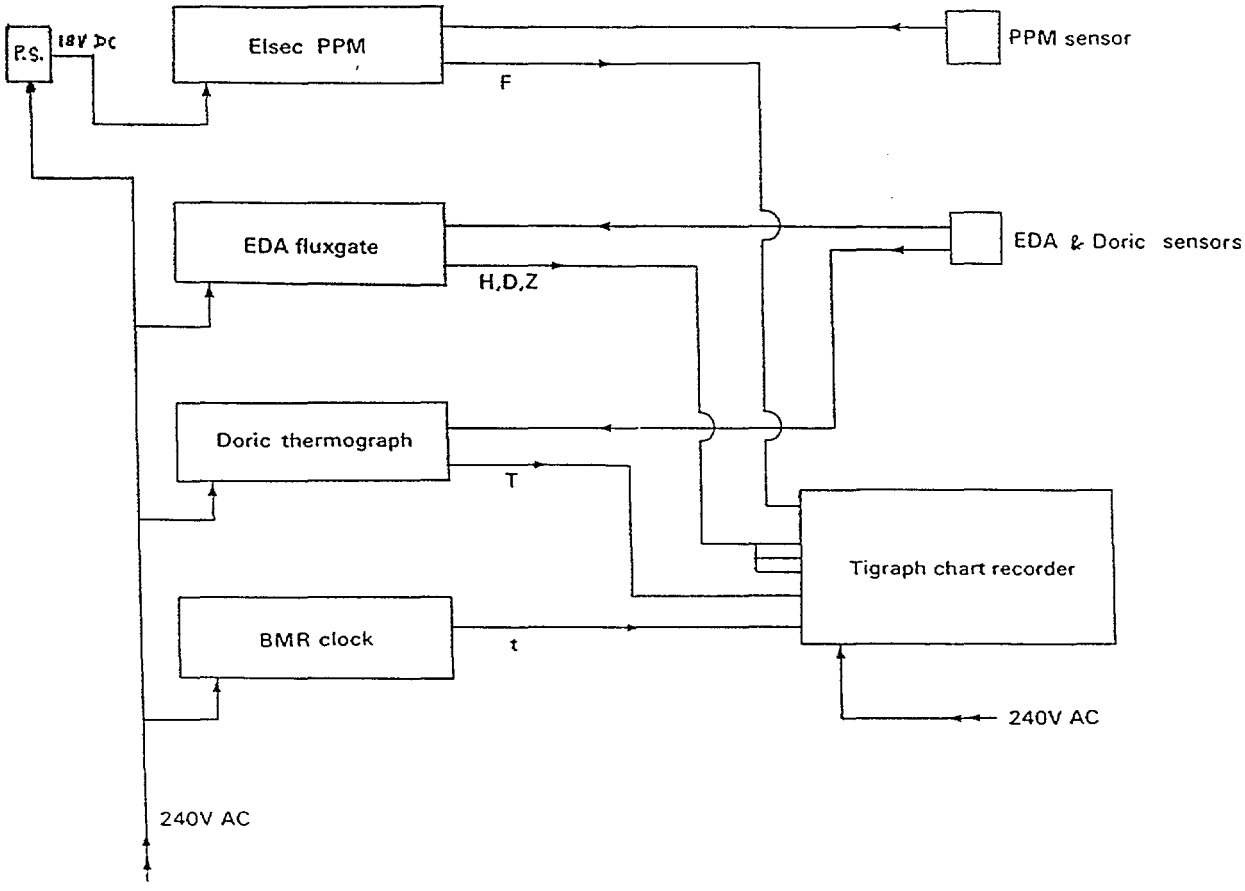
. domestic flights. All domestic travel was with Air Niugini. Flight schedules were generally suited to the requirements of the survey. It is essential that the airline be advised of the excess baggage requirements when the flights are booked. Appendix 1 contains the itinerary for the visit.

. accommodation. It is important that all accommodation is booked beforehand. At most stations there are only limited facilities available. Since many hours of work are involved in the evenings, suitable accommodation for the party must be guaranteed.

. hire cars. As with accommodation, cars are at a premium and should be arranged prior to commencing the survey. Payment for these is most conveniently made with a purchase order issued by the Australian High Commission in Port Moresby. In these circumstances vehicles may be able to be hired at the reduced Australian High Commission rate.

. access to stations. Most of the stations are located on airports and prior approval to work there should be obtained from the Department of Civil Aviation.

. shelter for recorders. Facilities of the National Weather Service are used to house the recording equipment at some of the stations. Assistance from the Service should be sought in advance to avoid costly and inconvenient delays on arrival.



SCHEMATIC DIAGRAM OF FIRST ORDER VARIOMETER EQUIPMENT

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Figure 2. Schematic diagram of first-order variometer equipment.

. customs clearance. The PNG Comptroller of Customs should be informed of the visit and his assistance sought to facilitate the unimpeded passage of the equipment through customs on arrival and departure from Port Moresby. Usually some paperwork will need to be filled out beforehand, including an itemized list of the equipment with the value of each piece.

3. EQUIPMENT

The equipment taken on 'first-order' surveys can be separated in two groups according to its function. Some of the equipment comprises a 'portable' observatory and is used to record the variations of the strength and direction of the field throughout the occupation of the station. This forms the bulk of the freight carried. The remainder of the equipment is used to make absolute measurements of the field regularly throughout the recording. Each set of equipment is described below. An inventory is given in Appendix 2.

Variometer Recording Equipment

A minimum of three elements of the field were continuously recorded during the occupation of the station to define the vector field. Usually a fourth element is also recorded to provide a degree of redundancy in the data.

Three components of the field were monitored by an EDA FM-100B triple axis fluxgate magnetometer. These components are D (declination), H (horizontal intensity) and Z (vertical intensity). There is some temperature sensitivity in the H and Z sensors. The effect of this was reduced by insulating the sensor head throughout the recording and shading it with a tent fly. The temperature of the sensors were monitored and temperature coefficients derived. These were later applied to the data to remove any remaining temperature effect. A Thermilinear YSI series 700 thermistor mounted in the sensor head, coupled with a Doric Trendicator, were used for this purpose.

The fourth component of the field, F (total intensity), was measured using an Elsec 820 PPM sampling at 1 minute intervals.

Each of these four magnetic field components, together with the temperature, were recorded on a Tigraph six-channel analog chart recorder. Hourly timemarks for the magnetograph were provided by a simple clock constructed in-house at BMR.

Figure 2 depicts the variometer equipment schematically, and details of the records obtained at each station are set out in Table 1.

The variometers were housed as close to the site of the absolute stations as possible. The requirements for their location being that continuous 240 V AC power was available and the equipment was accessible at all times during the visit. Convenient buildings, usually at the airports, included National Weather Service or Provincial Government facilities, hangars or workshops.

Absolute Equipment

Absolute measurements of the field were made using a Declination-Inclination magnetometer (DIM) and a proton precession magnetometer (PPM).

The DIM is comprised of an Elsec 810 fluxgate sensor mounted on the telescope of a Zeiss-Jena non-magnetic theodolite. It measures absolutely the

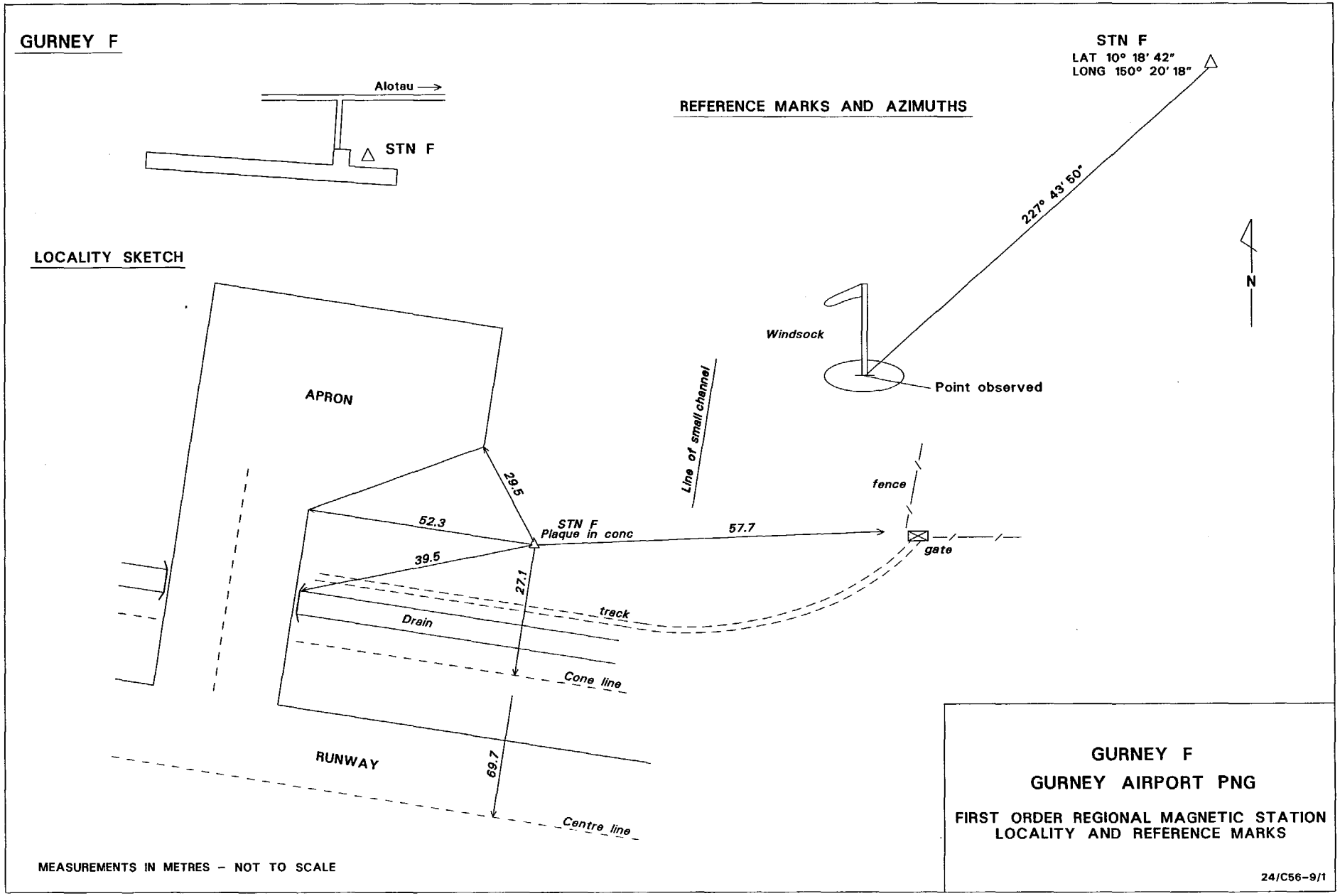

Figure 3. Gurney F : station descriptions.

declination (or variation) and inclination (or dip) of the field using the null readings produced when the fluxgate sensor is oriented in a direction perpendicular to the field.

A Geometrics G816 PPM was used to measure the total intensity of the field absolutely.

Backup absolute instruments were also taken in the event of equipment failure, these were a quartz horizontal magnetometer (QHM) (to measure H and D) and a spare PPM.

All equipment was comprehensively compared with standard instruments at the Canberra Magnetic Observatory before and after the survey. The results of these comparisons together with preliminary instrument corrections are given in Table 2.

4. STATION OCCUPATION REPORTS

The coordinates and local meridian time for each station are given in Table 3. Reference marks and true azimuths are listed in Table 4. The differences measured between the primary and secondary stations are set out in Table 5.

Station descriptions are included in Figures 3 to 9 and the local total magnetic intensity surveys at the stations in Figures 10 to 16.

GURNEY F

Contacts

Mr Levi George (Alphy Levi George) was the first contact - in the local government buildings in Alotau. He presented the field party to the Premier of the Milne Bay Province and then transported the field party to four possible variometer sites around Alotau. The site chosen was in the yard of the Department of Housing. It would be useful to contact them in the next visit.

The airport inspector was contacted at Gurney.

Variometer installation

The 1985 site had been built upon. There is no continuous power at Gurney airport. The site used was the yard of the Department of Housing, about 100m up the road from the Provincial offices. Mr Levi George made the introduction. The Department of Housing staff gave permission after contacting head office in Port Moresby. The instruments were set up in a corner of the office, the staff cut a small hole in the flyscreen of a door to allow the cable to pass. The sensors were set up in a fenced-in yard which was locked at night. Vehicles occasionally parked within 50 metres.

Azimuth mark

Windsock to the southwest - bottom centre of the pole.

Observations

Observations were made on station F which is a plaque and footpads set in a triangle of concrete. Grass had grown over the concrete and it was located by prodding around with a tent peg. When cleared, the station remained under about two cm of muddy water. A small PPM site survey was made.

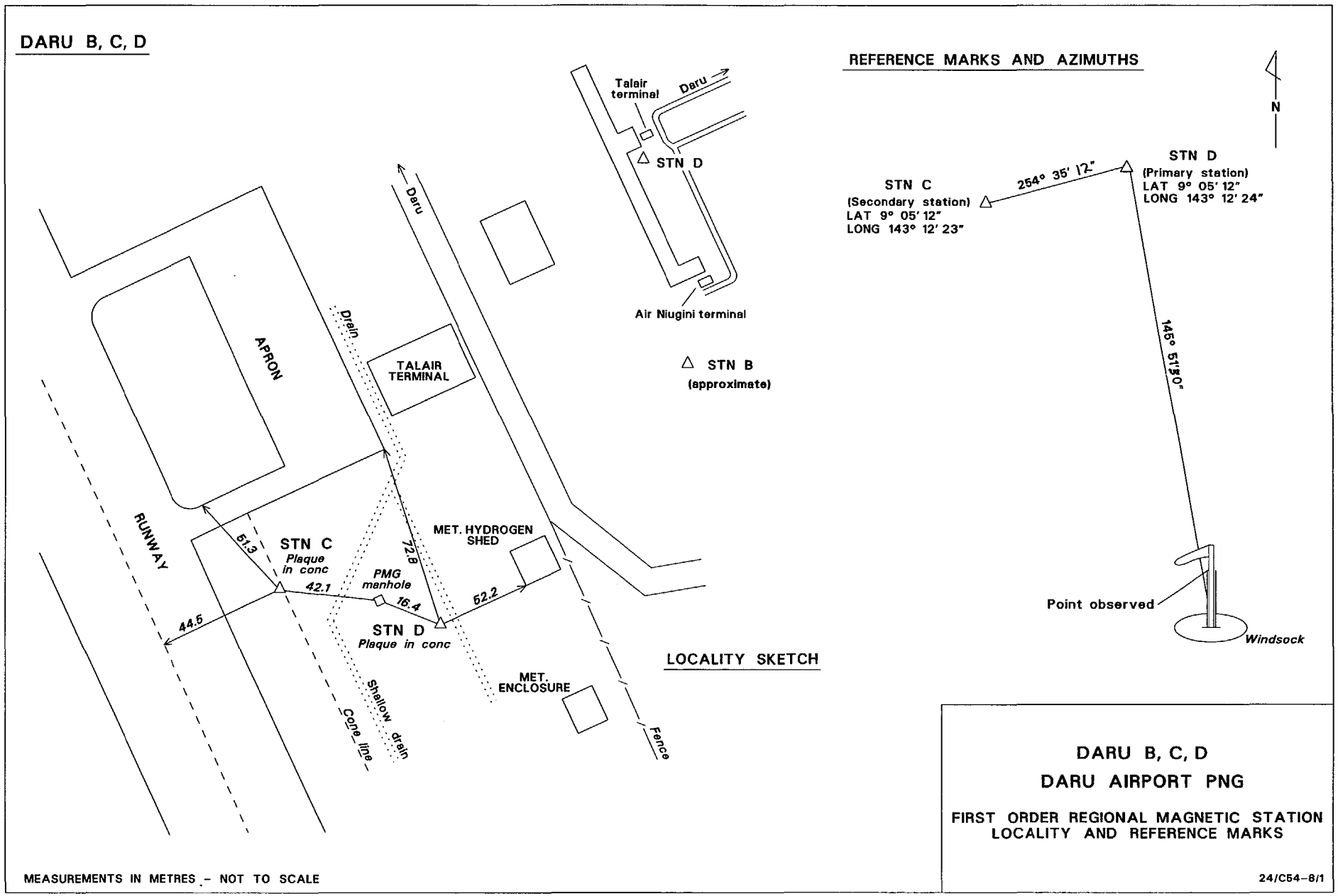

Figure 4. Daru C, D : station descriptions.

Equipment

The Elsec 820 PPM gave many spikes. These were accompanied by low signal strengths of about 3 (the scale is 1 to 9, 9 is normal) caused by an intermittent fault. The Tigraph recorder stopped after only two nights' recording due to a capacitor failure. There is a small electrical/electronic shop in Alotau but there was no suitable replacement capacitor available. It was quickly replaced on return to Port Moresby.

Station Upgrading

None undertaken owing to time lost on equipment problems. It is recommended that a secondary station be installed on the next occupation.

DARU C,D

Contacts

The Airport Inspector and the Meteorology Observer were contacted on arrival.

Variometer installation

The variometers were installed in a corner of the Meteorologist's office at the airport. The sensors were placed to the southeast of the office in a scrubby area.

Azimuth mark

At D a line of sight was produced by flattening the thorny vegetation in the direction of the windsock to the southeast. A thin pole projects above the main mast. The centre of the thin pole was used at its base. At station C the centre of the base of the main mast of the windsock was used.

Observations

Absolute observations and rounds of angles were carried out at stations D and C and sunshots at station D. F differences were measured between D and C by alternating observations over a short time interval. A small PPM site survey was carried out around C.

Equipment

The EDA recorded well, the PPM produced many 'embayments' in the chart reducing the amount of recoverable data. See section 5. When the EDA sensor was uncovered at the end of the survey it was found to have tilted slightly, according to its level bubble. The Tigraph chart recorder paper jammed on one of the nights.

Station Upgrading

The secondary station (Station C) was upgraded from a plaque in the ground to a concrete triangle containing the plaque and three footpads.

AROPA C,D

Bougainville Island was experiencing a crisis with conflict between secessionists and the PNG Government. The airport terminal and a number of houses had been burned down about three weeks before the arrival of the field

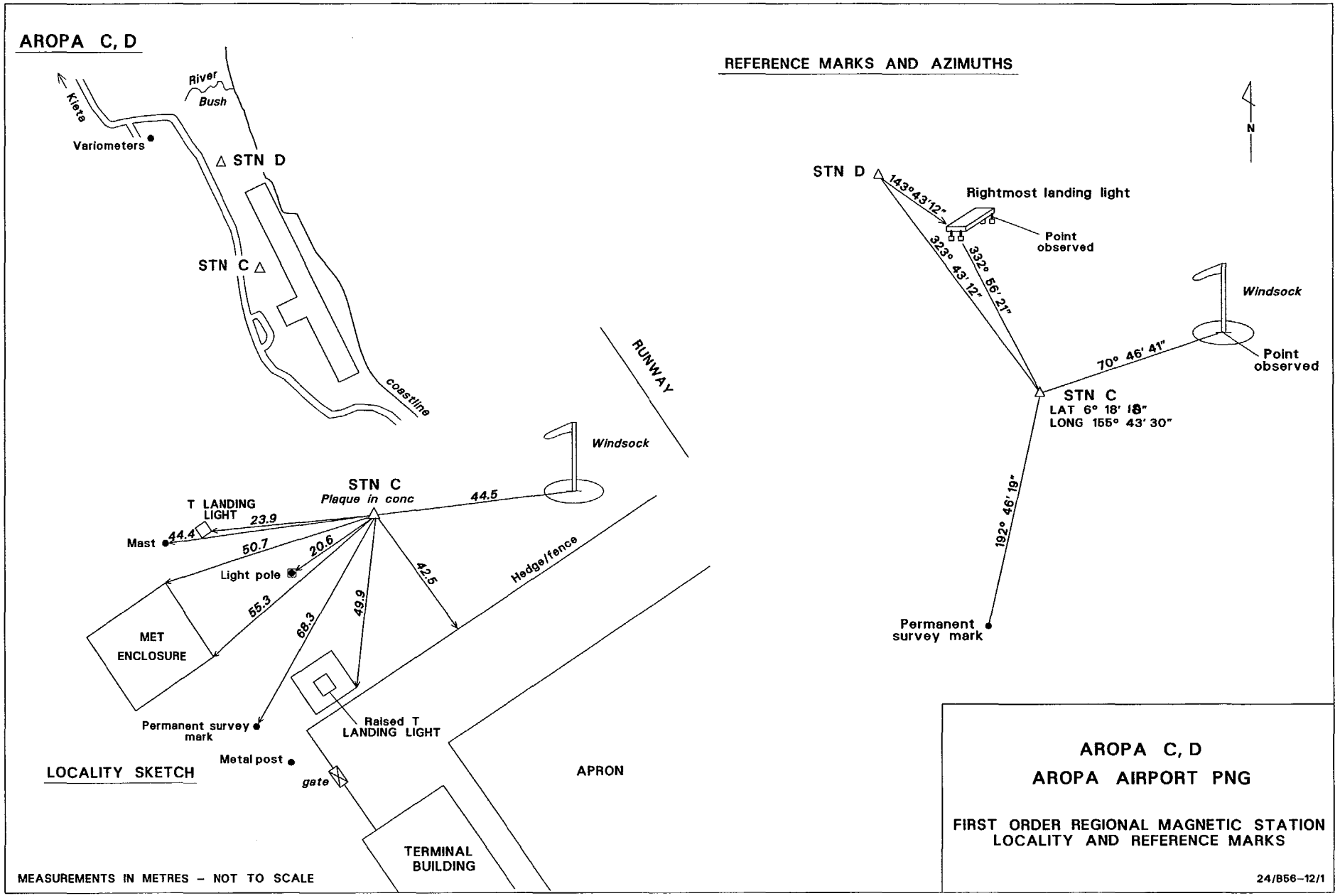

Figure 5. Aropa C, D : station descriptions.

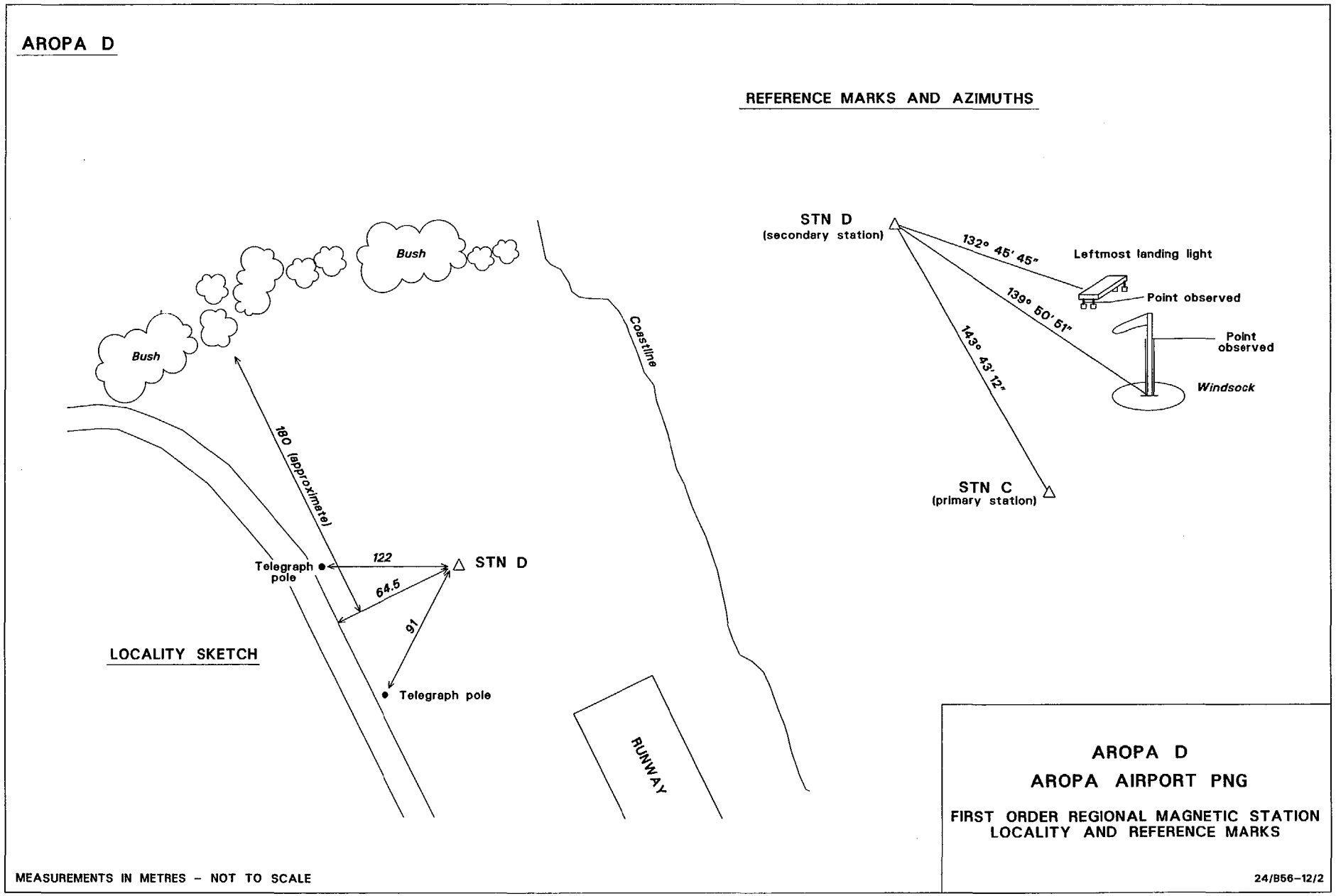

Figure 6. Aropa D : station description.

party and a curfew was in force each night between the hours of 6pm and 5am.

Contacts

The Airport Inspector/OIC, Mr Lennie Kailou, was contacted at Aropa Airport. The North Solomons Provincial Government Liaison Officer, Mr Joe Tsinoug, was visited in Kieta. The Meteorologist (Brian) was helpful at Aropa. His office was a caravan at the airport.

Variometer installation

There was no continuous power at the airport. The site used in 1985 was unavailable as it was being used as a temporary airport terminal. An arrangement was made with Bougair to keep their generator running at night in return for payment for its use and diesel. The variometers were housed below one of their houses, the location was about one kilometre north of station C. At this point the road takes a large bend away from the coast as it leaves the airport area. The sensors were near the edges of the lawn.

Azimuth mark

A new reference mark was used as the windsock on the far side of the runway had washed away a few months earlier. (Similarly magnetic station B had washed away before the 1985 reoccupation). From station C a line of landing lights can be seen (on the west side of the runway). The reference mark used was the rightmost leg of the rightmost (most distant) landing light. The same reference mark was used from station D.

Observations

Absolute observations and rounds of angles were made on stations C and D. C was used as the main station. No sunshots were completed. Azimuths were tied back to the Permanent Survey Mark (PSM) to the south of station C and and from each of stations C and D the other was included in the round of angles. A PPM site survey was carried out around station C and a very local one around D.

Equipment

The equipment generally worked well. The variometer PPM gave low signal and wild readings for some time on setting up but came good after much persuasion. The absolute PPM and spare were both temperamental on one afternoon after a thunderstorm, perhaps from high humidity. The clock and Tigraph chart recorder were reset a few times when the generator was switched over for refueling - the short power interruption caused it to print its self-check and the hour marks to change, however all was recoverable.

Station Upgrading

A new station (Station D) was installed - a plaque and three footpads enclosed within a concrete triangle. Station C may be threatened by rebuilding at the airport.

KAVIENG C,D

Contacts

The Department of Works foreman, Mr Wilson Kubo, was contacted for use of the airport area and clearance for installing a secondary magnetic station. The meteorologist was also contacted at his office near the terminal.

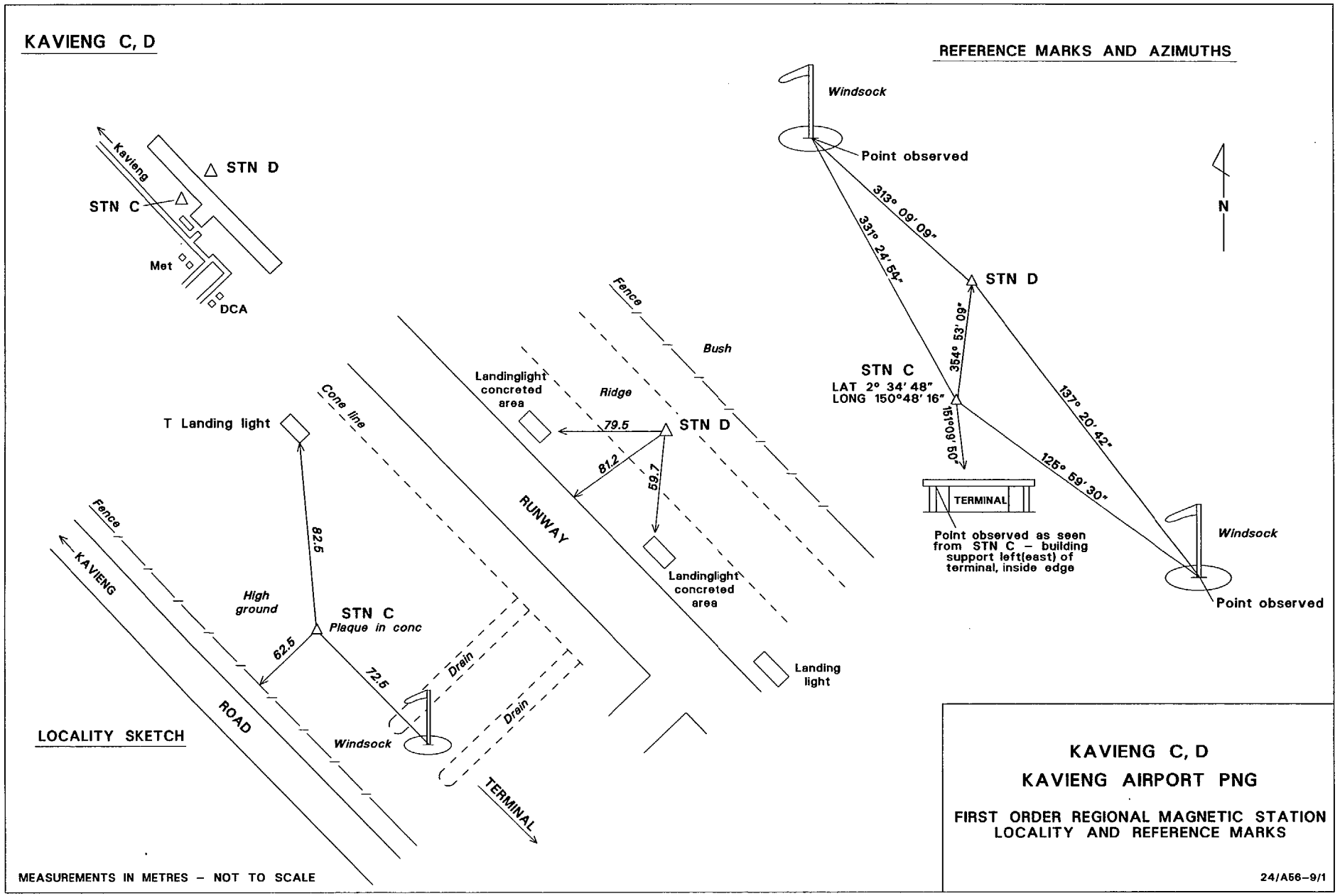

Figure 7. Kavieng C, D : station descriptions.

Variometer installation

The site used in 1985 was no longer suitable as it had been broken into and cleared out by "rascals". Instead the equipment was housed in the Meteorologist's balloon shed with the sensors in the yard. The area was not very secure so the meteorologist's helper was paid as a nightwatchman for the three nights.

Azimuth mark

The base of the windsock to the northwest was used as the main reference mark. The first observation from C was commenced in darkness owing to delays in the installation of the variometers. The reference mark used was the inside (lit up) edge of the support for the terminal's roof on the left side of the building. The inside edge is the right side of this pole. From station D the reference mark was the mast of a distant windsock to the southeast.

Observations

Absolute observations and rounds of angles were made at stations C and D. Sunshots were done at station C. PPM site surveys were carried out around both stations C and D. It was required that the tent fly over the magnetic station be taken down before each landing of an aircraft.

Equipment

The E820 PPM failed to start. The connection to one of the spade clips had broken completely within the heatshrink. It was resoldered and the equipment worked without problems for the rest of the time at Kavieng.

Station Upgrading

Station C consisted of a central plaque and three separate footpads. One of the footpads was more separate than others, it was found in a ditch about twenty metres away. It was replaced and a triangle was excavated to enclose all four parts in continuous concrete. Station D was installed on the other side of the runway. It consists of a central plaque and three footpads all enclosed by a triangle of concrete.

MOMOTE D,E

The airport was used in the Second World War where it apparently played a key role. It was the largest runway with the least traffic of any visited during the survey.

Contacts

The Airport Supervisor, Mr Rafael Sale, was contacted on arrival. He was very helpful.

Variometer installation

The variometers were installed in the office of the fuel depot, the cables were fed through the fence to the open area beyond. Permission to use the fuel depot office was obtained, Mr Sale introduced the party to the person in charge of the fuel depot, at the airport.

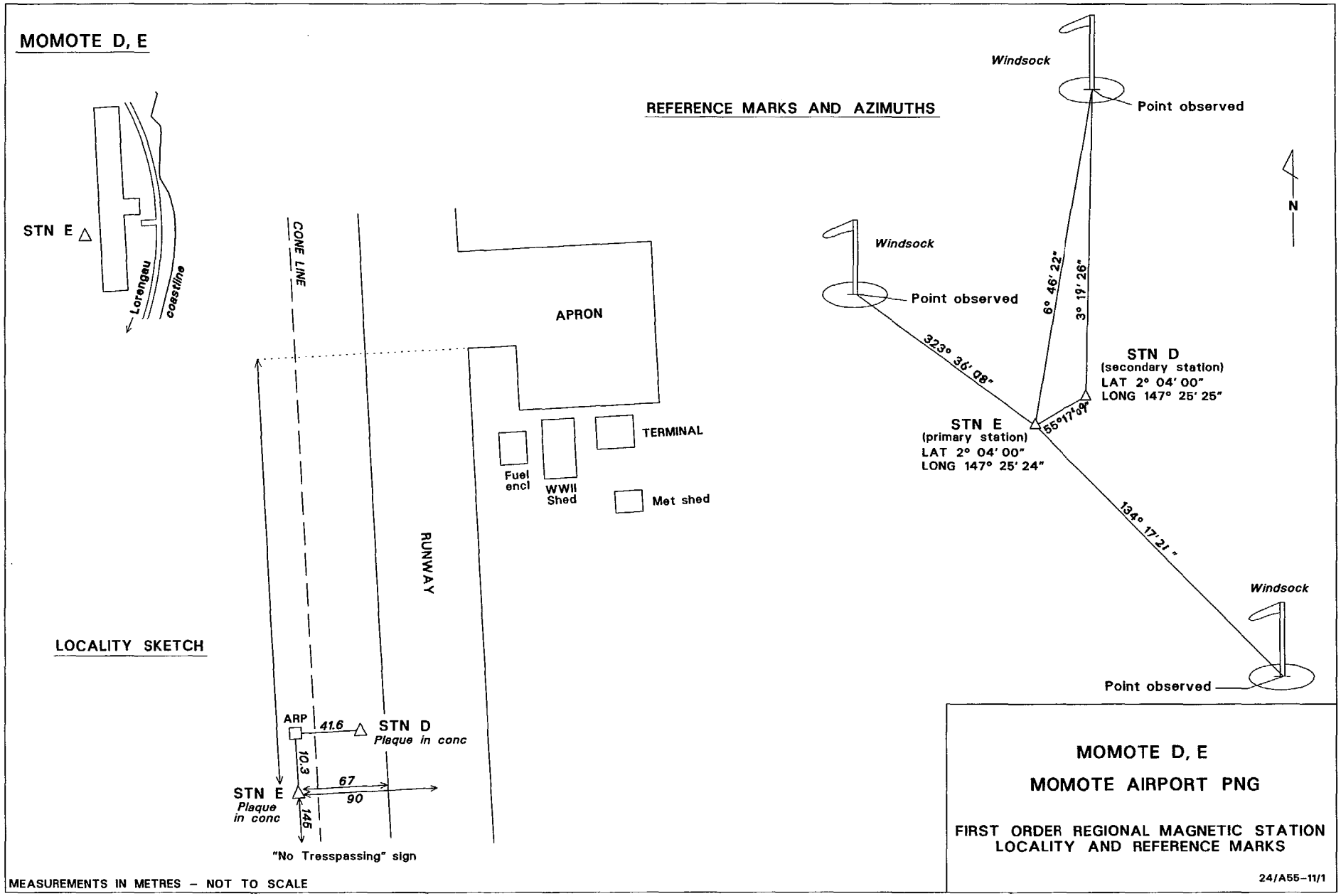

Figure 8. Momote D, E : station descriptions.

Azimuth mark

The base of the windsock to the northwest was used as the reference mark at both stations D and E. The sock is mounted on a pole which has a shorter, thicker pole on its right side supporting it. The line of contact between these two poles was used.

Observations

Station E was used as the main station. Absolute observations and rounds of angles were made at both stations. Sunshots were made at station E. The stations are only 42 metres apart, a PPM site survey centred on Station E was carried out, it covers both areas adequately. The vertical gradient was tested by making F observations at two different heights: 1500 mm and 150 mm above the plaque. Station E was found to have a difference of 16.2 nT in contrast to 1.5 nT at D. It is recommended that station D be used as the main station in future. The airport is built on non-magnetic coral and sand, but a number of metallic objects were dropped on it in the Second World War.

Equipment

The Elsec 820 PPM stopped working within a hour of starting. It locked up with an error message RAM06 and could not be persuaded to restart. E820/128 was replaced by the spare PPM E820/133. At first this did not appear to be working either but the output of the First Order Survey PPM had been modified to give 1 volt out, whereas the spare came from Mawson Observatory where a 10 mV analogue output was maximum. The display was normal. The rest of the equipment worked well.

Station Upgrading

Both stations were upgraded. Cement was purchased in Lorengau, and Mr Sale very kindly sent over a work gang to do the concreting. Aggregate was obtained from a quarry about 100 m away, a mixture of shells and coral. Station E was upgraded from a central plaque and three footpads to a concrete triangle enclosing all of them. Station D was upgraded from a plaque on a tilted submerged concrete block to a tilted plaque with three footpads all enclosed in a concrete triangle. It is well coupled to the basement, being locked into an irregular basement of coral heads.

WEWAK D,E

Contacts

The first contact was the Airport Inspector, Mr Gabriel Pasum. The Provincial Government was also contacted. Their yard was not suitable for installing variometers. Sister Grant, the headmistress of Bishop Leo High School was contacted at Wewak for permission to install the variometers at the school. The meteorologist would also be a useful contact - see below.

Variometer installation

The variometers were installed in the library of the Bishop Leo High School, which is part of the Mission. This was satisfactory because they were operated between Friday afternoon and Sunday evening. This couldn't be done during the week. It was a secure fenced-in area. For future visits the Meteorologist's balloon shed near the airport terminal may be satisfactory - provided the hut is still lockable and secure. The sensors would best be placed in the jungle/swamp on the south side of the road to keep them from the eyes of curious passers-by.

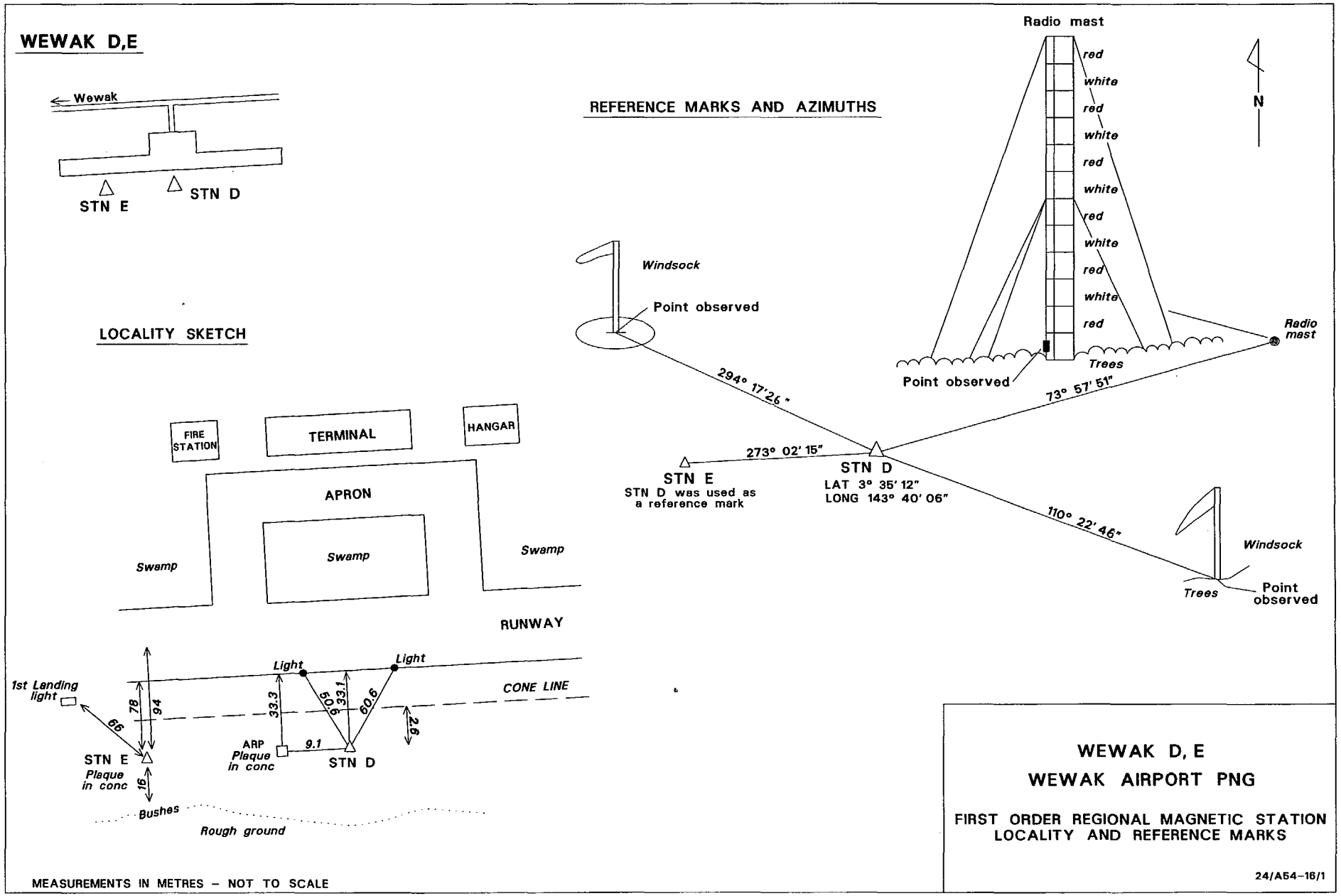

Figure 9. Wewak D, E : station descriptions.

Azimuth mark

The base of the windsock to the west was used as the main reference mark from station D, station E as the reference mark from station D. The mid line of the "T" of the smaller "Talair" sign on the airport terminal was used as an emergency night-time mark - it probably won't be there for the next survey.

Observations

Absolute observations were made at stations D and E. A round of angles was completed on station D. No sunshots were attempted owing to persistent rain and overcast conditions. A small informal PPM site survey was made around station E to a distance of two metres, values varied within a range of five nanoteslas. F observations were made at heights of 250 mm and at 1500 mm above the station marker. At station D the low level F value was 38.3 nT higher than readings made at 1500 mm. At station E the low level F value was 3.7 nT lower than readings made at 1500 mm. The temporary PPM station readings confirmed this pattern - at a second tripod about 5-10 m from each station marker the total field differences were:
F(D') - F(D) = -120.3 nT and F(E') - F(E) = +1.7 nT.
Hence it is recommended that station E be used as the main station in future.

Equipment

The variometers and chart recorder performed without problems. The only problem was that the batteries in the E770 went flat and the new spares brought from Canberra were also flat, this was not detected until the second morning. It showed as wildly scattered readings and low signal without a clear low battery indication. For this reason the variometers were sited away from the airport - a quick PPM survey around the proposed site appeared to indicate either high gradients or electromagnetic interference. New batteries from Wewak improved this, although the PPM was still a bit temperamental.

Station Upgrading

A secondary station E was installed. It consists of a plaque and three footpads enclosed in a triangle of concrete.

5. PROTON PRECESSION PERFORMANCE

The PPMs were uncharacteristically unreliable. A sensor failed, battery lives were greatly shortened and an Elsec 820 completely failed. A weak connection within the long cable appeared as an intermittent fault in various forms at Gurney, Daru, Aropa and Kavieng. It appears to have been a break at the connection between the long cable and one of the spade clips that connects to the PPM sensor. When the other end of the cable was shorted the resistance measured by a meter from one spade clip through the cable to the other spade clip was about two ohms. But it wouldn't carry a current. The problem was present at Gurney where it manifested itself as spikes, at Daru where it showed as embayments in the Tigraph trace, at Kieta after initial difficulties with low signal on the PPM display the recording was good. Finally at Kavieng the PPM could not be started and the problem was detected and fixed.

Another problem that masked the fault was the very thin coiled cable (approx two metres long) supplied with the E820 - when the spare PPM was used to survey the sites it also gave low signal strengths, so it appeared that the problem was that the sites were magnetically noisy. The batteries in the absolute PPM ran low at Wewak, this was manifested as scattered readings and

low signal strengths rather than low voltage warnings at first. The spares which had been newly obtained from the Bureau's store may have been on the shelf a long time so time was wasted chasing other hypotheses before another set of spares was bought (under normal observatory use with semi-weekly absolute observations a set of batteries lasts more than a year). An E770 PPM sensor failed also at Gurney - soldered connections inside had weakened (the manufacturer now crimps them).

6. LOCAL SURVEYS - TOTAL MAGNETIC INTENSITY (F)

A temporary PPM station was used during the occupations of the First Order Stations to make it unnecessary to remove the DIM from the tripod between sets of absolute observations. The temporary PPM station was a second tripod about five to ten metres from the survey plaque. It was also used as an intermediate reference for the local total field intensity (F) surveys. The difference in F was measured between the temporary F station and the first order station located over the plaque. This difference was used to relate measurements of F at each local F survey point back to the first order station. Thus the final reference location is a point 1.5 metres above the station plaque.

At Gurney local F survey measurements were made with sensor on top of the 2.5 m pole provided, sensor's bolts facing down, and the electronics box on the ground. At other stations the sensor was attached (bolts down) to the 300 mm pole provided in the PPM case. The electronics box was again placed on the ground, the sensor was held aloft on the pole to a height of about 1.5 metres.

Three consecutive readings were taken at the PPM station then groups of three readings made at distances of 5, 10, 15, 20 and 25 metres, then the observer returned to the PPM tripod to take another set of three readings. Readings were then taken at 50, 75 and 100 metres before returning to the PPM tripod, then measurements at 150, 200 and 250 metres before returning to the PPM tripod. If this sequence was interrupted by obstacles such as fences, buildings or by approaching thunderstorms or darkness extra sets of readings at the PPM tripod were made before and after any interruptions. Time-related changes in the field were removed using linear interpolation between PPM station observations.

At Gurney and Aropa D the local F survey was carried out by the BMR observer. The other surveys were carried out by personnel from the Papua New Guinea Geological Survey under instruction from the BMR observer.

The results of these local surveys are included in Figures 10 to 16.

7. DATA REDUCTIONS

As previously described absolute observations were used on-site to calibrate the magnetograms. Scale values (in nT/mm or min/mm) were determined for each magnetic field trace by graphing the observed field value against the distance from a baseline, measured from the magnetic records. From these data preliminary baseline values were derived:

Baseline = Field value - (scale value * scaling)

The consistency of the baseline values reflects the quality of the data being recorded, and was used to monitor the adequacy of the occupation before the station was closed.

On returning to BMR the absolute observations were recalculated and preliminary instrument corrections applied to give the observed field values in Table 6. The magnetograms were digitized at hourly intervals, the baseline calculations reworked with temperature corrections applied to produce revised baselines and scale values for each trace. Preliminary mean hour values (MHV) were then derived from these data (Table 7).

The data reduction was checked by plotting the observed field values onto the MHV plots.

The data obtained from the occupation of each station should be representative of the long term quiet field. The magnetic field is subject to activity of varying intensity superimposed on the quiet daily variation. This 'non-quiet' activity needs to be removed from estimates of the quiet field. The effect of short term disturbances is reduced by continuing the occupation until at least two magnetically quiet nights are recorded. The field around local midnight on a magnetically quiet night seems to most closely represent the value of the long term quiet field (McEwin 1984). To remove any continuing long term disturbance such as magnetic storms (which can depress H for weeks afterwards), a more representative mean value of the quiet field at a station is obtained by comparing the variations recorded at the station with several months of variations recorded at a suitably close magnetic observatory. This is possible since the variations of the magnetic field seem not to change significantly over short distances (say 1000 km) at similar latitudes.

The quiet field values adopted for each station (Table 8) at the epoch of occupation represent the final stage of the data reduction. These values are the best possible estimate for the long term quiet field at the station.

The survey was undertaken to provide data for production of the AGRF model and the set of epoch charts of the geomagnetic field covering the Australian region for epoch 1990.0. The quiet stations values were used in conjunction with previous occupations to derive an estimate of the secular variation and the field at January 1 1990 (1990.0). These are listed in Table 9 for the seven elements and compared with values derived for the stations from the candidate IGRF model USGS90. Table 10 contains the residuals (adopted - USGS) from this comparison. Secular variation plots for declination, inclination, horizontal and total intensity covering the last three occupations since 1980 are shown in Figure 17.

8. CONCLUSIONS

Six first order repeat stations were successfully re-occupied. Seven stations were either installed or upgraded - all stations now consist of a plaque and three footpads enclosed in a triangle of concrete. All locations except Gurney have a secondary station. Local total field intensity surveys were carried out using a proton precession magnetometer (PPM) at most stations.

The local contacts were co-operative.

All of the equipment worked without problems at Newcastle one week before departure. Problems were experienced on the survey, mainly with the Proton Precession magnetometers. The faults were mainly in connections, although the Elsec 820 is inclined to lock up if it is switched on with out the sensor head connected. A sensor failed.

Apart from the capacitor failure in the Tigraph chart recorder at Gurney the rest of the equipment performed very well. The declination/ inclination magnetometer (DIM) proved to be an excellent field instrument. When more DIMs become available a spare DIM could be carried in place of a QHM and QHM

circle. A dedicated DIM tripod could then be used. The feet of the tripod used were found to be magnetic. At a distance of about 300 mm the difference is up to 10 nT. No effect was detected at normal tripod height (1.5 metres).

A long aerial for the radio would be a useful addition. About 15 metres of wire was borrowed from Port Moresby Geophysical Observatory.

At Aropa it is recommended that seven to nine days be allowed so that a new site can be found away from Aropa airport as the volcanic sand contains a large amount of magnetite, leading to gradients of many tens of nanoteslas per metre.

It is recommended that Momote station D be used as the main station in preference to station E, and at Wewak station E is to be preferred over station D as the magnetic gradients are lower.

A small PPM site survey out to five metres from each station or at least the main one would be worthwhile to detect any contamination since the last occupation (for example underground cables or pipes).

Acknowledgements

The assistance of the following people is gratefully acknowledged:
Ian Ripper, Officer in Charge of Port Moresby Geophysical Observatory, for liaising with the various authorities in Papua New Guinea, providing contacts at each station and organising financial transfers.
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Lawrence Anton from PMGO, for assistance in the survey work at Aropa and Kavieng
Mathew Moihoi from PMGO, for assistance in the survey work at Kavieng, Momote and Wewak, and also the various local officials who cooperated and assisted with the smooth running of the survey.

9. REFERENCES

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Hitchman, A.P., 1990b, First-order regional magnetic survey of southwest Pacific islands, June - July 1989. Bureau of Mineral Resources Record, 1990/90.

McEwin, A.J., 1984, First Order Magnetic Survey of Australia for Epoch 1980.0, March 1978 - July 1979, Operations Report. Bureau of Mineral Resources Record, 1984/15.

Appendix 1 Itinerary

Date	From	To	dep	arr	Carrier	Flight
23/4/89	Canberra	Sydney	0640	0715	Australian	TN460
23/4	Sydney	Port Moresby	0945	1515	QANTAS	QF95
24/4	Port Moresby	Alotau	1415	1530	Air Niugini	PX754
29/4	Alotau	Port Moresby	1700	1815	Air Niugini	PX755
1/5	Port Moresby	Daru	0615	0735	Air Niugini	PX802
6/5	Daru	Port Moresby	1045	1205	Air Niugini	PX751
6/5	Port Moresby	Kieta	1500	1645	Air Niugini	PX254
11/5	Kieta	Kavieng	0740	0955	Air Niugini	PX269
14/5	Kavieng	Manus Island	1300	1350	Air Niugini	PX211
18/5	Manus Island	Wewak	1135	1230	Air Niugini	PX269
22/5	Wewak	Port Moresby	0730	1020	Air Niugini	PX129
23/5	Port Moresby	Sydney	1500	2000	Air Niugini	PX3
24/5	Sydney	Canberra	0840	0920	Australian	TN421

Appendix 2 Equipment Inventory

1. Recording Box 1

Tigraph chart recorder
EDA sensor
EDA/Doric cable
spikes (short, long, collar)
circuit breaker
tape measure
tent fly
8 tent pegs
6-piece aluminium poles
spare Tigraph paper (1 roll)

2. Recording Box 2

Elsec 820 consoles (2)
Elsec power supply
Elsec sensor and cable
3 pc pole, 3 pegs, twine, adaptor
EDA console + lead
Doric thermograph + lead
Digital clock
power distribution board
toolkit
tool roll
Fluke multimeter
jeweller's screwdrivers
torch
spare fuses
nuts + bolts
extension lead

3. Absolute Box

Zeiss theodolite 317214
DIM console 208
Geometrics G816/1024 ppm + sensor
Geometrics G816/1025 ppm + sensor
digital stopwatches (2)
radio + wire aerial
calculators + handbooks
observing fly
8 tent pegs
stand for ppm sensor
absolute forms
pencilling boards (2)

4. Esky

QHM circle 14
QHM 173
tent pegs (3)
aluminium pole (1 pc)
hammer
compass
electrical tape
hacksaw
soldering iron and flux
station markers (10)
brass footpads (21)
nylon rope
masking tape
block of wood
spare aluminium catches
analog stopwatch
damping magnets
EDA cards
batteries
tent fly
QHM thermometer
electronics cleaner
garbage bags
BNC - banana plug connectors
forms
station descriptions
tent repair kit
raincoat

5. Tripod Bag

theodolite tripod
Askania tripod
poles for observing shelter
umbrella
3 lengths aluminium

Appendix 3 List of Hotels

Port Moresby
Davara
Ela Beach
P.O.Box 799
Port Moresby
Telephone 21 2100
Telegrams 'Davara'
Telex NE 23236

A high standard hotel, close to town. 80 Kina per night.

Gurney
Masurina Lodge
P.O.Box 5
Alotau
Telephone 61 1212

The only hotel in Alotau. It is run co-operatively by the Milne Bay people. An air-conditioned unit is worth requesting when booking, it is very hot and humid there. The cost includes all meals, a cut lunch may be ordered - it is usually not feasible to return from Gurney airport for lunch. K76.50 per night. The vehicle used was hired from the hotel.

Daru
Wyben Hotel/Motel
P.O.Box 121
Daru, Western Province
Ph: 65 9055

The only hotel in Daru. Daru is a fairly run-down town. The hotel had fans, no air-conditioning, mosquitoes found their way in (insecticide provided). Running water was a bit intermittent. Lighting ok for evening work. K70.00 per night.

Aropa
Davara
Toniva Beach
P.O.Box 241, Kieta
Bougainville/North Solomons Province
Telephone 95 6175
Telex NE95852
Fax 956218

A high quality hotel. Air-conditioned. Room perhaps a little dark but OK. K70.00 per night. Avis is next door. Rather empty at the time because of the Bougainville crisis.

Kavieng
Kavieng Hotel
P.O. Box 4 Kavieng
Tel 94-2199
Fax 94-2283

Comfortable, air-conditioned, large room. Good for repairing PPMs.
K75.00 per night. There would only be one or two hotels here.

Momote
Lorengau Harbourside Hotel
P.O.Box 89
Lorengau Manus Province
Telephone 40 9093, 40 9262
Telex 40802

The new rooms are very good. Air-conditioned, spacious and well-lit. It is worth requesting a room in the new section. K65.00 per night. The manager is the Avis agent.

Wewak
The Sepik Hotel
P.O.Box 51
East Sepik Province
Papua New Guinea
Telephone 86 2422
Telex 86143

Air-conditioned, close to shops, banks. Shows a few signs of age but OK. K72 per night. Another one about half-way between Wewak and the airport may be worth considering, faster access to the airport.

Appendix 4 Vehicles

Vehicles were hired from Avis at Aropa (Kieta), Kavieng, Momote (Manus Island) and Wewak. In each of these places the vehicle was available at the airport except Momote where the agent (Manager of Lorengau Hotel) transported the field party back to Lorengau.

At Gurney a car was hired from the Masurina Lodge in Alotau. The Masurina Lodge provided transport from the airport to Alotau. At Daru the vehicle was hired from the Department of Works.

All hire was paid for by Australian High Commission Purchase Orders in PNG kina. They were generally accepted happily. Some of the Avis branches give a special Australian High Commission rate if it is asked for. Budget may do the same. The exchange rate was K1.00 = $A1.50.

Reservations should be made before arrival in Papua New Guinea as vehicles are not abundant.

Location	cost	contact phone	distance from airport to town
Gurney	K58 per day	611214	15 km
Daru	K62 per day	*	3 km
Aropa	K49 per day	956337	15 km
Kavieng	K62 per day	942394	2 km
Momote	K70 per day	409207	30 km
Wewak	K62 per day	862041	7 km

* At Daru it was originally intended to hire the vehicle from the Wyben Motel (phone 659055) at K7.50 per hour but the Department of Works was cheaper. Other possibilities are Daru Trading (659141), Karawane Trading (659101)

Appendix 5 Names and Addresses of Contacts

The Observer-in-Charge, Port Moresby Geophysical Observatory (Mr Ian Ripper) contacted the rest of the people listed. The field survey party contacted the people listed in the provincial centres and representatives of the Provincial Government in most provinces visited. It is important to contact the Airport Supervisor/Inspector before commencing work at each site.

Mr Ian D Ripper
Observer-in-Charge
Port Moresby Geophysical Observatory
Box 323
Port Moresby, PNG
Ph (675) 214500 / 214634
fax (675) 213976

Comptroller of Customs (Mr A Aria)
Bureau of Customs
P.O. Box 923
Port Moresby

Manager, Public Relations,
Air Niugini (Mr G McLaughlan)
P.O. Box 7186, Boroko
ph 273200

Mr Peter Vincent was contacted regarding Miscellaneous Charges Orders for excess baggage (ph 273466)

Assistant Secretary (Aerodromes), (Mr Harry K Wagorn)
Department of Civil Aviation
P O Box 684 Boroko
Ph 225200, fax 225253

Mr James Nako, Director,
National Weather Service,
Box 1240
Boroko PNG

Mr L L E Joseph
High Commissioner
Australian High Commission
P O Box 9129
Hohola, Port Moresby PNG

Mr Bill Jackson was contacted for Aust. H.C. Purchase Orders (phone 259333)

Avis Rent a Car
P.O. Box 1533
Port Moresby PNG

Gurney/Alotau:

Airport: Mr T. Duba ph 611360

Secretary of Department of Milne Bay
Attention Assistant Secretary, Planning and Policy (Mr A. Levi George)
P.O. Box 104
Alotau, Milne Bay Province PNG
ph 611069

The Department of Housing (across the road from the Provincial Government) could be contacted via Mr Levi George.

Daru

Airport: Mr C Haoda ph 659005

Weather Office (Mr August Bartsaka)
P O Box 89
Daru
Western Province, PNG

Aropa/Kieta

Airport: Mr Lennie Kailou ph 956478

Mr Joe Tsinoug
Provincial Government Liaison Officer
Kieta,
North Solomons Province, PNG

Kavieng

Airport: Mr Wilson Kubo - office 942075 or via Met: 942260

Meteorology: Mr Joe Wurwur ph 942260
at Kavieng Airport

Government contact:
Lands District Officer
ph 942111 xtn 250 (no contact made)

Momote/Manus Island

Airport: Mr Rafael Sale ph 409382

Wewak

Airport: Mr Gabriel Pasum Ph 862411

Table 1 Magnetograph Recording

Station	Start	End	Remarks
Aropa	0535 7/5/89	2046 10/5/89	good record (H,D,Z,F,T)
Daru	0905 1/5/89	2305 5/5/89	good record (H,D,Z,T) lost 3 hrs all traces F data highly suspect
Gurney	0748 25/4/89	0050 27/4/89	good record (H,D,Z,F,T) lost 3 hrs F trace
Kavieng	0702 11/5/89	0144 14/5/89	good record (H,D,Z,F,T) lost 31 hrs F trace
Momote	0100 15/5/89	0025 18/5/89	good record (H,D,Z,F,T) lost 8 hrs F trace
Wewak	0744 19/5/89	0900 21/5/89	good record (H,D,Z,F,T) lost 3 hrs F trace

Table 2 Instrument comparisons and adopted corrections

Station	Date	Instrument A	Instrument B	A-B
		Declination Inclination Magnetometer		
Canberra	5/4/89	Ruska 4813	312714/208 'D'	0.1'
		QHM 461/MNS2.3	312714/208 'I'	0.2'
	7/8/89	Ruska 4813	312714/208 'D'	-0.2'
		QHM 461/MNS2.3	312714/208 'I'	0.3'
		Proton Precession Magnetometer		
Canberra	5/4/89	MNS2.3	E770/193	-0.5nT
	2/6/89	MNS2.3	G816/1024	1.7nT
	7/8/89	MNS2.3	G816/1024	0.0nT
		MNS2.3	G816/1025	-3.6nT
	11/9/89	MNS2.3	E770/193	-0.8nT

Adopted corrections

Ds = DIM 312714/208 - 0.4'
Is = DIM 312714/208 +0.0'
Fs = Elsec 770/193 - 0.6 nT
Fs = G816/1024 + 0.9 nT
Fs = G816/1025 - 3.6 nT

Table 3 Station coordinates and local meridian time

Station	Latitude ° '	Longitude ° '	Time UT
Aropa C	-06 18.3	155 43.5	0137
Daru C	-09 05.2	143 12.2	0227
D	-09 05.2	143 12.2	0227
Gurney F	-10 18.7	150 20.3	0159
Kavieng C	-02 34.8	150 48.3	0157
Momote D	-02 04.0	147 25.4	0210
E	-02 04.0	147 25.4	0210
Wewak D	-03 35.2	143 40.1	0225

Table 4 Reference Marks and Azimuths

		°	′	″	
Aropa C					
Windsock to east, base			70	46	41
Metal post, base			192	01	55
PSM			192	46	19	85
Station D			323	43	12
RH leg of rightmost landing light	RM	332	56	21	
Aropa D					
Landing light leg (same as used from C)			132	45	45
Windsock, base	RM	139	50	51	
Station C			143	43	12
Daru C					
Station D			74	35	12
Windsock to southeast, at half height	RM	142	49	07	
Daru D					
Windsock to southeast, at half height	RM	145	51	30	89
Station C			254	35	12
Gurney F					
Windsock to southwest	RM	227	43	50	85
Kavieng C					
Windsock to southeast			125	59	30
LH support of terminal roof, top RHS			151	09	50
Windsock to northwest	RM	331	24	54	85
Station D			354	53	09
Kavieng D					
Windsock to southeast	RM	137	20	42	
Station C			174	53	09
Windsock to west			313	09	09
Momote D					
Windsock to north	RM		3	19	26
Windsock to southeast			137	43	22
Windsock to northwest			318	25	30
Station E			235	17	09
Momote E					
Windsock to north	RM		6	46	22
Station D			55	17	09
Windsock to southeast			134	17	21
Windsock to northwest			323	36	08
Wewak D					
Mid line of 'T' in Talair sign			9	45	55
Radio mast to NE			73	57	51	85
Windsock to E			110	22	46
Station E			273	02	15
Windsock to W (base)	RM	294	17	26	
Wewak E					
Station D			93	02	15

Table 5 Station differences

Station 1	Station 2	Station 1 - 2 D '	H nT	Z nT	F nT
Aropa C	Aropa D	17.4	-216	42	-164
Daru C	Daru D	-2.7	29	-42	-92
Kavieng C	Kavieng D	0.3	-8	-6	-8
Momote D	Momote E	-7.3	-57	40	-42
Wewak D	Wewak E	-27.7	64	70	86

Table 6 Observed field values

	F UT	F nT	D UT	D ° '	I ° '	F UT	F nT
Gurney F							
26 Apr 89	0350	43158.6	0417	7 14.0	-34 57.1	0434	43159.9
	0450	43146.7	0505	7 17.5	-35 10.8	0517	43135.6
	0525	43125.0	0548	7 18.7	-35 01.1	0602	43123.0
	0622	43138.3	0635	7 17.8	-34 59.4	0644	43150.2
	0705	43159.7	0715	7 17.1	-34 59.2	0725	43161.9
	2233	43246.3	2247	7 15.0	-34 55.2	2300	43235.4
	2209	43232.9	2319	7 13.7	-34 56.7	2328	43222.4
27 Apr 89	0707	43169.8	0720	7 15.9	-34 58.4	0720	43163.5
28 Apr 89	0331	43216.2	0337	7 14.7	-34 53.5	0344	43218.3
	0358	43216.6	0403	7 14.9	-34 53.5	0411	43213.6
	0519	43208.2	0524	7 15.4	-34 54.0	0531	43210.0
	0555	43209.1	0600	7 16.9	-34 55.0	0607	43208.1
	0654	43204.8	0658	7 16.5	-34 56.0	0702	43202.8
Daru C							
2 May 89	0228	43497.6	0244	5 32.1	-33 47.2	0300	43479.1
	0721	43440.8	0738	5 35.7	-33 50.3	0749	43452.4
	0805	43449.1	0817	5 35.2	-33 50.7	0831	43446.3
3 May 89	0234	43502.1	0251	5 31.9	-33 47.5	0304	43494.3
	0358	43513.9	0411	5 32.4	-33 48.0	0427	43492.0
	0441	43485.0	0451	5 33.2	-33 47.8	0501	43479.3
	0642	43465.3	0652	5 35.3	-33 49.0	0701	43468.3
	0711	43470.0	0720	5 35.4	-33 49.2	0728	43469.6
4 May 89	0045	43510.2	0054	5 31.2	-33 46.2	0102	43512.2
	0111	43510.6	0120	5 31.7	-33 45.8	0126	43511.9
	0142	43510.1	0152	5 32.5	-33 45.6	0200	43502.9
	0208	43497.3	0216	5 32.7	-33 46.1	0223	43487.5
	0755	43463.4	0805	5 35.5	-33 49.7	0815	43464.5
	1018	43502.9	1025	5 32.6	-33 49.1	1032	43500.3
	1043	43498.3	1050	5 32.4	-33 49.1	1057	43494.4
Daru D							
5 May 89	0543	43396.7	0556	5 33.0	-33 51.6	0607	43398.9
	0631	43409.6	0647	5 33.5	-33 51.6	0700	43430.5
Aropa C							
7 May 89	2342	40741.7	2359		-26 58.4		
8 May 89						0011	40747.8
	0109	40752.2	0124	8 33.0	-26 57.0	0135	40749.8
	0204	40750.3	0218	8 33.8	-26 56.0	0226	40751.4
	0456	40742.2	0511	8 37.8	-26 56.3	0520	40738.9
	0607	40727.0	0627	8 38.1	-26 57.2	0639	40724.4
	0657	40726.4	0710	8 38.1	-26 57.4	0727	40731.8
	2233	40774.3	2252	8 34.4	-26 56.8	2307	40778.8
	2321	40783.2	2335	8 33.6	-26 56.1	2348	40785.0

	UT	F	UT	D	I	UT	F
9 May 89	0008	40787.2	0022	8 33.7	-26 55.1	0035	40793.8
	0700	40752.7	0725	8 38.3	-26 56.4		
	2043	40768.9	2055	8 36.6	-26 56.8	2107	40767.9
	2137	40770.3	2251	8 35.1	-26 56.6	2211	40773.6
10 May 89	0812	40768.2					
Aropa D							
10 May 89	0701	40934.5	0713	8 22.0	-26 42.9	0735	40935.4
Kavieng C							
11 May 89	0915	39075.1	0944	6 25.4	-20 53.9	1006	39069.7
12 May 89	0006	39144.2	0018	6 24.0	-20 54.8	0036	39157.7
	0143	39151.6	0200	6 24.4	-20 53.0	0215	39149.4
	0721	39035.9	0736	6 27.5	-20 53.5	0750	39038.0
	2204	39092.9	2217	6 25.2	-20 56.4	2240	39100.9
	2301	39105.7	2314	6 24.0	-20 55.8	2328	39113.2
13 May 89	0818	39079.8	0838	6 27.0	-20 54.6	0856	39082.3
	2127	39101.3	2140	6 27.2	-20 55.6	2151	39105.8
	2204	39109.4	2217	6 26.7	-20 55.5	2234	39118.0
	2247	39121.7	2301	6 26.2	-20 55.3	2324	39131.5
	2355	39139.0					
14 May 89			0011	6 25.5	-20 54.4	0025	39150.1
Kavieng D							
13 May 89	0433	39093.5	0445	6 24.2	-20 52.9	0458	39085.5
	0516	39082.6	0532	6 29.3	-20 53.2	0543	39076.8
Momote D							
16 May 89	0801	39328.0	0822	5 22.6	-20 18.4	0845	39329.8
	2312	39365.6	2336	5 18.1	-20 17.1	2347	39369.8
17 May 89	2140	39332.2	2153	5 20.5	-20 19.1	2205	39335.6
	2218	39338.3	2230	5 19.7	-20 18.4	2241	39339.7
Momote E							
16 May 89	0215	39336.5	0233	5 10.7	-20 21.5	0247	39335.7
	0319	39333.3	0333	5 11.2	-20 21.9	0345	39331.6
	0449	39321.0	0504	5 13.6	-20 22.8	0517	39302.5
	0605	39298.0	0619	5 14.8	-20 23.3	0632	39294.0
17 May 89	0255	39343.6	0310	5 11.7	-20 21.8	0331	39331.3
	0341	39327.5	0405	5 12.8	-20 22.2	0424	39312.3
	0511	39299.7	0528	5 15.1	-20 23.8	0541	39300.2
	0551	39300.7	0605	5 15.9	-20 24.3	0623	39287.6
	0757	39274.0	0816	5 15.3	-20 23.9	0842	39275.0
Wewak D							
19 May 89			0943	4 29.2	-23 58.6		
20 May 89	0354	40676.4	0410	4 26.2	-23 56.9	0422	40675.0
	0436	40672.2	0456	4 27.5	-23 57.1	0502	40671.7
	0705	40638.5	0718	4 29.4	-23 57.8	0731	40639.1
	0745	40637.1	0801	4 29.6	-23 58.1	0822	40635.6
	2332	40680.0	2345	4 26.1	-23 58.8	2358	40682.6
21 May 89	0014	40686.1	0025	4 25.8	-23 58.5	0036	40687.3
	0108	40690.5	0120	4 25.7	-23 58.0	0131	40688.5
	0158	40688.2	0209	4 25.7	-23 58.0	0220	40689.8
	0257	40702.0	0309	4 26.0	-23 57.6	0320	40700.1
	0409	40686.4	0420	4 27.9	-23 57.1	0431	40678.3
Wewak E							
21 May 89	0721	40544.2	0736	4 56.8	-23 55.4	0749	40541.0

Table 7 Preliminary mean hourly values

DECLINATION EAST

MEAN HOURLY VALUES

PRELIMINARY

	UT	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
April 1989																										
1	D																									
2																										
3																										
4	D																									
5	D																									
6																										
7																										
8																										
9																										
10	Q																									
11																										
12	Q																									
13																										
14																										
15																										
16																										
17																										
18																										
19	Q																									
20																										
21	Q																									
22	Q																									
23		Gurney									7 Deg +tabular values in 0.1min															
24																										
25										112	126	127	123	122	127	127	127	126	134	135	131	147	140	129	107	
26	D	98	94	92	114	144	184	177	162	141	137	128	121	112	114	120	130	140	141	140	147	149	148	124	104	132
27	D																									
28																										
29																										
30																										
May 1989																										
		Daru									5 Deg +tabular values in 0.1min															
1											314	316	323	325	328	328	329	332	338	336	340	343	343	329	320	
2		313	312	317	324	329	332	347	350	352	345	342	340	338	337	337	341	343	344	351	347				308	
3		299	309	319	317	325	340	349	355	352	349	347	345	343	345	349	350	352	354	357	356	361	355	338	325	341
4		309	316	325	332	337	348	358	362	356	351	348	347	348	349	351	354	357	361	359	363	369	361	348	336	348
5	D		320	323	330	337	349	366	380	382	376	372	365	357	358	366	367	371	375	381	381	381	385	385	369	
		Aropa									8 Deg +tabular values in 0.1min															
6																										
7	D							359	360	346	353	357	355	346	353	359	360	364	369	373	382	379	355	339	330	
8	Q	328	330	338	353	367	379	379	380	374	370	366	365	366	363	365	366	368	372	372	372	368	361	346	338	362
9	Q	337	343	356	370	384	386	379	375	376	372	369	368	367	369	369	372	373	373	373	373	364	357	342	338	366
10	Q	334	338	356	371	385	389	388	379	375	368	366	366	371	367	370	369	368	371	370						
		Kavieng									6 Deg +tabular values in 0.1min															
11	Q								270	268	261	257	256	254	257	258	259	264	266	264	264	266	263	253	242	
12		240	241	244	252	268	279	282	275	269	261	258	258	258	258	258	257	260	262	261	261	266	262	250	238	259
13		228	227	226	237	257	276	284	282	276	268	260	264	263	263	264	265	269	270	270	269	274	271	264	260	262
14		254																								
		Momote									5 Deg +tabular values in 0.1min															
15			80	99	116	133	153	147	145	142	132	134	129	127	126	126	131	130	129	131	132	132	127	122	111	
16		104	98	100	111	127	138	147	153	155	144	137	134	133	131	134	133	136	134	133	133	139	139	130	113	131
17		100	94	102	117	130	149	157	151	148	138	134	130	127	126	129	130	134	135	134	137	140	132	118	108	129
18																										
		Wewak									4 Deg +tabular values in 0.1min															
19	Q									269	280	276	276	272	272	273	275	275	274	274	277	281	285	280	271	
20		261	250	244	249	268	281	290	294	293	288	283	270	271	271	270	278	274	273	272	276	281	288	275	262	273
21		258	256	256	263	279	289	290	290	295																
22																										
23	D																									
24	D																									
25	D																									
26																										
27																										
28																										
29																										
30																										
31																										

HORIZONTAL INTENSITY
MEAN HOURLY VALUES

PRELIMINARY

	UT	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
April 1989																											
1	D																										
2																											
3																											
4	D																										
5	D																										
6																											
7																											
8																											
9																											
10	Q																										
11																											
12	Q																										
13																											
14																											
15																											
16																											
17																											
18																											
19	Q																										
20																											
21	Q																										
22	Q																										
23		Gurney									35000. +tabular values in nT.																
24																											
25										467	462	467	473	470	456	457	468	472	458	472	472	451	434	432	405		
26	D	385	381	406	385	360	330	339	357	353	339	350	374	378	385	387	396	412	412	414	417	424	434	428	429		386
27	D																										
28																											
29																											
30																											
May 1989																											
		Daru									36000. +tabular values in nT.																
1											143	141	140	138	138	138	142	137	144	142	137	139	138	143	140		
2		146	164	156	138	132	121	99	90	91	94	88	97	107	111	119	114	114	114	125	117				127		
3		139	159	153	148	140	109	107	110	115	112	109	108	112	109	112	116	117	118	124	128	132	135	135	136		124
4		153	166	144	146	131	113	105	92	84	93	90	90	89	87	90	88	97	105	107	110	119	119	118	117		111
5	D		117	82	73	61	42	9	16	38	44	41	39	27	41	47	57	51	56	66	71	77	78	92	103		
		Aropa									36000. +tabular values in nT.																
6																											
7	D							298	277	258	239	252	239	227	235	257	257	260	273	280	293	293	288	295	302		
8	Q	316	322	328	330	322	307	300	302	306	307	310	312	310	306	307	313	314	316	321	321	326	332	342	358		315
9	Q	370	375	371	365	357	344	330	325	327	326	326	326	326	325	325	329	333	335	337	339	341	345	350	360		345
10	Q	367	376	377	375	366	352	342	340	340	335	331	328	326	326	329	335	339	341	345							
		Kavieng									36000. +tabular values in nT.																
11	Q								513	510	502	495	490	489	492	493	501	511	514	518	523	532	544	553	565		
12		576	582	577	579	551	511	481	472	470	473	471	473	475	476	477	478	484	490	491	492	490	498	514	529		505
13		537	537	527	521	516	504	488	495	507	507	506	504	500	498	503	503	502	500	502	505	511	520	536	553		512
14		574																									
		Momote									36000. +tabular values in nT.																
15			890	895	890	876	855	825	815	808	804	790	789	789	792	798	804	810	806	801	801	804	811	815	831		
16		851	866	875	870	861	839	829	824	825	823	819	822	816	813	814	815	813	811	816	826	838	846	854	866		835
17		886	890	889	870	845	834	817	807	811	809	802	802	805	802	799	799	799	804	810	813	820	827	838	853		826
18																											
		Wewak									37000. +tabular values in nT.																
19	Q									114	113	108	107	106	114	117	119	121	125	123	130	136	141	153	166		
20		172	181	180	174	167	158	140	132	128	123	104	70	80	94	95	98	100	107	106	111	120	138	155	168		129
21		179	183	183	188	177	164	135	124	110																	
22																											
23	D																										
24	D																										
25	D																										
26																											
27																											
28																											
29																											
30																											
31																											

VERTICAL INTENSITY
MEAN HOURLY VALUES PRELIMINARY

	UT	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
April 1989																											
1	D																										
2																											
3																											
4	D																										
5	D																										
6																											
7																											
8																											
9																											
10	Q																										
11																											
12	Q																										
13																											
14																											
15																											
16																											
17																											
18																											
19	Q																										
20																											
21	Q																										
22	Q																										
23		Gurney									-24000. -tabular values in nT.																
24																											
25										741	743	741	741	745	748	744	744	744	748	751	745	756	758	762	748		
26	D	733	729	728	720	721	741	743	747	743	747	751	753	753	756	758	761	763	758	757	758	761	765	757	737		748
27	D																										
28																											
29																											
30																											
May 1989																											
		Daru									-24000. -tabular values in nT.																
1											171	172	173	174	175	177	179	177	180	181	181	182	182	179	173		
2		168	167	164	165	168	165	167	172	179	181	184	188	189	190	191	190	191	194	198	195				186		
3		178	181	181	185	187	179	182	190	192	195	197	197	194	198	199	200	201	203	202	203	202	204	200	194		198
4		185	182	177	182	181	180	182	188	195	199	205	204	203	203	205	207	207	209	209	211	214	214	211	205		198
5	D		189	178	181	186	190	189	198	209	213	212	214	214	218	217	218	217	218	218	220	221	222	223	220		
		Aropa									-18000. -tabular values in nT.																
6																											
7	D							446	453	454	456	464	463	463	467	475	473	473	475	477	481	483	487	488	484		
8	Q	476	464	447	450	451	452	456	460	462	464	465	467	467	469	471	470	472	472	472	473	474	478	473	469		466
9	Q	463	457	455	454	455	462	462	462	462	463	463	467	469	473	471	475	475	475	473	476	475	475	471	467		467
10	Q	451	443	433	431	428	430	441	448	455	456	456	457	459	464	466	469	470	471	471							
		Kavieng									-13000. -tabular values in nT.																
11	Q									929	933	936	937	938	941	946	948	956	959	960	960	961	963	970	971	971	
12		970	960	946	939	924	910	908	917	928	935	940	945	949	951	952	953	957	960	958	959	959	966	975	970		947
13		966	959	943	933	929	925	928	939	949	956	955	952	951	956	956	959	957	958	961	961	964	966	970	970		953
14		967																									
		Momote									-13000. -tabular values in nT.																
15			683	683	683	685	690	679	679	683	681	682	683	684	688	690	692	696	694	696	700	698	697	694	686		
16		682	682	682	684	689	686	690	688	689	689	689	689	689	690	693	693	694	697	699	702	704	705	697	690		691
17		683	681	686	687	685	693	692	687	688	686	686	688	687	692	693	693	695	697	700	703	704	701	692	688		691
18																											
		Wewak									-16000. -tabular values in nT.																
19	Q									512	514	512	515	516	519	520	524	524	524	522	527	527	530	531	529		
20		523	521	513	507	507	506	503	503	508	509	503	490	514	523	520	520	522	524	522	527	531	544	542	534		517
21		532	530	531	527	517	513	505	511	508																	
22																											
23	D																										
24	D																										
25	D																										
26																											
27																											
28																											
29																											
30																											
31																											

TOTAL INTENSITY

MEAN HOURLY VALUES

PRELIMINARY

	UT	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
April 1989																											
1	D																										
2																											
3																											
4	D																										
5	D																										
6																											
7																											
8																											
9																											
10	Q																										
11																											
12	Q																										
13																											
14																											
15																											
16																											
17																											
18																											
19	Q																										
20																											
21	Q																										
22	Q																										
23		Gurney									43000. +tabular values in nT.																
24																											
25										289	283	290	296	293	279	280	293	294	279	299	297	277	255	256	217		
26	D	179	178	209	176	147	121	130	148	148	132	147	178	186	193	197	212	226	227	226	233			109			
27	D																										
28																											
29																											
30																											
May 1989																											
		Daru									43000. +tabular values in nT.																
1											457	461	462	464	467	468	469	471	472	473	478	483	485	483	481		
2		476	469	472	486	490	462	458	460	461	475	481	475	481	486	491	496	504	509	506	508						
3		506	489	487	488	490	491	491	489	488	492	497	501	504	505	504	504	509	517	525	526	520	512	505	499		502
4		491	484	487	490	493	499	503	508	512	514	517	515	517	518	517	518	517	513	511	509	506	510	513	509		507
5	D		491	485	483	486	488	498	500	500	498	506	513	514	506	505	505	505	496	489	488	485	485	489	488		
		Aropa									40000. +tabular values in nT.																
6																											
7	D							735	728	718	710	720	716	711	711	724	722	723	729	732	740	739	744	752	750		
8	Q	751	749	746	743	743	736	734	739	749	748	742	736	733	730	731	732	731	730	732	732	734	777	779	784		743
9	Q	788	794	793	788	784	778	771	772	772	769	768	766	764	763	753	756	757	756	755	756	759	762	766	775		769
10	Q	777	780	779	780	777	774	773	769	767	765	759	754	754	754	755	760	759	758	758							
		Kavieng									39000. +tabular values in nT.																
11	Q																										
12																57	62	66	72	73	73	78	89	100	111		
13		118	116	101	89	86	72	57	69	79	81	77	73	71	70	77	79	77	78	79	83	92	103	116	132		86
14		151																									
		Momote									39000. +tabular values in nT.																
15											266	256	252	252	260	264	270	276	272	268	268	270	274	276	294		
16		312	326	334	331	323	289	289	281	278	278	274	274	272	272	270	274	270	272	276	289	297	310	326	326		293
17		342	347	350	331	309	303	287	272	274	270	266	264	269	266	265	263	266	271	274	278	286	289	297	311		290
18																											
		Wewak									40000. +tabular values in nT.																
19	Q												600	606	597	587	589	587	582	593	604	608	619	615	627		
20		642	642	681	690	685	670	653	644	645	645	636	587	612	623	625	625	627	629	625	634	644	660	683	681		645
21		689	689	692	692	681	666	636	630	617																	
22																											
23	D																										
24	D																										
25	D																										
26																											
27																											
28																											
29																											
30																											
31																											

Table 8 Quiet field station values at epoch of occupation.

Station		D °	H nT	Z nT	F nT	I °	X nT	Y nT
ARO	C	8.607	36336	40764	-18469	-26.954	35927	5438
DRU	D	5.573	36130	43510	-24202	-33.862	35959	3509
GUR	F	7.220	35470	43277	-24749	-34.955	35189	4458
KAV	C	6.430	36509	39081	-13961	-20.903	36279	4089
MOM	E	5.220	36815	39273	-13700	-20.379	36662	3349
WEW	D	4.458	37123	40640	-16521	-24.012	37011	2886

Table 9 Adopted field values and secular variation at epoch 1990.0.

Station		D ° '/yr	H nT nT/yr	Z nT nT/yr	F nT nT/yr	I ° '/yr	X nT nT/yr	Y nT nT/yr
Aropa	C	8.610	36328	-18484	40760	-26.968	35918	5439
		0.4	-6.0	14.6	-12.0	0.87	-6.5	2.8
Daru	D	5.560	36125	-24255	43512	-33.878	35955	3500
		-1.1	-2.0	-7.6	3.0	-0.59	-0.8	-12.0
Gurney	F	7.228	35462	-24806	43277	-34.973	35180	4462
		0.7	-11.8	-6.4	-6.0	-0.95	-12.7	6.1
Kavieng	C	6.437	36506	-13942	39078	-20.902	36276	4093
		0.6	-4.1	1.2	-5.8	-0.03	-4.8	6.0
Momote	E	5.227	36813	-13673	39270	-20.376	36660	3354
		0.7	-3.4	0.6	-3.4	-0.05	-4.1	7.0
Wewak	D	4.463	37120	-16552	40643	-24.032	37007	2889
		0.6	-2.0	-14.7	4.5	-1.2	-2.5	6.0

Table 10 USGS90 field values and station residuals 1990.0

USGS90 field values

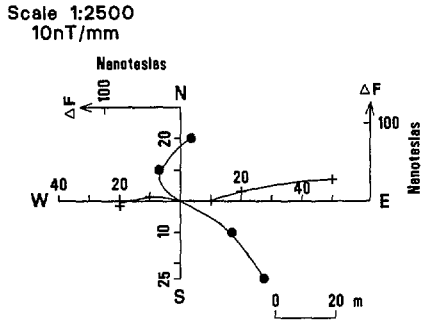
Station		D °	H nT	Z nT	F nT	I °	X nT	Y nT
Aropa	C	8.072	36051	-17856	40231	-26.349	35694	5062
Daru	D	5.615	36099	-24180	43449	-33.815	35926	3532
Gurney	F	7.399	35630	-24621	43310	-34.645	35334	4588
Kavieng	C	6.459	36501	-13725	38997	-20.607	36270	4106
Momote	E	5.595	36765	-13601	39200	-20.301	36590	3585
Wewak	D	4.971	36947	-16309	40386	-23.817	36808	3201

Residuals (adopted - USGS90)

		'	nT	nT	nT	'	nT	nT
Aropa	C	32.3	277	-628	529	-37.1	224	377
Daru	D	-3.3	26	-75	63	-3.8	29	-32
Gurney	F	-10.3	-168	-185	-33	-19.7	-154	-126
Kavieng	C	-1.3	5	-217	81	-17.7	6	-13
Momote	E	-22.1	48	-72	70	-41.9	70	-231
Wewak	D	-30.5	173	-243	257	-12.9	199	-312

GURNEY STATION F

Local Survey – Total Magnetic Intensity
(plotted at two scales)



Difference from station F in nanoteslas

metres	North	East	South	West
10	28	1	−69	5
20	−14	13		−6
25			−110	
50		28		

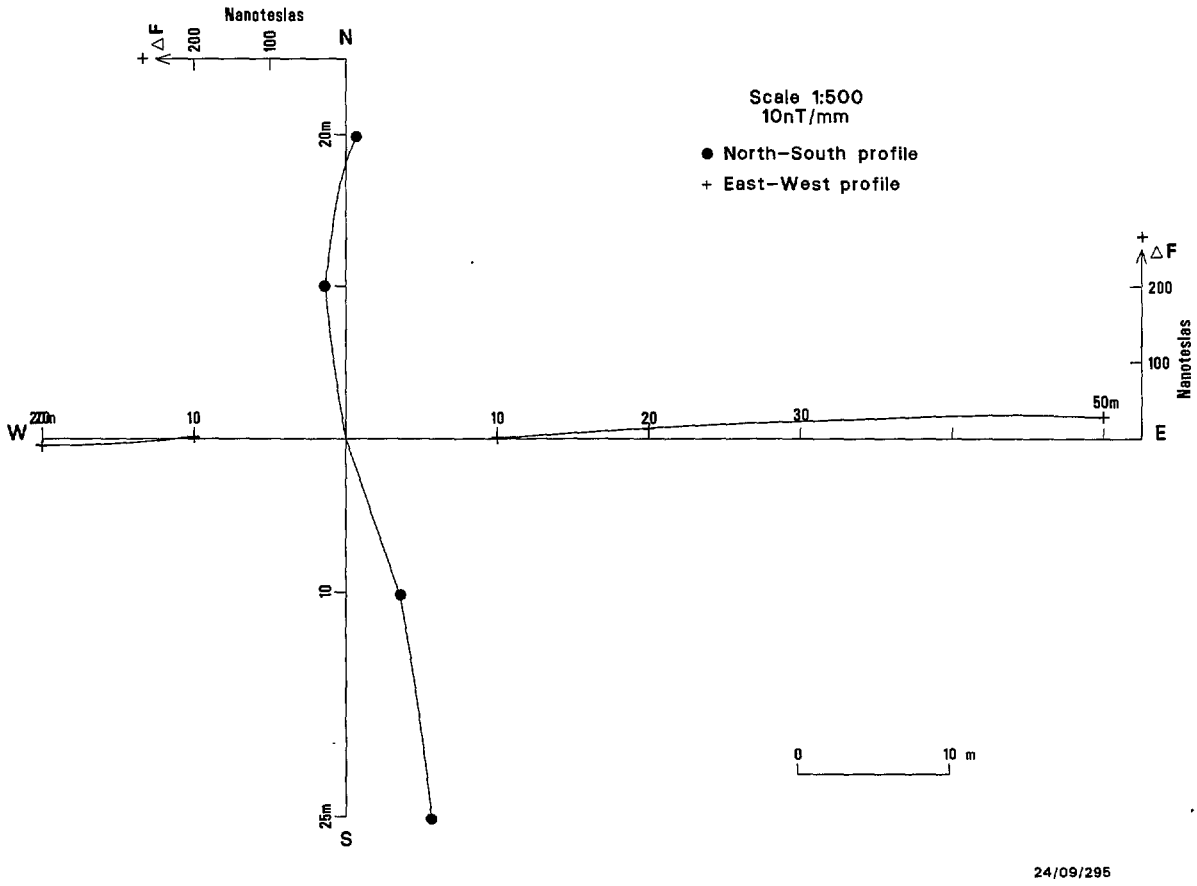
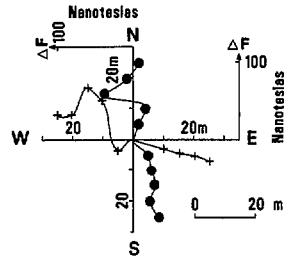


Figure 10. Gurney F : local survey - total magnetic intensity.

DARU STATION C

Local Survey – Total Magnetic Intensity
(plotted at two scales)

Scale 1:2500
10nT/mm



Difference from station C in nanoteslas

metres	North	East	South	West
5	−6		−22	−15
10	−16	−12	−26	49
15	37	−18	−27	66+/−40
20	8	−21	−23	31+/−20
25	−9	−28	−36	31

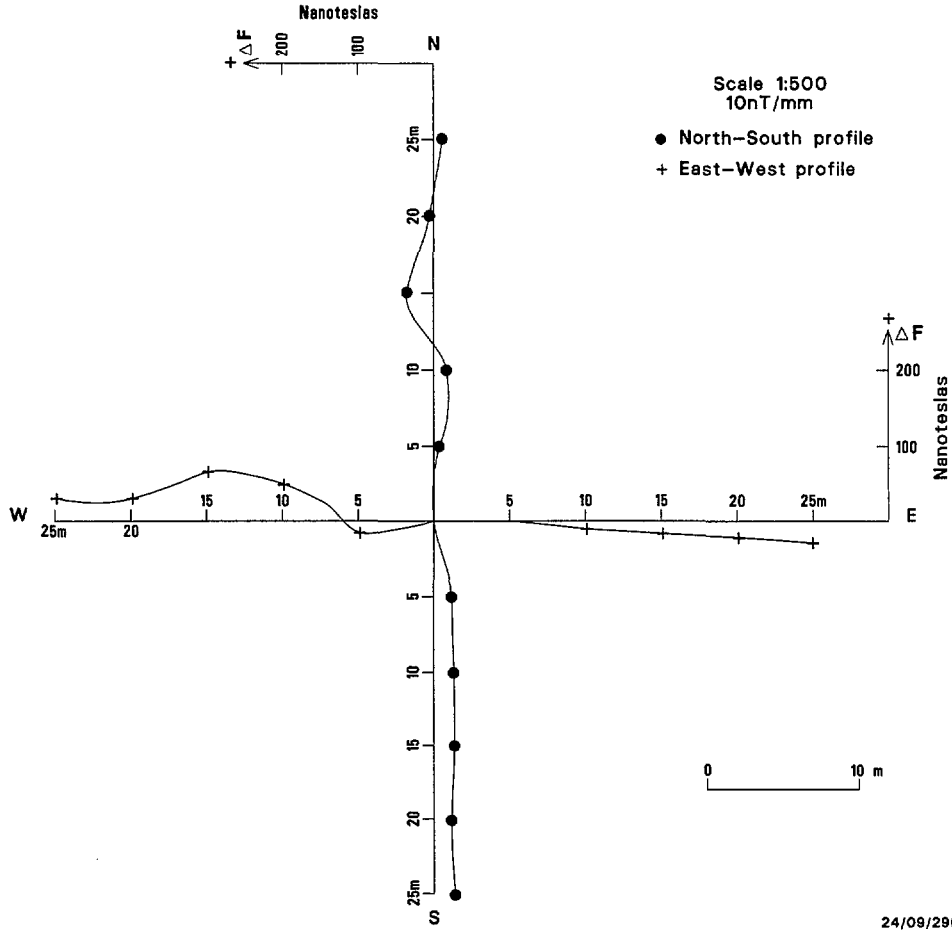


Figure 11. Daru C : local F survey - total magnetic intensity.

AROPA STATION C
Local Survey – Total Magnetic Intensity

It is certain that aliasing has occured at separations greater than five metres

Difference from station C in nanoteslas

metres	North	East	South	West
5	−245	−603	−277	−108
10	−1219	−1329	111	−406
15	−645	−768	209	−396
20	606	−71	800+/−200	292
25	504	417	78	345
30			209	
35			109	
50	851	−3		385
75	227	307		255
100	222	435		−632
150	209			357
200	938			
250	597			

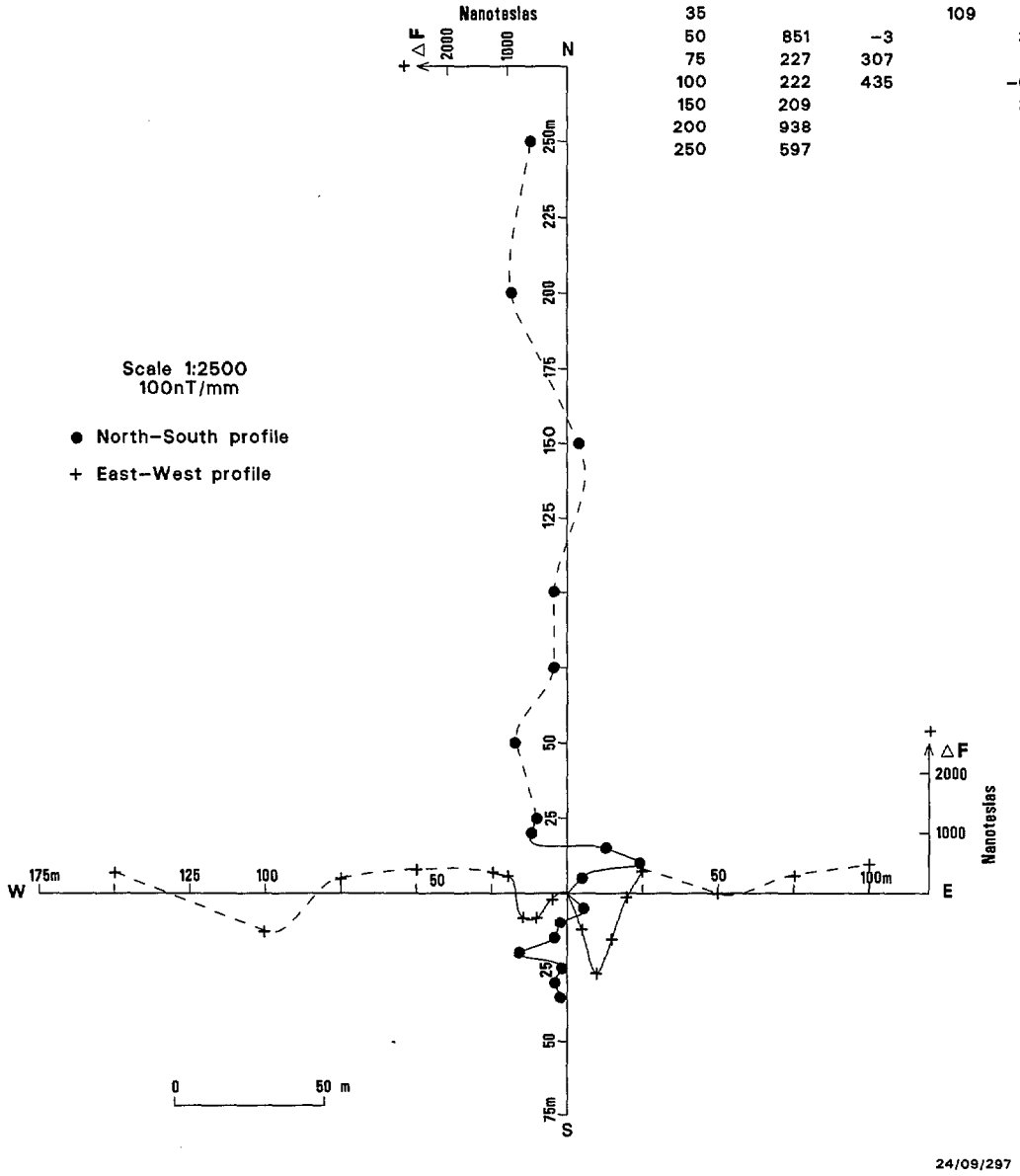


Figure 12. Aropa C : local F survey - total magnetic intensity.

AROPA STATION D

Local Survey – Total Magnetic Intensity

Difference from station D in nanoteslas

metres	North	N.E.	East	S.E.	South	S.W.	West	N.W.
1	7	18	12	3	2	22	15	6
2	23		53		2		54	
3	52		112		7		92	
4	84		173		8		110	
5	105		207		−21		91	

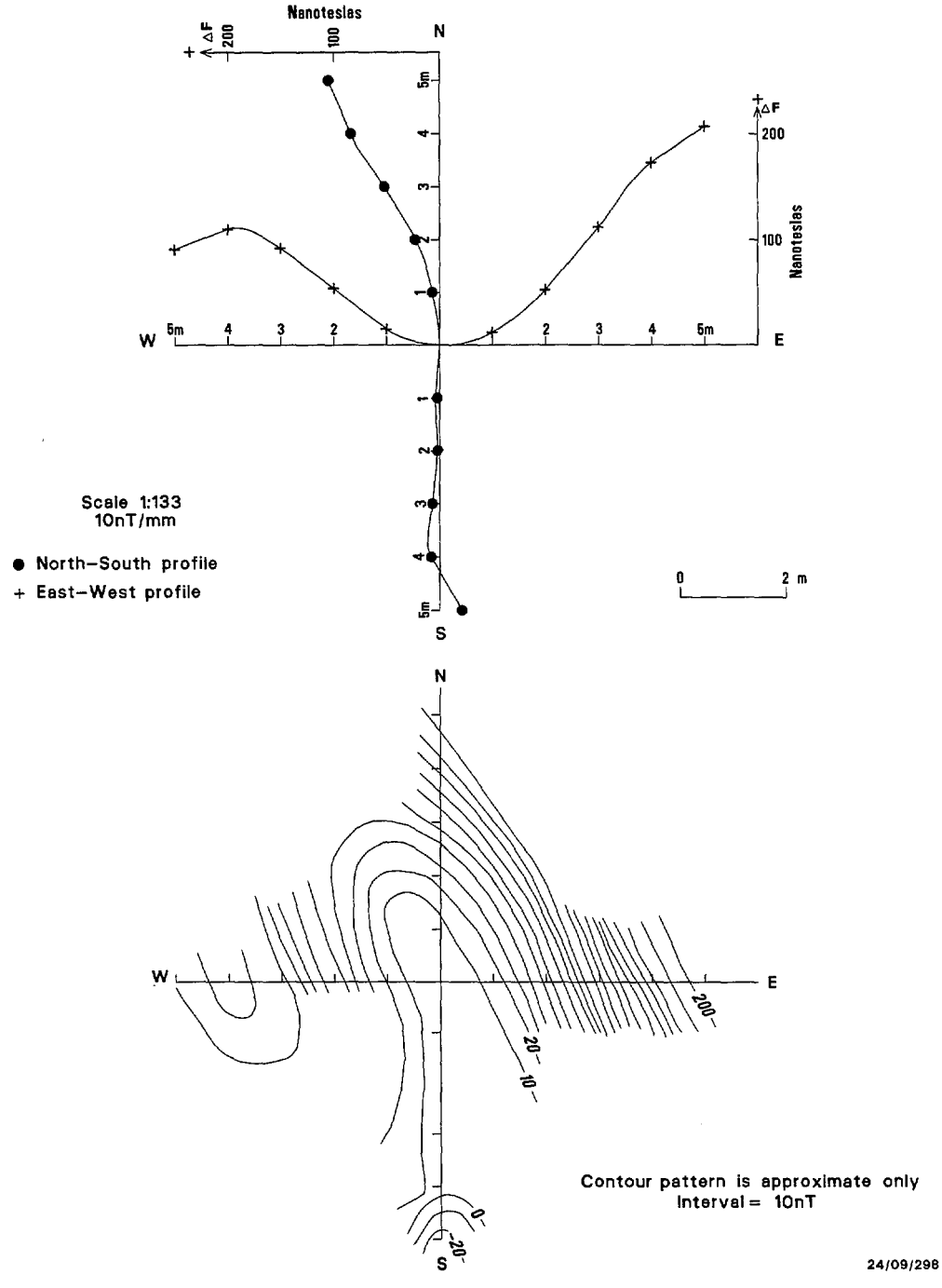
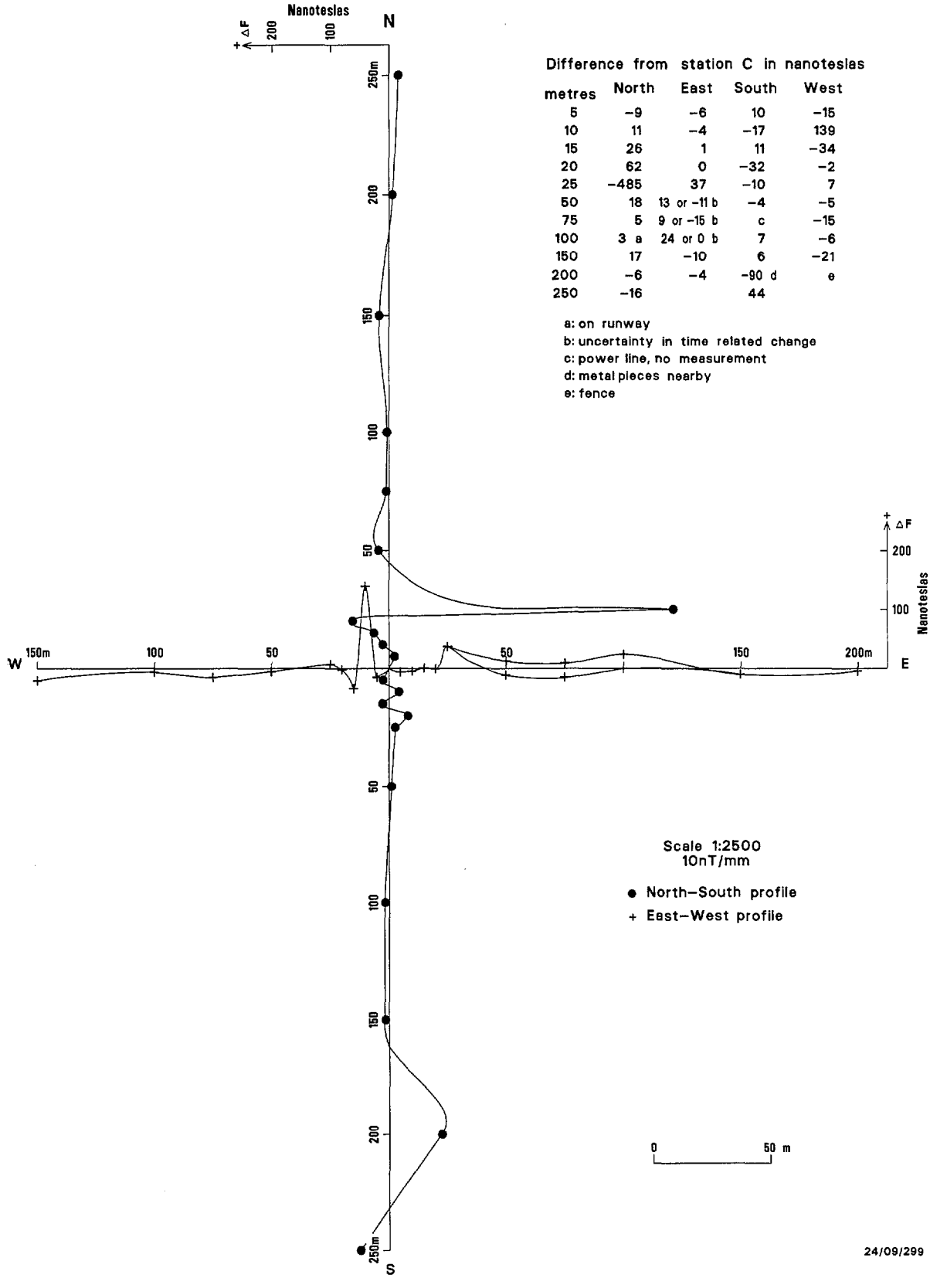


Figure 13. Aropa D : local F survey - total magnetic intensity.

KAVIENG STATION C
Local Survey – Total Magnetic Intensity



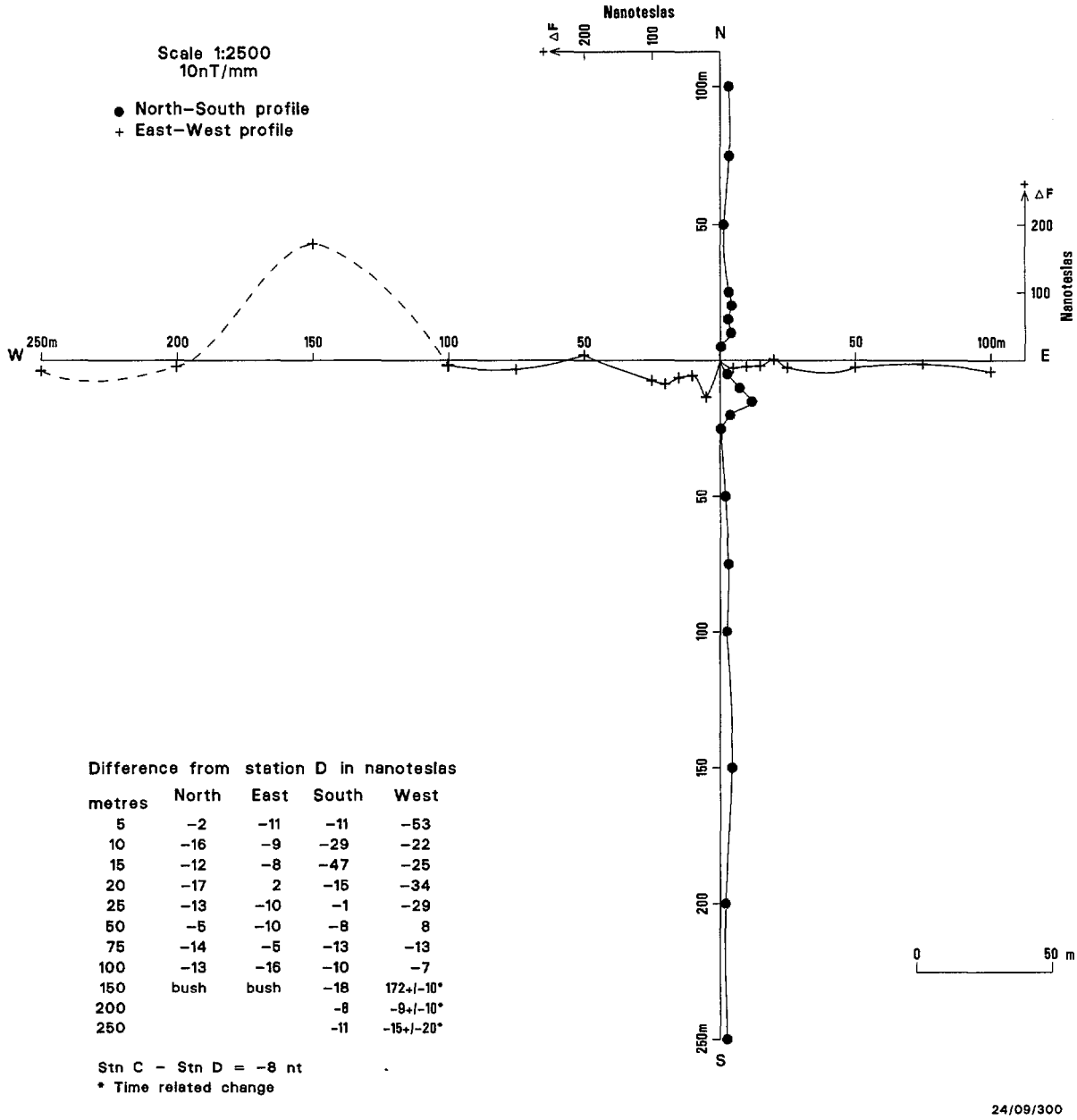
Difference from station C in nanoteslas

metres	North	East	South	West
5	−9	−6	10	−15
10	11	−4	−17	139
15	26	1	11	−34
20	62	0	−32	−2
25	−485	37	−10	7
50	18	13 or −11 b	−4	−5
75	5	9 or −15 b	c	−15
100	3 a	24 or 0 b	7	−6
150	17	−10	6	−21
200	−6	−4	−90 d	e
250	−16		44	

a: on runway
b: uncertainty in time related change
c: power line, no measurement
d: metal pieces nearby
e: fence

Figure 14. Kavieng C : local F survey - total magnetic intensity.

KAVIENG STATION D
Local Survey – Total Magnetic Intensity



Difference from station D in nanoteslas

metres	North	East	South	West
5	−2	−11	−11	−53
10	−16	−9	−29	−22
15	−12	−8	−47	−25
20	−17	2	−15	−34
25	−13	−10	−1	−29
50	−5	−10	−8	8
75	−14	−5	−13	−13
100	−13	−16	−10	−7
150	bush	bush	−18	172+/−10*
200			−8	−9+/−10*
250			−11	−15+/−20*

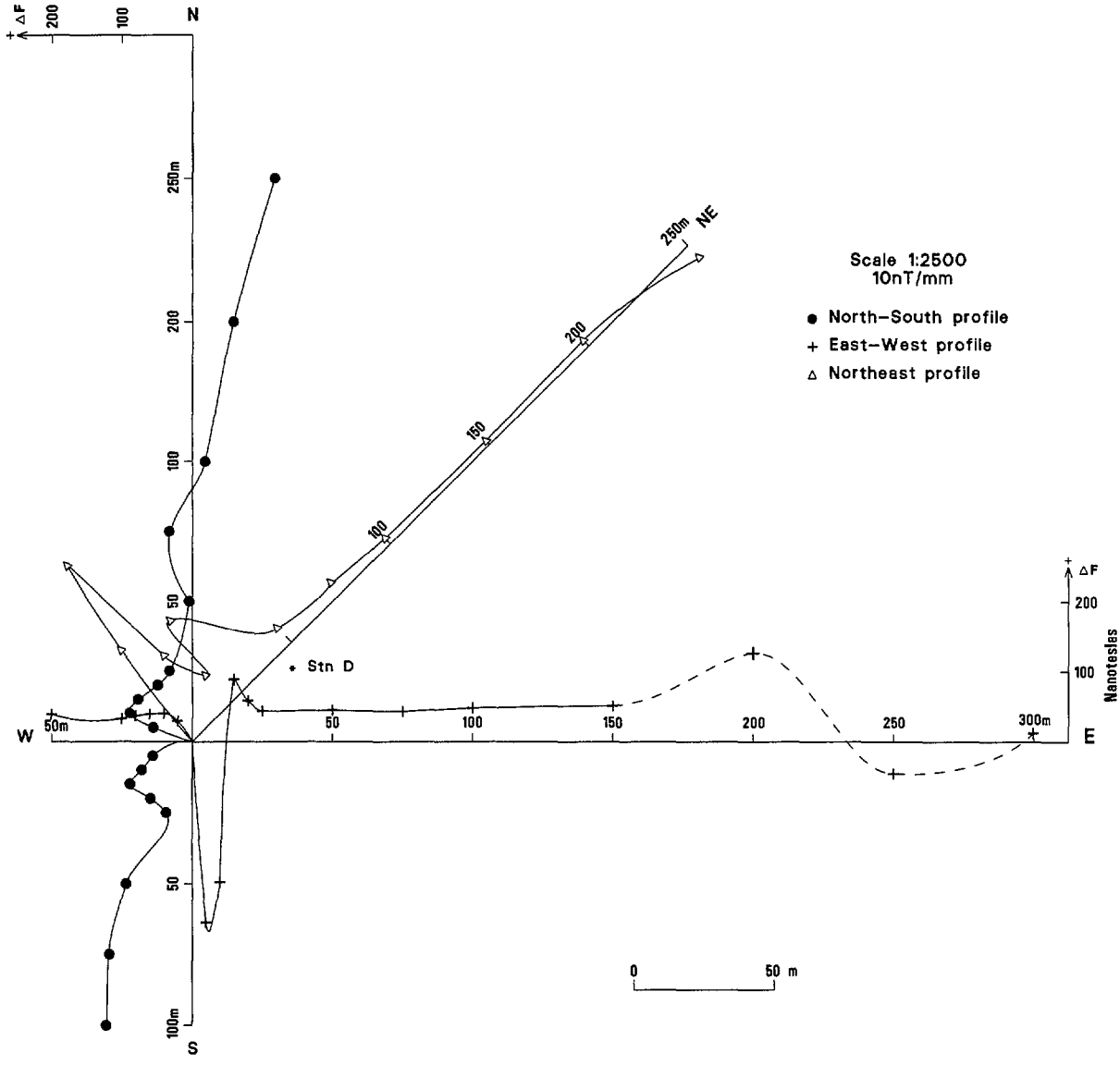
Stn C – Stn D = −8 nt

* Time related change

Figure 15. Kavieng D : local F survey - total magnetic intensity.

MOMOTE STATION C

Local Survey – Magnetic Intensity



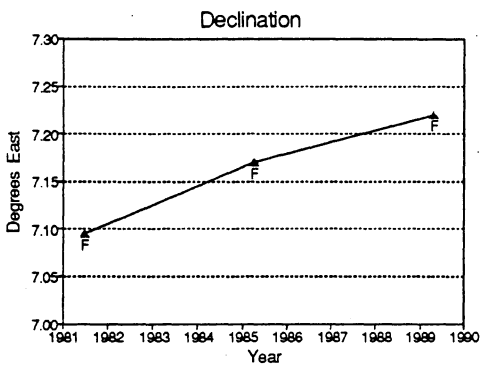
Difference from station C in nanoteslas

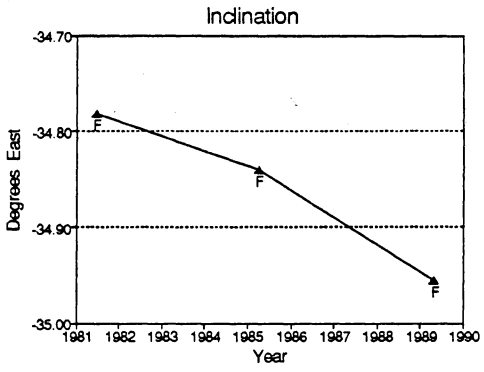
metres	North	Northeast	East	South	West
5	55	163	−254	56	29
10	89	302	−197	72	40
15	77	114	88	88	39
20	49	53	58	59	37
25	32	144	44	37	32
50	4	29	45	94	34
75	33	21	43	118	
100	−18	11	48	122	
150	−59	7	51		
200	−118	11	126		
250	−163	−23	−45		
300			13		

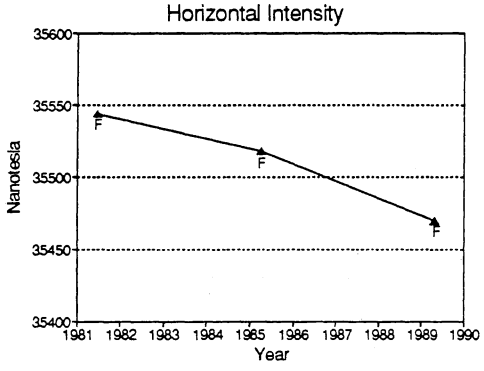
24/09/301

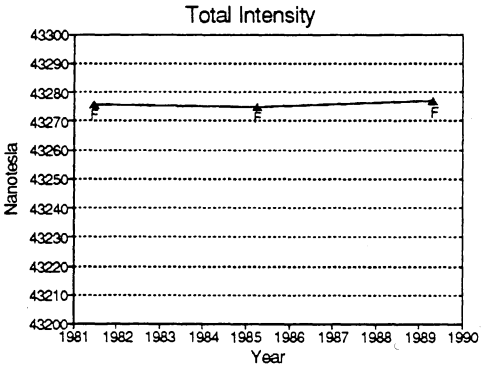
Figure 16. Momote D : local F survey - total magnetic intensity.

GURNEY

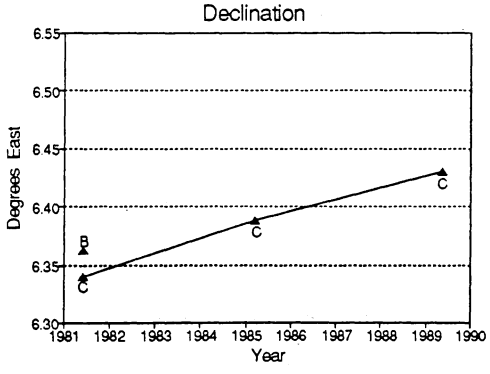


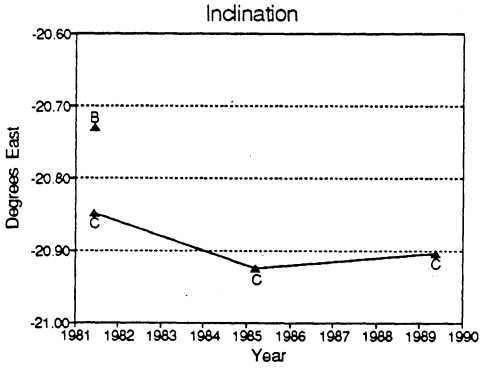


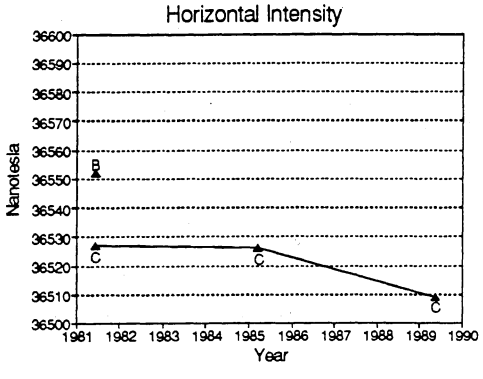




KAVIENG







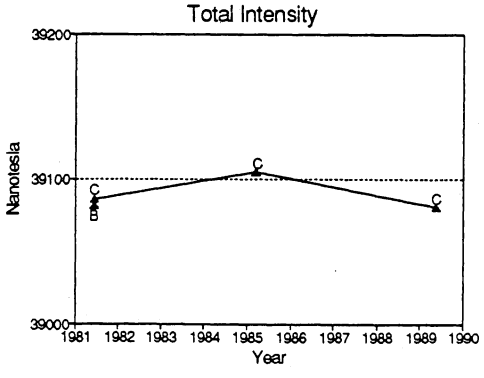
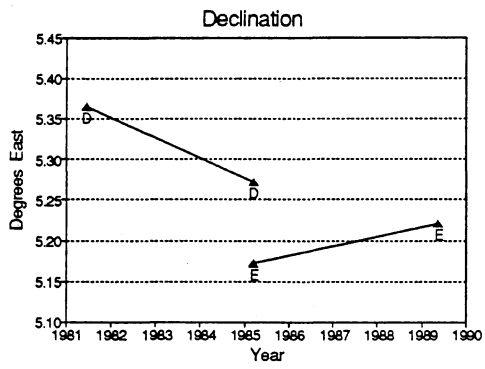
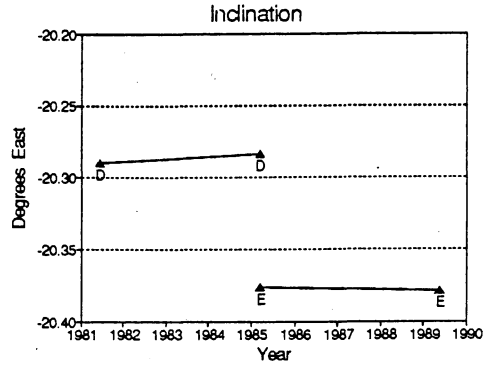
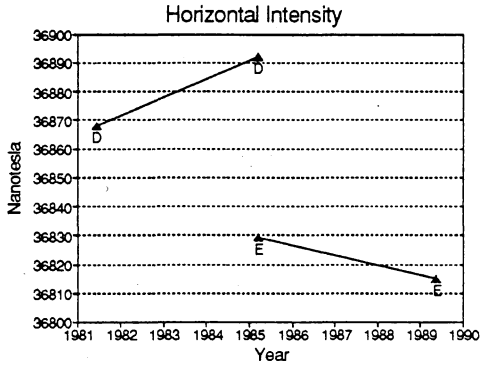


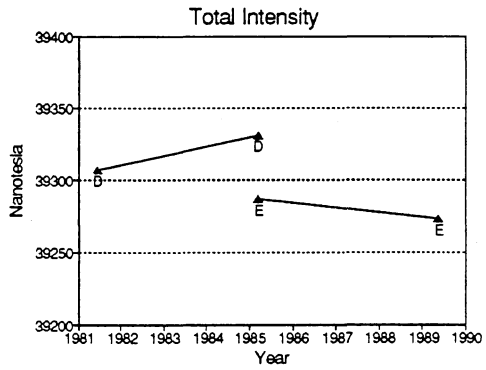
Figure 17. Secular variations from 1980.

MOMOTE

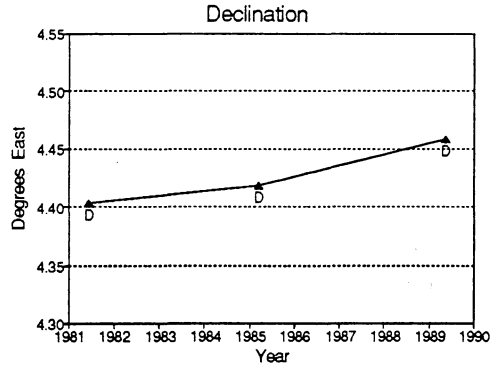


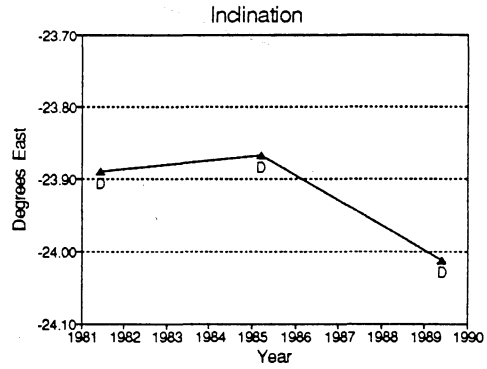


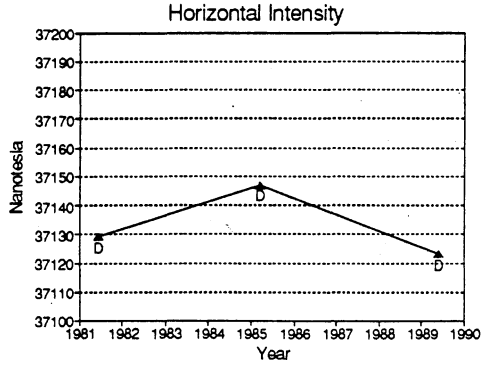




WEWAK







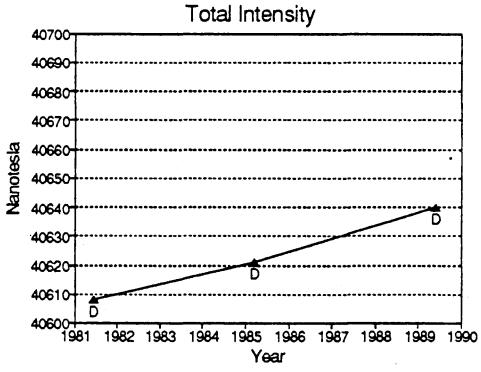
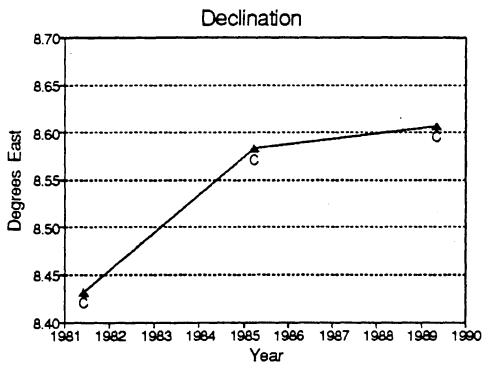
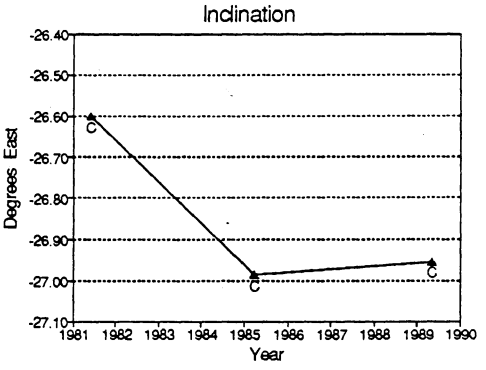
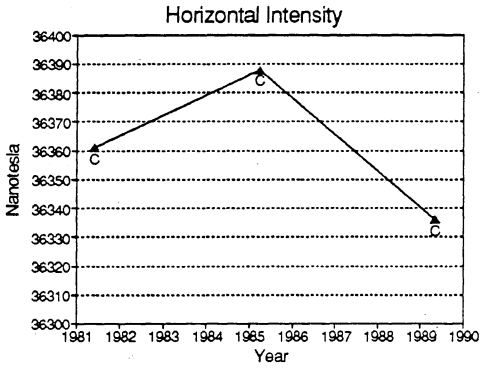


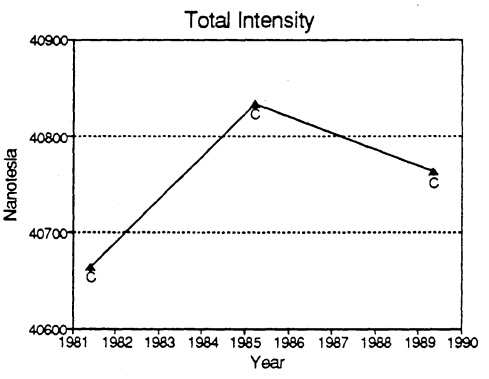
Figure 17. cont.

AROPA

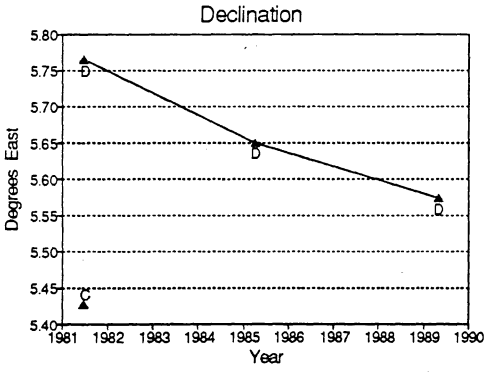


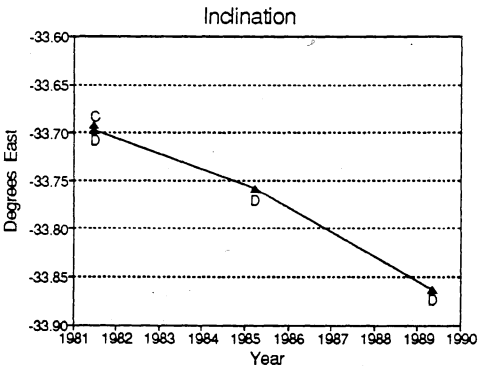


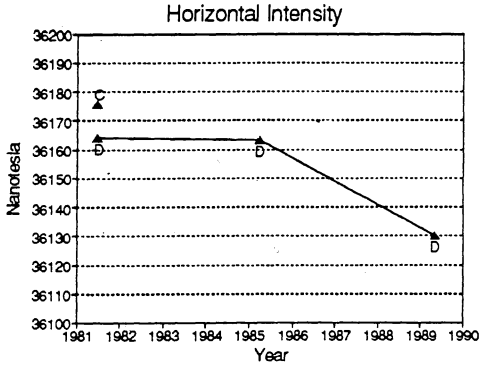




DARU







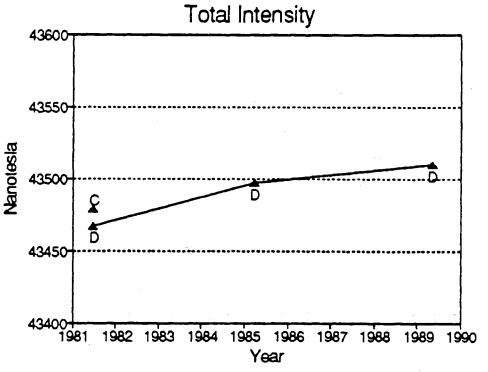


Figure 17. cont.