CLIMATE 27

SUSTAINABLE ANIMAL AND RANGE DEVELOPMENT PROGRAMME (SARDEP)

The Productivity of Rainfall in the Western SARDEP Pilot Areas

by

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A study on the GTZ-SARDEP areas of West Namibia

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ANALYSIS OF RAINFALL IN DAMARALAND.

1.0 Introduction

The area described by the former ethnic name of Damaraland is noted as being of considerable cattle grazing potential, but only in the "good" rainfall years. During such years there is an abundance of rainfall, sufficient enough to maintain grass growth and cattle ranching at an ample level. To use these "good" years as a sample of the whole is not good enough: these years recur irregularly and are few and far between over any range of years which are objectively used. Farming in this area is largely communal in its organization and is of the subsistence level. From the analysis, the chance of greater reliability of a successful seasonal outcome will be seen to lie in the area of small-stock, hardier and with suitable vegetation which has a reduced requirement of rainfall. In this area, cattle ranching should go hand-in-hand with a regular supply of fodder and water. Such sources are rare in Damaraland, perched on the lip of the escarpment.

2.0 Geographical Location of area of Analysis.

Rainfall analysis is required by SARDEP in three Pilot Areas in the Erongo and South Kunene Regions:
Pilot Area 1 Grootberg
Pilot Area 2 Omatjette
Pilot Area 3 Okombahe

The location of the area under analysis includes the western edge of the plateau which comprises the interior of the southern African sub-continent. This is a very ancient area with a geological record of some 3000 million years; the granite rock does not provide great areas of soil and the whole area contains many hills, mountains and steep valleys. The valleys have river beds where some dampness exists and where the rivers flow irregularly following a heavier thunderstorm in the catchment area.

This area lies within the summer rainfall zone and within the frost line in winter. The area is in a zone of limited and very variable amounts of rainfall. The rainfall is thundery by nature and these storms have a limited width, perhaps one kilometre across, the general life of an individual storm rarely exceeds an hour.

Locality descriptions are included in the text for the individual Pilot Area.

Map 1 indicates these areas on a Scale of 1:250 000.

3.0 Rainfall Stations used in the Analysis and their relationship to the Pilot Areas

Pilot Area 1 Grootberg:

4.0 The Analysis Criteria

Certain factors have been established as providing the most appropriate base from which this form of analysis can function. There is a shift from the basis of cumulative rainfall and the resultant of the monthly total which is compared to the monthly average; this detail lacks value when used in the Namibian context because the range of variability of amounts and the impact of rainfall on the rangeland is overlooked. This impact of the rainfall is identified by certain values which are proposed and evaluated in this section. The following proposed values of rainfall are designed for rangeland use with regard to rainfall productivity, so avoiding the regularly applied figure of cumulative rainfall.

4.1 The foundation parameters

4.1.1 Rainfall Year

This is from September to August, thus keeping the summer months under the same group[1].

4.1.2 Rainfall Season

Record books will indicate that good, effective, rains have occurred during the range of months from September to May. As far as the analysis for Namibia has gone, though, this has never happened within one season. The good years of rainfall have focussed on prolonged and regular, effective value, rainfalls occurring from December or January to March or April. The contribution of other months, in such years, varies from the non-existent to negligible. We are really looking at a season which has a peak in a set of months and those months which fringe this peak period.

4.1.3 Rain-days

A day on which rainfall occurs is considered as a day of rainfall; this means all precipitation from just drops to the deluge. The term precipitation also covers hail and snow. These occurrences are normally totalled up and the mean calculated. This figure is then used as a pillar upon which all further data must rely. In the Namibian context this conclusion to the "rain-days" is frequently mis-leading. However, the rain-day description remains in place, but is adapted to reveal other values, as is noted below. The actual period of the "day" is from 08h00 on the one day to 24 hours later, 08h00 on the next day.

4.1.4 Substantial Rainfall

This is the type of fall which will have a very deep penetration and will refresh the aquifer levels. Such falls supplement the productive levels of penetration and the growth which is maintained by an increased moisture content of those levels. The value of this is 25 millimetres in one day.

4.1.5 Productive Rainfall

This term is used to describe, specifically, the amount of rainfall during one particular day which will has been further adapted in this analysis and its methodology. By stating that 83 per cent of the normal rainfall total is "ineffective", the inference is that only some 17 per cent of the annual rainfall has any effective value. From the point of view of the Hydrologist, this figure compares closely with the "substantial" rainfall occurrence figure. In-effective describes the considerable number of rainfall occurrences which do not generate grass growth on the rangeland. This term will be applied as being both relative to the individual season and to certain values which occur during any rainfall season and refers to all values below 10 millimetres in one day. A year with rainfall consisting of only Ineffective Values, no matter on how many days, will be a year of rangeland drought.

4.2 Absence of Rainfall

Definitions of drought, as found in a dictionary, amount to overall generalizations. In relation to the agricultural and rangeland requirements, however, the need is for a definitive value to be brought out: the absence of productive and substantial falls in any day will identify a drought spell or a drought-ridden year. The opposite of effective rainfall are those periods when there is a lack of such values: drought.

But drought will have several levels of its own method of effectiveness.

4.2.1 Threshold Drought

The long winter drought which begins with the first day after the last effective fall of the previous season and is only relieved by the next effective fall in, presumably, the forthcoming season needs a practical name: this is described as Threshold Drought. This is the period which is centred around the dry winter months, linking them with the autumn months of the past season with the summer, or spring, months which form the threshold of the forthcoming season when rain may fall. This is the lengthy period between the last effective fall of the one and the first effective fall of the next season. Although this represents a Winter drought, there can be occasions of winter rain. These very infrequent falls are often below 10 millimetres and so are not discussed further.

4.2.2 Total Drought

Should the Threshold Drought carry on throughout the forthcoming season, with no relief provided by an effective fall of rain, then the term Total Drought is deemed the most descriptive: the anticipation is that annual grasses will be dormant and will not commence their growth-cycle. The perennial grasses and plants will remain dormant: palatable growth cannot be anticipated. There will be no growth for a complete season. Such occasions, fortunately, are rare, but not beyond the range of actual occurrence.

4.2.3 Absolute Drought

This term applies to those very rare seasons when not one drop of rain is recorded. The importance

4.2.5 Large Stock Drought

The cattle prospects in all three Pilot Areas are limited, the area appears to be very marginal for a serious cattle industry. Nevertheless, it deserves fuller attention. In the marginal areas,Large Stock Drought is an all-too-frequent occurrence. The drought causes the values of palatability to be lost completely and the annual grasses will be dormant for the rest of the season. Such occurrences can happen twice, or even thrice, in the course of one season. 40 days without a further effective fall of rain hallmarks Large Stock Drought.

4.2.6 Small-stock drought

The demands of the sheep and goat populations are less heavy, but so is the spread of vegetation. This vegetation is generally much hardier: the period of survival is longer between occurrences of effective rainfalls. The period is about double that of the large stock requirement. The die-back which accompanies such drought reduces the palatability of the various plants. Such occurrences are limited in this region, but they have still been recorded. The 80th day sees the start of a Small-Stock Drought.

4.2.7 Drought Warning: The Alert system

Following the occurrence of an effective fall of rain, the term "Large-Stock Alert" is raised and set in place for those areas where such falls are confidently reckoned/reported as an occurrence. The anticipated rain-area will enjoy a period of growth. But this growth-period will last for a limited period of time. If no further productive falls are recorded within that limited period, then a drought period will return. The idea of the alert is that, although there is no immediate problem currently, a problem will arise if no further effective falls occur. Bulletins are to be issued every 10 days or so, one of the purposes of these bulletins is to provide a breakdown of the persistence or relief of an alert. Persistence will mean no further productive falls have occurred, relief means that further falls have occurred so the alert period is extended.

To determine the detail used for this period of Alert, use would be made of applied satellite imagery. First, there is the daily Cold-Cloud-Duration as read off from the sequence of images which indicate the likelihood of further productive falls. Second, the Vegetation Index shows the increasing greenery of the rain-affected area; a yellowing image shows the decreasing palatability of the rangeland. When no further effective falls are registered in the following 39 days, the 40th day means the onset of Large-Stock Drought. A similar technique will perform this function for the Small-Stock areas with the 80-day parameter providing the bench-mark. The Small-Stock Alert lasts for 79 days: the 80th day sees the commencement of Small-Stock Drought.

The advice of an impending return of a drought condition should be used to ensure that measures or links to fodder supplies are available and that the fodder-supply process can be set in motion to forestall a serious loss of condition of the live-stock involved. The prospect of, the need for, a de-stocking, and thus a marketting strategy, to be applied will require prompt implementation.

4.3 Other relevant factors concerning Rainfall

4.3.1 Rainfall Probability across the season

Recently, in South African Weather Bureau Technical Paper 24, a section was devoted to the progress of the rainfall season across Southern Africa . The term "core months" was used to denote the peak of the season. In an unpublished work, Olszewski has adapted the principle of the "core months" to the Namibian scene. These core months provide some 70 per cent of the total rainfall and depict the heart of the agricultural season. The rainfall season focusses around these core months. It can rain during any one month or any set of months from September to May; so these occurrences need to be set against a rainfall season framework.

Olszewski has delved into this sphere also: If we take the Core months and then investigate what happens prior to or after these months, we find months which contribute satisfactorily to the events of a season and which are clearly more rain prone than those months more removed from the core of the season. These months are named the Associated months which contribute some 22 to 25 per cent of the rainfall. The outer periphery, when effective rains can and have fallen, are named the Possible months which contribute barely 5 per cent of the rainfall.

For the Erongo and southern Kunene regions, therefore, the season is demarcated thus:

Core	**January**	**February**	**March**
ASSOCIATED	NOVEMBER	DECEMBER	APRIL
Possible	September	October	May

4.3.2 Variability of the Rainfall Season

Major features of arid climates are, first, the scarcity of rainfall and, second, the wide range of variability experienced as to both the amount of rainfall and spacing, across the months, of the days of rainfall. People and a natural environment have coped successfully with these conditions for millenia. The task, these days, is to extract the best from these basic conditions and even develop an improved infrastructure with regard to rangeland use and management which in turn is dictated by the on-going rainfall season and the pattern which is emerging for that year. This type of rainfall analysis is designed to point the way for what is possible and what is just impossible against this background of excessive variability.

The point is this: having set out the rainfall season into perspective, it should be clearly understood that, in the worst of seasons, the Core months can be virtually rainless, with one effective fall in one of the Possible months or even with no productive fall registered over the entire calendar year, let alone the actual rainfall season. The variability factor is ever-present in the Namibian rainfall picture.

because such an event occurred on one day, the next similar day will do the very same thing. This sequence of thought can hold water in the temperate zones of the world. The sub-tropics differ in the range of variability which can occur across small distances, from day to day, fom one weather pattern to another similar system.

4.3.4 PROGNOSIS OF THE PROBABILITY OF RAINFALL AT A GIVEN PLACE

No matter how advanced the technology, no matter how powerful the computer, no matter how thorough the programming, there is no hard and fast tool which can used to predict the occurrence of rain at a given point in the sub-tropics. It boils down to the difference between "It will rain, today" and "It will rain here, today". The likelihood of there being rain "within sight" of a given place can be, and is, forecast with high percentages of accuracy. The precision of "it will rain here", at that given place, is far less accurately achieved. The idea of forecasting amounts of rainfall across 6-hour periods has received practical attention in the output of the Bracknell Forecast Centre and the products of the ECMWF[3]. These prognoses cover the period 48 hours ahead from the time of issue. Their accuracy, which is no more than an areal indicator, is sound, but it is only 48 hours, at this period of time. Good, but there is much further to go.

While we are unable to perceive the future, we are able to monitor the present and note the ebb and flow of the various events as they occur across the day, the week, the dekad and the month. The analyses which flow from such monitoring will improve with practice and perseverance. For those who seek the rapid results which the computer world has suggested should be readily or reasonably available, this is bad news. For those who understand the value of research and the labours which go with it, this will underscore the value of diligence.

4.3.5 THE RAINFALL STATIONS AND THEIR DURATION.

Having established the rainfall station and ensured that all is well with its functioning, the next occasion should be as far removed, in time, as it is possible: the matter of its closure.

The normal duration of a rainfall station does not exceed ten years. This is a very short period from which to use its data for long-term assessments. Barely twenty-per-cent of the government stations exist for a thirty-consecutive year stretch. This is the normal, regular, approach, which maybe called the horizontal, because it takes a straight line of data.

It does mean therefore that another approach must be tried to obtain full value from the many shorter-period stations.

By taking one or two stations of long-duration in an area and calling them core stations, from which the general rainfall aspect of that area becomes apparent, and then taking the various brief-duration stations which have come and gone within that area, satellite stations perhaps, and matching these stations to the time-scale and see what variation, if any, occurs to the initial aspect. This can be called is not deemed essential across any one of the four areas and the individual places pin-pointed for the GTZ-SARDEP plan of operations for rangeland management on the basis of rainfall expectation regarding the frequency and amounts associated with Productive values of Rainfall.

4.3.6 Rainfall Station data, Rainfall Variability and the Pilot Area Analysis.

It has been noted that thunderstorms, thundery showers, the regular precipitation of the tropical regions, are very small in areal extent, perhaps a kilometre across. The range of accountability of an individual rainfall station is perhaps as little as 500 metres across. These dimensions are as small as pin-pricks on the normal sized wall-map. The factor of variability serves only to highlight the limited range of reliability that can attached to a rainfall reading from one station on one particular day. The regular description of the precipitation pattern on that particular day will vary from "isolated" to "scattered" which means not more than a 30 per cent to not more than a 60 per cent chance of precipitation occurring, irrespective of the amounts of rain which are recorded.

This litany of problems serves to keep in the forefront of the mind that Namibia, let alone any one particular part of the country, is situated in an arid zone. That rain falls to any effective extent across a span of years is remarkable. That such rain supports an ecology and an environment in which livestock farming has any viability is equally remarkable. To determine the values which apply to this rainfall means that a level of adaptation, of whatever detail is available, needs to be made. This process will mean that levels of precision in this adaptation process will not mean the same as those levels more usually associated with the understanding of the word "precision".

This analysis, in particular, and any other analysis made on the rainfall in an arid region will need to search for an applicable methodology. This methodology will be the base of this actual analysis of similarities and probabilities across any particular region and, in this case, the designated Pilot Areas. These similarities and probabilities are based on the analysis of the rainfall station record from the point of view of the productivity of the rainfall and the absence of such productive occasions together with the numbers of days elapsing between such occasions of productive rainfall.

It appears that no such analyses are available for perusal and adoption to the Namibian scene. This is confirmed by the Climate Research Group at the University of the Witwatersrand, where the advice has been that a methodology would have to be created and tested against known criteria.

To burden the approach even further, the likelihood of local features imposing an influence is ever-present. These factors receive attention as much as their imponderability can be given an outline.

Therefore, the Pilot Area analysis is based on rainfall data from that area or from those places which are deemed to have a practical similarity to the Pilot Area. The rainfall data presented should not be taken as being precisely applicable to the Pilot Area, but it can be taken as presenting a good level of similarity to the conditions anticipated in the Pilot Area.

5.0 RAIN-FALL ANALYSIS OF THE PILOT AREAS

Three Pilot Areas are under consideration: Grootberg 191, Omatjete and Okombahe.

Although the Core and Associated months have been described, the Pilot Areas have March as their wettest Core month and April as the wettest Associated month. A late Summer, really an Autumn, rainfall season typifies the entire area. With the heat of summer having returned by October, this can indicate that some 5 months of unrelenting heat and desiccation will be experienced before major, widely spread, relief can be anticipated. Although this is the norm to which flora and fauna have adapted, this is a hallmark arid area, exemplary of the marginal nature of much of Namibia.

Because the isohyets run from north-west to south-east, the preferred comparisons will lie to the north-west and the south-east of the Pilot Area(s): featuring the rainfall stations of Zessfontein, Franzfontein and Khorixas. The cross-section from north-east to south-west reveals a dramatic decline in anticipated rainfall amount; those stations which are much further inland will have little relevance. There are no stations on the south-west side.

Okombahe and Omatjette lie reasonably close to one another. The comparisons include Usakos and Karibib, while near-by Otjomue-süd in the Omaruru district should complete the picture.

Maps are attached as an Annexure, please see notes under 7.5 Maps.

5.1 GROOTBERG PILOT AREA

5.1.1 The rainfall stations which are used to provide the analysis and the conclusions for this Pilot Area are Zessfontein, Grootberg School[5] at Libra 191, Neuland 612, Condor 617, Kakatswa Onguati 236, Khorixas, Fransfontein.

5.1.2 Grootberg 191 farm lies on the north-east side of the Grootberg massif. The farm is large and there are three settlements noted on the map: Grootberg itself is the most southerly, the rainfall station was situated at Libra.

The western end of the Grootberg massif marks the edge of the escarpment, downhill and to the west lie the fringes of the Namib. The factor which this plays in the actual rainfall of the area is uncertain.

The orographic effect of the mountain appears to lie in the moderating influence which appears in the rainfall records of neighbouring areas such as Condor 617, Neuland 612 and, especially, Grootberg, Libra, 191. The absence of any record of falls in excess of 75 millimetres, from the period from by the 1950's to the very early 1980's is noteworthy. It would appear that the presence of such a massif enables precipitation to begin earlier in the growth and culmination of large cumulus cloud than happens over other areas where lesser mountains are found or over the rolling plains.

right set of circumstances, will have a considerable effect upon the rainfall prospects along and just behind this escarpment. Cold air can be drawn inland, for instance, and will slide under the warmer air of the interior. This "under-cutting" has very positive effect on the potential thunderstorm development. This effect can also occur in situations which are otherwise not favourable for thunderstorm development. The presence of mountains, and escarpments, has an undeniably positive value in determining the rainfall potential for that locality. The Otaviberge provides a classic example where Namibia is concerned.

Although, the north-east side of this massif would be exposed to much wetter conditions in certain, rather rare, circumstances; the more frequent occurrences of thundershowers would tend to drift from the north-west, or at least a north-westerly, direction. What is certain, though. is that there is no rain-shadow or lee of the mountain effect. With brief detail available, it is not easy to establish the correlation between other stations in the neighbourhood.

Exceptional precipitation, especially hail, has been reported at Condor 617 only. Whether or not this is actual or another instance of sloppy recording is not known, but does seem very odd: mountains and hail do have an affinity of occurrence. Over a span of 13 complete rainfall seasons, Condor 617 rainfall station experienced 5 hailstorms.

Drought, as Large Stock Drought, was virtually an annual occurrence at all three stations, even Grootberg, Libra, where, apart from 1976, each year endured a spell of Large-Stock Drought. Small Stock Drought occurred in 1973 and 1978. Close calls (79 days) occurred in 1961 and 1967. The record at Grootberg, Libra, lasts from 1968 to 1982, this means the "wet" 1970's are included when the prevailing rainfall conditions were at their best. The other two stations present a similar picture.

Rainless months, across the Associated and Core months, feature more strongly in the November and December period than they do elsewhere in the calendar. There was, generally, one rainless month for each of the Core and Associated months across each stations' record. These, obviously some 30 days long, do not necessarily feature in the periods of Large Stock Drought. But, with the sun very much in an apex position, the toll taken by such dry months on water supply, general vegetation and so on, must be excessive.

These closer comparisons, when taken with the further afield stations of Zessfontein, Franzfontein and Khorixas, provide an unaltered picture, generally.

5.1.3 Zessfontein may be used to provide an idea of what the drier years would be like, were they to increase in number and become the major feature of the climate. In which case, even small-stock farming would be at some risk.

At Zessfontein, during the period 1957 to 1986, there were 3 periods of Total drought. The 1961 to 1963 period covering 613 days, the 1980 to 1982 period covering 676 days and 1984 to 1986 period covering 660 days. Small stock drought occurred on one other occasion: 80 days in 1968. There were 10 periods conjunction with the earlier comments about rainfall reporting and recording.[6]

However, should this be a true record of events, that no occasion of precipitation was noted, this might just be an underscoring of data noted from the contiguous western Owambo stations during the 1980's, and even into the 1990's. Ombalantu, especially, with some support from both Tsandi and Mahanene, appear to indicate that a form of dessication is being introduced to the north-western end of Namibia which is indicated by an increasing ability to avoid the occasions of precipitation falling from the on-going weather patterns and their potentially rain-bearing systems.

The direct relation between this apparently increasing failure of the rain to fall and the considerable loss of tree cover in the Omusati region, at least, is uncertain. This deforestation could be either that one deciding factor in the disturbance of this rainfall regime, with no climate change, or be indicative of a decline due to both climate change and environmental degradation.

With two reported hailstorms and with effective rainfall occurrences varying between 1 and 6 falls each year, usually, the ability to improve matters with heavier downpours is also limited. Only 3 years: 1971, 1984 (11 falls each) and 1976 (7 falls) exceeded the 6 days of effective rainfall level a year. The growth period and its strength of growth is surely limited in these circumstances.

The rainfall season and the core months at Zessfontein:

Core	**February**	**March**		
ASSOCIATED	NOVEMBER	DECEMBER	JANUARY	APRIL
Possible	September	October	May	

March and April are still the wettest months of their category, despite the thinning of the Core with January moving from the Core and becoming an Associated month.

The marginality, perhaps protected a bit by the Grootberg massif, of the Grootberg 191 vicinity is underscored.

5.1.4 The older station at Franzfontein and the current station at Khorixas present a more positive aspect. First, there were no occasions of Total Drought recorded at either station from the period 1914 to 1956, when Franzfontein was reporting alone. From 1956 to 1981 the same absence prevailed with both stations reporting. This condition continues from 1982 onwards with Khorixas, only, recording.

Bad years were 1932 where the Threshold Drought was only interrupted in early April, after a period lasting from early 1931, a period of 601 days; also 1980 to 1981, when 538 days, at least, (to closure of station) were noted. The Khorixas record, for this last period, indicates one effective shower during April 1981 and more positive relief from January to April 1982. The Franzfontein record shows frequent occasions of Large Stock Drought with only 16 years escaping this scourge and some of those 16 years having a very poor balance shown either as a very brief growth period or by an early sequence

Core	January	February	March
ASSOCIATED	NOVEMBER	DECEMBER	APRIL
Possible	September	October	May

Although March is prominent as being the maximum core month, with January clearly third. Keeping in mind that this area is on the western edge of this configuration area, this imbalance shows the lateness of the major part of the season. So, it is interesting to note, that in the Wet Years (those which exceed the 130 per cent of normal: this is the accumulated rainfal total across both Core and Associated months) January inflates to become on average at a par with February and March: the three months then stand out so clearly as being the core of the wet season. The overall picture, which is subject to the considerable variability factor, supports this core month feature. The occurrence of productive and substantial falls puts further emphasis on these months which comprise the core of the season.

The expectation of hailstorms is not very well catered at Franzfontein. The original records from 1913 to 1940 exclude the occurrence of both hail and thunder[7]. For the time being, though, the available detail is presented, but should be accepted with caution. Franzfontein endured **5** hailstorms during 1963 and only another seven between 1942 and 1981. Khorixas records show only two occurrences between 1956 and 1995.

Khorixas notes two falls of hail, 1964 and 1970[8], which could be in keeping with the idea that it is "hard to rain" in such years and hail-fall meant that, eventually, one cloud was able to remain convectively active long enough to "force" precipitation to occur.

The Nil rainfall months feature equally December as much as they do November. In recent years April features more strongly at Khorixas; April is usually the fourth best month. The pre-war years at Franzfontein show only one such occurrence, while 5 occurrences were noted during the 1900's: 1903 to 1909 for exactitude. But this is a more heartening picture than that of Zessfontein.

The annual occurrences of productive and substantial rainfalls are also indicative of an improved environment. 20 years reached at least 10 occurrences in a year at Franzfontein and 11 at Khorixas. The likelihood of a growing season of decent length is a very reasonable proposition at both points. The Threshold Drought is of an 8 month duration, by rule of thumb from mid-April to mid-December.

The rainfall season aligns with the Grootberg area configuration of Core and Associated months.

5.1.5 Because there seemed to be a gap in the Grootberg analysis, a check was made and the station Kakatswa Onguati 236 was unearthed. This means the full entry and analysis had to be done. There are several stations in the western parts of the Outjo district which had not properly been investigated since their positions had been checked and, if necessary, re-coordinated[9] (Olszewski, 1990-92) this station was one of the original commercial farms of the Outjo district which was appropriated under the requirements of the Odendaal Commission to be added to the Damara homeland, as were Grootberg, Condor and Neuland. With data from 1931 until mid-1965 season, a better range for analysis was anticipated. Apart from the odd months' missing data, there is a break from the end of a barren 1932 through all of 1933 until the December of that year

Although most years provide either a reasonable spread of Productive and Substantial falls or a reasonable cluster of such events across the core and its immediate periphery of the season, the prospect of cattle ranching is limited. The occurrence of Large Stock Drought is often masked by this picture and this occurrence is recorded among all but the wettest of years, say 6 years out of the 32. 26 occasions (say 80 %) of Large-Stock Drought does not offer a good scene for cattle.

From the names of farms in the vicinity: Hillendale, Bergveld, for instance, the impression is gained of a broken countryside of hills and valleys; contours confirm this. Countryside which favours the more agile small-stock than their heavier bovine counterparts.The rainfall pattern also favours small-stock.

With only three occasions of mid-season drought exceeding the Small-stock parameter of 80 days, these three occasions occurred across a stretch of five years from 1939 to 1943. Apart from 1932, the worst year was 1946 when, by the end of January, the growing season was over: with no productive rain after the 14th of December the growth achieved thus far would have been burnt off by the end of January. The normally drier year of 1952 had one wet spell in February; the growth period will have ceased by the, cooler, end of March. All in all, this area of Kakatswa Onguati is, by Namibian standards, well suited to small-stock farming, using an assessment based on productive-rainfall records.

Oddly enough, hail-fall was registered during the wetter years of 1944, 1953 and 1957. The occurrence of the Nil rainfall month across the core months is limited to a period from 1941 to 1948. 1944 and 1947 apart, the decade of the 1940's is part of a drier sequence of years across much of southern Africa, unfortunately Namibia is no exception to this dry period, rather even 1944 and 1947 are more often included in this dry spell of years.

In the search for re-affirmation of what appears to be a favourable trend, but still with only Khorixas as a current station the defunct Ehobib 209 has been researched[10]. Covering the years from 1957 to 1982, which includes the dry 1960's and the wet 1970's and ends during the exceptionally dry 1981-3 period, this station has no Total Drought, has only 2 spells of Small-Stock Drought and its longest Threshold drought, 395 days occurs between 1981 and 1982: a couple of Productive-fall days across an incredibly dry period. If this spell between 1981 and 1983 is a precursor of drier times due to a deterioration of the climate, this is not a good sign. Climate change may well show itself in the arid zones more obviously than in the wetter parts of the world. This is a prospect which Namibia must be prepared to face.The small-stock droughts coincided with the dry El Niño years of 1964 and 1973 (see Footnote 6). Hail-fall occurred in 1957, same as Kakatswa Onguati, and also in both 1958 and 1964, (both El Niño years) in early season falls. Kakatswa Onguati lies in the same parallel band.

Generally, the prospects for Small-Stock appear very reasonable in the Grootberg Pilot Area.

The following set of tables should encapsulate this, and the above detail, clearly. (See Annexure A where the tables are set out consecutively for all three areas.)

The Pilot Area analysis is based on rainfall data from that area or from those places which are deemed to have a practical similarity to the Pilot Area. The rainfall data presented should not be taken as being precisely applicable to the Pilot Area, but it can be taken as presenting a good level of similarity to the conditions anticipated in the Pilot Area.

Table 1

THE OCCURRENCE AND DURATION OF THRESHOLD DROUGHTS AT GROOTBERG, PILOT AREA 1

The Threshold Drought means exclude the years which endured Total Drought.

Station & Detail	No. of Years on record	Mean Duration in Days	Maximum Duration in Days for the Years on record
Grootberg, Libra	14	247	362
Neuland	15	257	400
Condor	13	242	399
Zessfontein	34	308	435
Kakatswa Onguati	32	263	400
Franzfontein	62	242	342
Khorixas	40	259	387

Table 2
TOTAL DROUGHT OCCURRENCES AT GROOTBERG, PILOT AREA 1:
The " /Year " indicates the Rainfall Season (Jan. Feb Mar) with no Effective Rainfall

Station & Detail	Occurrences	First/Year	Second/Year	Third/Year
Grootberg, Libra	Nil			
Neuland	Nil			
Condor	1*	606/1962		
Zessfontein	3	745/1914	676/1981	660/1985

Table 3
THE OCCURRENCE AND DURATION OF LARGE STOCK (40+ DAYS) AND SMALL-STOCK (80+ DAYS) DROUGHTS

Station & Detail	Years	40+ days	80+ days	Mean Duration	Max. Duration/Year
Grootberg, Libra	14	12	2	71	142/1973
Neuland	15	11	2	70	102/1961
Condor	13	7	4	93	129/1967
Zessfontein	34	12	2	65	93/1916
Kakatswa O.	32	15	3	64	126/1940
Franzfontein	62	40	13	80	149/1920
Khorixas	40	54	12	91	142/1962

Notes:
Zessfontein with the lengthy Threshold Drought, there is not much calendar time left for Large and Small-Stock Droughts.

5.2 OKOMBAHE PILOT AREA

5.2.1 The rainfall stations which are used to provide the analysis and the conclusions for this Pilot Area are Okombahe Welfare Office, Khorixas, Fransfontein, Cypress 64, Otjomüe-sud 110, Karibib, Usakos.

5.2.2 By Namibian standards, Okombahe is relatively low lying. The rainfall regime will be conditioned by the fact that it lies on the north, the windward and wetter, side of the Erongoberge. The assumption that this massif has a favourable orographic effect lacks proof either for or against. Also, the town and district are below the main rim of the escarpment towards the Namib; this situation can be of consequence where rainfall expectations are concerned.The relatively few, but very productive, occasions of rain-bearing north-easterly wind conditions may not extend westward over the edge and on to the down-slopes of the escarpment. Most certainly, the river will receive a valuable in-flow. Such a flow can infiltrate the sandy environs of the river-side, thereby favourably influencing the vegetation growth. Local knowledge could well supply some detail about these considerations.

Okombahe has recorded rainfall data since 1904 and, apart from a break in the mid-1940's, kept going until 1975, unfortunately, the dry spell of the 1980's is unrecorded. Two periods of Total Drought are noted: 1940 to 1942, 761 days, and 1961 to 1963, 649 days. These are the two worst occasions. Year-long droughts occurred in 1914 and 1915, 384 and 394 days respectively, 1918 had a 350 day Threshold Drought. The rainfall years of 1926, 1929, 1930, 1932, 1935, 1958, 1960 1971 and 1973 pattern of events. Only the very dry years, though, have one and two such falls as their total number of occurrences.

Of the 60 years where daily values are available, 24 indicate occurrences of large-stock drought, 10 of which were extended and passed the 80-day mark. So 16% of the years can provide a small-stock drought. This must be a very marginal area, indeed. The absence of data from the 1980's and the early 1990's does mean that a notable period of likely drier conditions cannot be considered in this report for Okombahe.

This detail over the 15 years from 1980 onwards could be deemed as being very necessary before a final assessment is made of the potential here. These past 15 years, as the evidence shows from the distant Omusati region of Owamboland, are of considerable importance when data is being put together to indicate whether or not there is a shift in the delicate balance of rainfall across the marginal areas of the country, if not Namibia as a whole.

There is a weight of evidence to show how recent values of rainfall have diminished at a variety of stations country-wide: newly established stations have a clear set of lower values than their longer-running counterparts which may be only a matter of kilometres away. This set of comparisons shows up when three stations are compared. The new station, the older long-running station and the defunct station which gave some 30 years of data earlier than the 1980's will show up this situation. In the Omusati region, for instance, Mahanene is the new station, Ombalantu the long-running station and the defunct station is Tsandi.

5.2.3 How does one get an assessment from a place with no detail available is a pertinent question. Just over the magisterial border, the Otjomue-Süd station can provide readings from the early 1980's until today. Further afield, Usakos, also below the escarpment rim, still functions, too.

At first glance, Usakos would seem to be within the bounds of small-stock farming with reasonable comfort. The first glance takes in the occurrences of Productive and Substantial rainfalls; a fair monthly spread seems to ensue. However, the spacing of these falls reveals a harsher picture. This picture could be used to provide the image of Okombahe in its drier years.

The length of the growing season, when productive rain is falling, is frequently restricted to little better than one month; this assessment is based on the length of time when productive rains are falling. After that time, the growth will continue but will receive no further sustaining rainfall. A decline in the growth is the certain eventuality. From 71 years of daily record there are 45 years where the full growth period (the period from the first productive fall to some 30 days after the last such fall) is either restricted to less than 40 days or is punctuated (terminated) by drought spells of 40 days and longer: very nearly two-thirds of the time. Drought periods of more than 80 days are limited in number, being 8 in all: 12 per cent of the total years. 3 years ofTotal drought are revealed: 1921-1923, 1931-1933 and 1958-1960. The Threshold drought is around the 300 day mark.

That Usakos is a very dry area is well known, but the dry 1980's did not serve Usakos much worse than

The rainfall season and the core months at Okombahe

Core	January	February	March
ASSOCIATED	NOVEMBER	DECEMBER	APRIL
Possible	*September*	*October*	*May*

The inclusion of Okombahe in this rainfall province deserves further comment. This must be one of the more coast-wards places which will have a January which is, both cumulatively and productively, so much wetter than April or December. It does appear that the Erongoberg has an influence on this; this ancient volcanic area lies some 20 kilometres south-east of Okombahe, clearly within sight. The mountain itself can be a building-up place against which clouds bank and then build into thunderstorms; the back-ward extension of this build-up could provide the opportunity for thundery showers to occur in the windward arc of the mountain. This is an explanation for the moderate ability to rain, that much, in January. Naturally the rainfall values are lower than those of Omatjette and other places to the north-east. It is to be expected that March would be the predominant month in the rainfall year because of the far westerly position of Okombahe in the January February and March core-month configuration area; the further to the west one goes so does the predominance of March as the major rainfall month increase.

It may be the correct assumption that the closer to the Erongoberg the proposed Pilot Area is, the better the rainfall prospects. Should assumption be correct, then there is the optimism that this situation of the Pilot Area could expect a better spread of the rain and with drought occurrences being even fewer. This possibility does exist.

The Pilot Area analysis is based on rainfall data from that area or from those places which are deemed to have a practical similarity to the Pilot Area. The rainfall data presented should not be taken as being precisely applicable to the Pilot Area, but it can be taken as presenting a good level of similarity to the conditions anticipated in the Pilot Area.

Table 1

THE OCCURRENCE AND DURATION OF THRESHOLD DROUGHTS AT THE OKOMBAHE PILOT AREA

The Threshold Drought means exclude the years which endured Total Drought.

Station & Detail	No. of Years on record	Mean Duration in Days	Maximum Duration in Days for the Years on record
Okombahe	59	272	416
Khorixas	40	271	387
Franzfontein	62	254	342

Table 2

TOTAL DROUGHT OCCURRENCES IN THE OKOMBAHE DISTRICT, PILOT AREA 2:

The " /Year " indicates the Rainfall Season (Jan Feb Mar) with no Effective Rainfall

Station & Detail	Occurrences	First/Year	Second/Year	Third/Year
Okombahe	3	791/1941	649/1962	660/1985
Khorixas	1	680/1959		
Franzfontein	2	601/1933	536/1981	
Cypress	Nil			
Otjomue-süd	Nil			
Karibib*	2	650/1929	619/1991	
Usakos	3	697/1959	676/1922	590/1932

* Karibib received no Effective rain during 1919; with no data for 1918, the last effective rainfall date in 1918 is not known.

Table 3

THE OCCURRENCE AND DURATION OF LARGE-STOCK (40+ DAYS) AND SMALL-STOCK (80+ DAYS) DROUGHTS

Station & Detail	Years	40+ days	80+ days	Mean Duration	Max. Duration/Year
Okombahe	59	40	30	75	153/1939
Khorixas	40	23	7	91	142/1962
Franzfontein	62	40	13	80	149/1920
Cypress 64	20	15	4	64	100/1979
Otjomue-süd 110	11	7	1	68	106/1993
Karibib	76	54	12	84	145/1981
Usakos	76	27	8	65	220/1920

Notes:

Usakos with lengthy Threshold droughts, there is little calendar time for Large and Small-Stock Drought.

endemic three years out of four.

The nil months record across the Associated and Core group is limited; but an increase is seen from 1975 onward; this features the Associated months, November, December and, spasmodically, April. Hail is recorded just once, the absence of mountains may be a cause of this low figure.

Total Drought lasted from 1961 to 1963. The Threshold Drought duration is in the upper 200's: about 270 days. Generally, this is a more hospitable scene

Large Stock Drought, longer than 40 days, is too frequent to encourage rain-fed ranching. 50% of the available years of data record at least one occurrence of Large Stock Drought.

However, only 5 years, including the Total Drought year, experienced drought spells longer than 80 days; one of these covered a spell from January to an unusual wet day in June 1983.

By Namibian standards, this is surely encouraging for the potential small-stock farmer.

This prospect is supported, overall, by the stations in the neighbouring Omaruru Magisterial district. The growing season, of 40 days and less, is noted as occurring 24 years out of 52. With a slightly higher frequency of Productive and Substantial falls these limited growth periods give a better appearance.

The rainfall season and the core months at Omatjette:

Core	**January**	**February**	**March**
ASSOCIATED	NOVEMBER	DECEMBER	APRIL
Possible	September	October	May

The Pilot Area analysis is based on rainfall data from that area or from those places which are deemed to have a practical similarity to the Pilot Area. The rainfall data presented should not be taken as being precisely applicable to the Pilot Area, but it can be taken as presenting a good level of similarity to the conditions anticipated in the Pilot Area.

Table 1

THE OCCURRENCE AND DURATION OF THRESHOLD DROUGHTS AT OMATJETTE, PILOT AREA 3

The Threshold Drought means exclude the years which endured Total Drought.

Station & Detail	No. of Years on record	Duration in Days	Maximum Duration in Days for the Years on record
Omajette	48	249	383
Khorixas	40	271	387

Table 2

TOTAL DROUGHT OCCURRENCES IN THE OMATJETTE DISTRICT, PILOT AREA 3:

The " /Year " indicates the Rainfall Season (Jan Feb Mar) with no Effective Rainfall

Station & Detail	Occurrences	First/Year	Second/Year	Third/Year
Omatjette	1	571/1961		
Khorixas	1	680/1969		
Franzfontein	2	601/1933	536/1981	
Cypress	Nil			
Okombahe	3	791/1941	649/1962	660/1985
Karibib	2	650/1929	619/1992	
Usakos	3	676/1922	697/1959	590/1932

Total Drought:

Omatjette	1	571			
Okombahe	3	791,	649	&	660 days in each case
Franzfontein	2	601,	536,	(this last was unbroken when the Police station closed)	
Khorixas	1	680.			
Karibib	2	650,	619		
Usakos	3	676	697	&	580

Table 3

THE OCCURRENCE AND DURATION OF LARGE-STOCK (40+ DAYS) AND SMALL-STOCK (80+ DAYS) DROUGHTS

Station & Detail	Years	40+ days	80+ days	Mean Duration	Max. Duration/Year
Omatjette	48	33	4	75	129/1983
Khorixas	40	23	7	91	142/1962
Franzfontein	62	40	13	80	149/1920
Cypress 64	20	15	4	64	100/1979
Okombahe	59	40	30	75	153/1939
Otjomus süd 110	72	6	1	51	[illegible]

6.0 Conclusion

From the geographical situation, the prospect that there is considerable doubt that the Damaraland area is viable for cattle ranching, is brought to fact. The ability for small-stock farming to survive all but the worst of years could be the one positive factor for these pilot areas in this arid sector.

Generally, both the Grootberg and Omajete pilot areas give a fair promise of success over a run of years, without too much outside assistance in the way of regular fodder supplies being on hand. Okombahe is less promising, but the ability for a proper carrying capacity of stock for each hectare to survive in this area is a fair probability. This is an old settlement area, there can be more resilience in the area than the straight rainfall data, in this application, reveals.

Such considerations as vegetation depletion and a possible deterioration in the rainfall pattern cannot be totally overlooked, the seemingly arid excesses of the dry 1980's could be used as evidence in this direction[11]

Grootberg, across 14 years, recorded 2 years with spells of Small-Stock drought. Generally, the record across the area has one 80 day Small-Stock Drought every 5 years. Total Drought, no growth period brought on by an effective fall of rain in the season, occurs about 1 year out of 30.

Okombahe, with 59 years of data, recorded 30 years of Small-Stock Drought occurrence. This is a very high rate of occurrence which far exceeds the stations used as a comparison. The rate of one year out of two does not compare well with the 2 years in 19 of Karibib and Usakos. Total Drought occurs about once every 25 years.

Omatjette with 48 years of data on record shows 4 occurrences of Small-Stock Drought. 1 out of 12 years is better than the record of other stations in the locality, though. Total Drought occurred once, this is also better than the local records would indicate as being the likely occurrence. But even 1 year out of every 25 would be an reasonable risk in this western part of Namibia.

In an area of considerable aridity, of considerable variation in rainfall occurrence and of considerable variation in duration, and the length a timing of the commencement of the effective rainfall season, Small-Stock farming, Sheep and Goats (and most likely Ostrich, too), has a very good chance of providing an opportunity for successful ventures in this field. This opinion is based on the expectancy of effective rainfall and the duration in days between such falls of rain. The table immediately below will indicate these statements more clearly.

SUMMARY OF THE CONCLUDING COMMENTS

Area & Detail	Years	80 Day +	Risk factor	Total Drought	Risk factor
[illegible]	14	2	20 %	1	4 %

7.0 **Annexure A**

7.1 THE TABLES

The tables are constructed as follows:

Table 1	Threshold Drought Analysis
Table 2	Total Drought Occurrences
Table 3	Occurrence of Grazing & Small-Stock Droughts, Mean Drought duration, Maximum days of occurrence and the year of this occurrence

The Pilot Area analysis is based on rainfall data from that area or from those places which are deemed to have a practical similarity to the Pilot Area. The rainfall data presented should not be taken as being precisely applicable to the Pilot Area, but it can be taken as presenting a good level of similarity to the conditions anticipated in the Pilot Area.

PILOT AREA 1 Table 1

THE OCCURRENCE AND DURATION OF THRESHOLD DROUGHTS IN THE GROOTBERG PILOT AREA

Station & Detail	No. of Years on record	Mean Duration in Days	Maximum Duration in Days for the Years on record
Grootberg, Libra	14	247	362
Neuland	15	257	400
Condor	13	242	399
Zessfontein	34	308	435
Kakatswa Onguati	32	263	400
Franzfontein	62	242	342
Khorixas	40	259	387

The Threshold Drought means exclude the years which endured Total Drought.

PILOT AREA 1: Table 2

TOTAL DROUGHT OCCURRENCES, GROOTBERG PILOT AREA
The " /Year " indicates the Rainfall Season (Jan. Feb Mar) with no Effective Rainfall

Station & Detail	Occurrences	First/Year	Second/Year	Third/Year

This ended a Threshold Drought of at least 333 days.
" Condor had a gap in readings from May 1962 to January 1963. Productive rain fell on 03 Jan 1963. Whether or not there was an intervening fall which would have broken this spell is not known, but it is very unlikely. Certainly there were 399 days to the end of May 1962 with no Effective rain.

PILOT AREA 1 Table 3

THE OCCURRENCE AND DURATION OF LARGE STOCK (40+ DAYS) AND SMALL-STOCK (80+ DAYS) DROUGHTS

Station & Detail	Years	40+ days	80+ days	Mean Duration	Max. Duration/Year
Grootberg, Libra	14	12	2	71	142/1973
Neuland	15	11	2	70	102/1961
Condor	13	7	4	93	129/1967
Zessfontein	34	12	2	65	93/1916
Kakatswa Onguati	32	15	3	64	126/1940
Franzfontein	62	40	13	80	149/1920
Khorixas	40	54	12	91	142/1962

Notes:
Zessfontein with the lengthy Threshold drought, there is not much calendar time left for Large and Small-stock droughts.

The Threshold Drought means exclude the years which endured Total Drought.

PILOT AREA 2 Table 1

THE OCCURRENCE AND DURATION OF THRESHOLD DROUGHTS AT THE OKOMBAHE PILOT AREA

The Threshold Drought means exclude the years which endured Total Drought.

Station & Detail	No. of Years on record	Mean Duration in Days	Maximum Duration in Days for the Years on record
Okombahe	59	272	416
Khorixas	40	271	387
Franzfontein	62	254	342

PILOT AREA 2: Table 2

TOTAL DROUGHT OCCURRENCES IN THE OKOMBAHE PILOT AREA

The /Year indicates the Rainfall Season (Jan Feb Mar) with no Effective Rainfall

Station & Detail	Occurrences	First/Year	Second/Year	Third/Year
Okombahe	3	791/1941	649/1962	660/1985
Khorixas	1	680/1959		
Franzfontein	2	601/1933	536/1981	
Cypress	Nil			
Otjomue-süd	Nil			
Karibib*	2	650/1929	619/1991	
Usakos	3	697/1959	676/1922	590/1932

* Karibib received no Effective rain during 1919; with no data for 1918, the last effective rainfall date in 1918 is not known.

The " /Year " indicates the Rainfall Season (Jan Feb Mar) with no Effective Rainfall

PILOT AREA 2 Table 3

THE OCCURRENCE AND DURATION OF GRAZING (40+ DAYS) AND SMALL-STOCK (80+ DAYS) DROUGHTS

Station & Detail	Years	40+ days	80+ days	Mean Duration	Max. Duration/Year
Okombahe	59	40	30	75	153/1939
Khorixas	40	23	7	91	142/1962
Franzfontein	62	40	13	80	149/1920
Cypress 64	20	15	4	64	100/1979
Otjomue-süd 110	11	7	1	68	106/1993
Karibib	76	54	12	84	145/1981
Usakos	76	27	8	65	220/1920

PILOT AREA 3 Table 1

THE OCCURRENCE AND DURATION OF THRESHOLD DROUGHTS AT THE OMATJETTE PILOT AREA

The Threshold Drought means exclude the years which endured Total Drought.

Station & Detail	No. of Years on record	Duration in Days	Maximum Duration in Days for the Years on record
Omajette	48	249	383
Khorixas	40	271	387
Franzfontein	62	254	342
Cypress 64	20	234	294
Okombahe	59	272	416
Karibib	72	267	384
Usakos	76	316	378

Omajette opened in April 1932 and continued a period of Threshold drought for another 258 days, it is not known if this spell began in 1931, rather than 1932

* Omatjette had Small-stock & Grazing Droughts: 92 & 52 days in 1939 and 84 & 54 days in 1971 and 57 & 129 days in 1983, 3 Grazing Droughts: 45 & 70 & 46 days in 1952 and 40 & 58 & 48 days in 1968.

Khorixas had Small-stock & Grazing Droughts: 83 & 53 days in 1985.

Karibib had 2 Grazing Droughts: 60 & 41 days in 1914, 1 Grazing Drought: 73 days in 1932, 1 Small-Stock & 1 Grazing Drought: 114 & 44 in 1933, Small Stock Drought: 145 days in 1981.

PILOT AREA 3: Table 2

TOTAL DROUGHT OCCURRENCES IN THE OMATJETTE PILOT AREA

The " /Year " indicates the Rainfall Season (Jan Feb Mar) with no Effective Rainfall

Station & Detail	Occurrences	First/Year	Second/Year	Third/Year
Omatjette	1	571/1961		
Khorixas	1	680/1969		
Franzfontein	2	601/1933	536/1981	

PILOT AREA 3 Table 3

THE OCCURRENCE AND DURATION OF LARGE-STOCK (40+ DAYS) AND SMALL-STOCK (80+ DAYS) DROUGHTS

Station & Detail	Years	40+ days	80+ days	Mean Duration	Max. Duration/Year
Omatjette	48	33	4	75	129/1983
Khorixas	40	23	7	91	142/1962
Franzfontein	62	40	13	80	149/1920
Cypress 64	20	15	4	64	100/1979
Okombahe	59	40	30	75	153/1939
Otjomue-süd 110	72	6	1	51	106/1993
Karibib	76	54	12	84	145/1981
Usakos	76	27	8	65	2201920

Notes:

Khorixas: Small-& Large-Stock Droughts: 83 & 53 days in 1985

Comparison Tables:

Table 4

1 ALL THE STATIONS AND THEIR PARAMETERS AS GIVEN IN THE TABLES FOR THE 3 AREAS

Stn & Det	Yrs	Thr D	M Dur	Tot D	Mx TD	40+ D	80+ D	M Dur	Mx Dur
Zessfontn	34	308	435	3	745	12	2	65	93
Grootberg	14	247	362	Nil		12	2	71	142
Neuland	15	257	400	Nil		11	2	70	102
Condor	13	242	399	Nil	(609)	7	4	93	129
Kakatswa	32	263	400	1	469	15	3	64	126
Franzfontn	62	242	342	2	601	40	13	80	149

Abbreviations

The above table, Table 4, has abbreviated headings; these are:

Stn & Det: Station & Detail
Thr D: Threshold Drought
M Dur: Mean Duration
Tot D: Total Drought
Max TD: Maximum (longest) Total Drought (days)
40+ D: Grazing Drought of 40 Days and longer
80+ D: Small-Stock Drought of 80 Days and longer
M Dur: Mean Grazing/Small Stock Drought (days)
Max Dur: Maximum Grazing/Small-Stock Drought Duration (days)

Table 5
2 COMPARISON OF TOTAL DROUGHT YEARS WITH THE MEAN THRESHOLD DROUGHT PERIOD FOR EACH LONG TERM STATION AND THEIR COMPARISON WITH THE STATIONS CLOSE TO THE 3 PILOT AREAS

Station & Years	1914	1932	1933	1959	1981	1985	Mean
Grootberg, Libra	No data	No data	No data	No data	379	No data	251
Neuland	No data	No data	No data	291	No data	No data	260
Condor	No data	No data	No data	333+	No data	No data	229
Zessfontein	745	No data	No data	439	676	660	308
Kakatswa Onguati	No data	459+	No data	300*	No data	No data	256
Franzfontein	262+	338+	601	334	538+	No data	242
Khorixas	No data	No data	No data	680	387	210*	259
Okombahe	745	No data	No data	439	676	660	308
Cypress	No data	No data	No data	No data	290	270	234
Otjomue-süd	No data	No data	No data	No data	No data	290	263
Karibib	196+	369	270	308	394	319	271
Usakos	330	590	270	697	347	291	316
Omatjette	No data	258+	278	253	291	240	249

* Kakatswa had 2 Large Stock Droughts: 49 & 40 days in 1959

7.2 ADDENDUM: THE CRITERIA FOR SUCCESSFUL YEARS

The consideration is that there is a difference between those seasons not afflicted by a drought spell. These are seasons which will have provided rainfall enough to have stimulated growth and maintained that growth. Obviously, a range of criteria should be identified which will indicate the years when this level of satisfaction can be achieved and to what degree. Table 6 indicates the years of sustained, probably abundant, growth and the number of days during which this growth will have been active and kept active. Finally, growth is anticipated to have ceased some 30 days (probably an extreme figure) after the last effective fall of rain, 10 millimetres or more.

The criteria are:

1 No drought spells
2 Consecutive months with effective rain-days which are 30 per cent or more above the normal expectation
3 Periods of growth in excess of 60 days

Blank spaces indicate that the data does not meet the criteria.
Nil indicates that the station did not report during that year.

Table 7
EFFECTIVE RAIN & CONTINUOUS GROWTH PERIODS COMBINING TO INDICATE YEARS OF ABUNDANT GROWTH

Key 11 Effective number of rain-days
116 days of presumed consistent growth

T, in the end column, indicates the total number of years of Abundant growth.

Stn & Year	1917	1925	1934	1950	1954	1963	1971	1974	1976	T
Zessfontein	Nil	Nil	Nil	Nil	Nil		11/116			1
Grootberg	Nil	Nil	Nil	Nil	Nil	Nil				0
Neuland	Nil	Nil	Nil	Nil	Nil	19/136	Nil	Nil	Nil	3
Condor	Nil	Nil	Nil	Nil	Nil		12/105	Nil	Nil	2
Kakatswa O	Nil	Nil	26/147	20/127		16/131	Nil	Nil	Nil	6
Franzfontn	21/209		27/157	20/126						5
Khorixas	Nil	Nil	Nil	Nil	Nil	17/154	12/128	13/124	12/110	5
Cypress	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil		1
Omajette	Nil	Nil	24/136	17/112	11/114			14/139	15/107	6
Okombahe		13/112	25/136	20/144		13/122		14/139	Nil	6
Otjomue-süd	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	1

7.3 DEFINITION OF EFFECTIVE RAINFALL

This gives the benchmark values for Productive and Substantial Rainfalls: 10 and 25 millimetre falls.

The basis upon which these key values of Effective rainfall relies needs to be set out. While many shallow rooted plants will perform a cycle on scant amounts of rainfall, the various members of the grass family which are indigenous to the country-side provide the value of the veld; these grasses and their reaction to the rainfall are the substance of the values of Effective rainfall.

These grasses have similar rooting systems, the common characteristic of which is their depth. This depth is sufficiently below the surface to ensure a certain longevity, in days, which enables the grass to complete its growth cycle following a requisite amount of rainfall. This fall of rain is required over a brief time-scale to enable the required depth of penetration to be attained.

The rainfall values which these grasses require has been given as being of the order of 7.7 to 8.0 millimetres. Similar values pertain to the scrub-type vegetation which borders the grasslands, especially on the plateau lands in the south of the country.

The probability of convective, thundery, showers occurring is usually limited to later in day following considerable heating by the sun, usually after the maximum temperature has been attained.

The surface is at least very warm, if not very hot, and this extreme of temperature is consistent throughout the top-most layers of the surface. The probability of an 8.0 millimetre fall soaking through this hot layer, without loss, is unlikely. The loss will be by a process in which evaporation will play a major role.

Further, the individual raindrops are often large. Their impact on the surface does not automatically break them down. They arrive and compact the hot soil cover immediately beneath them, leading to another loss by the process of evaporation.

However, should there be a fair amount vegetation cover, dried grass stalks, twigs and leaf cover, the individual raindrop shatters and myriad droplets spatter over the immediate area. Once again, these minute droplets reach the hot surface and a quick evaporation-loss takes its toll.

Clearly, to provide an exact assessment of these evaporation losses is impossible. To attempt such a process and to arrive at a definitive, or at least a distinctive, answer would require a very lengthy process with risks of uncertainty still prevalent. Further, such a study would be bedevilled by such factors as the wind on the day or days of study, cloud cover, both before and after the precipitation of the rain, the humidity of the air (one can assume that it will be dry, but for such a study a measure of precision is surely necessary), other factors can be brought in, all of which will vary from day-to-day.

The other factor which can demand attention is the soil-type. This certainly does vary across farms and from farm to farm. The consistencies of the various layers beneath the surface is far homo-genious of penetration which is observed by indirect methods; in this case, the cooling brought about by the moisture penetration to the deepest level of the Soil Thermometer range: 120 centimetres. This cooling factor, usually about 0.1 of degree Celsius over a six-hour period, indicates that a supply of moisture has reached that level, or further.

7.4 Warm water on the Namibian coast

The west coasts of the major continents are featured by the phenomenon of up-welling. Providing that the continent in question straddles the latitudes of the Sub-Tropical High Pressure Belt and on the Equatorial side, thus lying witthin the Trade Wind Belt, then this phenomenon will be a regular feature of the coastal oceanographic and climatic and thus the environmental regimes.

Being the regular push of the wind in these latitudes, the Trade Winds are the most consistent of all the planetary wind patterns, these wnds literally push the surface waters away from the coast, the cold waters beneath well-up and, thereby, set in train a unique set of circumstances.

The major feature is the fogginess caused by the low temperatures which condense the water vapour in the atmosphere, the cold water leads to reduced temperatures along the immediate coastal belt. The air, apart from being cooled to condensation levels, is also cooled to a height of some kilometre and a half above sea level. Above this, there is a remarkable temperature inversion: the tempertaure rises instead of falls with height above the surface. This inversion layer is of some 4 kilometres in its vertical extent. Such an inversion inhibits cloud development and thus precludes the occurrence of precipitation. These coasts are among the most rainless parts of the world.

Above this temperature inversion, which has "sucked down" air from above, there is a weak, not active, low pressure area. This upper low pressure area is of considerable value in the fashioning of the Namibian rainy season with a considerable effect upon the sub-continental weather.

However, for reasons not fully explained, there is reversal of events. The source of the warm water is the Gulf of Guinea. Whether or not this is a coast-wise flow, or there is a more seaward component to the flow, is also not clear. What is known is that there is a notable increase in sea-water temperatures along the northern and usually the central coast also. It seems that Pelican Point marks the most southerly extent of the drift.

Warm water is identified by such events as the presence of sharks and the disappearance of the normal cold-water sea-life. It has other effects too. Warm water brings a breakdown of the temperature pattern of the air along the coast, it introduces the potential of moister air and a normal temperature decline with height: which means the ability for clouds, usually of a convective form, (and so rain) to develop and occur. The most recent event was during the months of March, April and May of 1995, January and February of 1993 saw a patch of warm water around the Kunene mouth. The resultant rainfalls produceds the wettest ever months and years in the Khorixas vicinity and a range of other places along and adjacent to the western escarpment

Nevertheless, there is the feeling that these events will have considerable influence, as already shown in one instance, across the extent of the former Damaraland and will have a viable influence across the western half of the Owambo regions. Any other set of influences cannot yet be favourably or profitably evaluated.

It does appear that there is some data indicating the warm water years across several decades, at least, of this century. The attempt is being made to locate this data, verify the source, so gaining ideas of the criteria used to gauge what is a warm water year.

The current attempts to use oceanographic data as prognostic tool(s) have not produced satisfactory results. There is the feel that this new field is currently at the point where atmospheric prognostic knowledge was after the work of the Bjerknes brothers became acknowledged in the early 1920's.

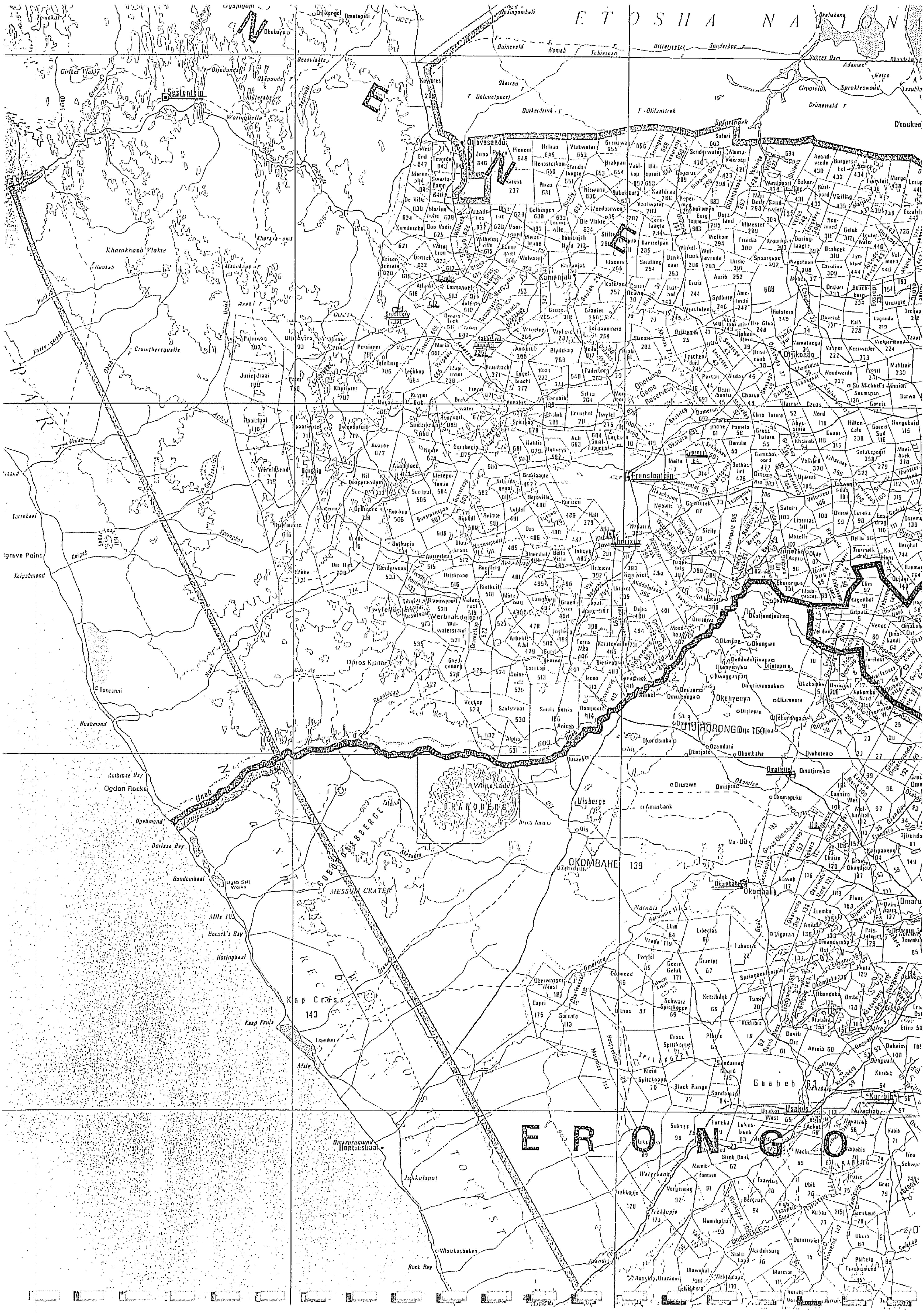
Thereis far to go and a store of knowledge to be unearthed and deciphered.

7.5 MAPS

The original maps from which these copies are made are to be found at the Office of the Surveyor-General. Being of the regular map size, these maps are too cumbersome to be included in their original size.

7.5.1 Area Maps: these are based on the 1:250 000 scale.

7.5.2 District Maps: these are based on the 1:50 000 scale.



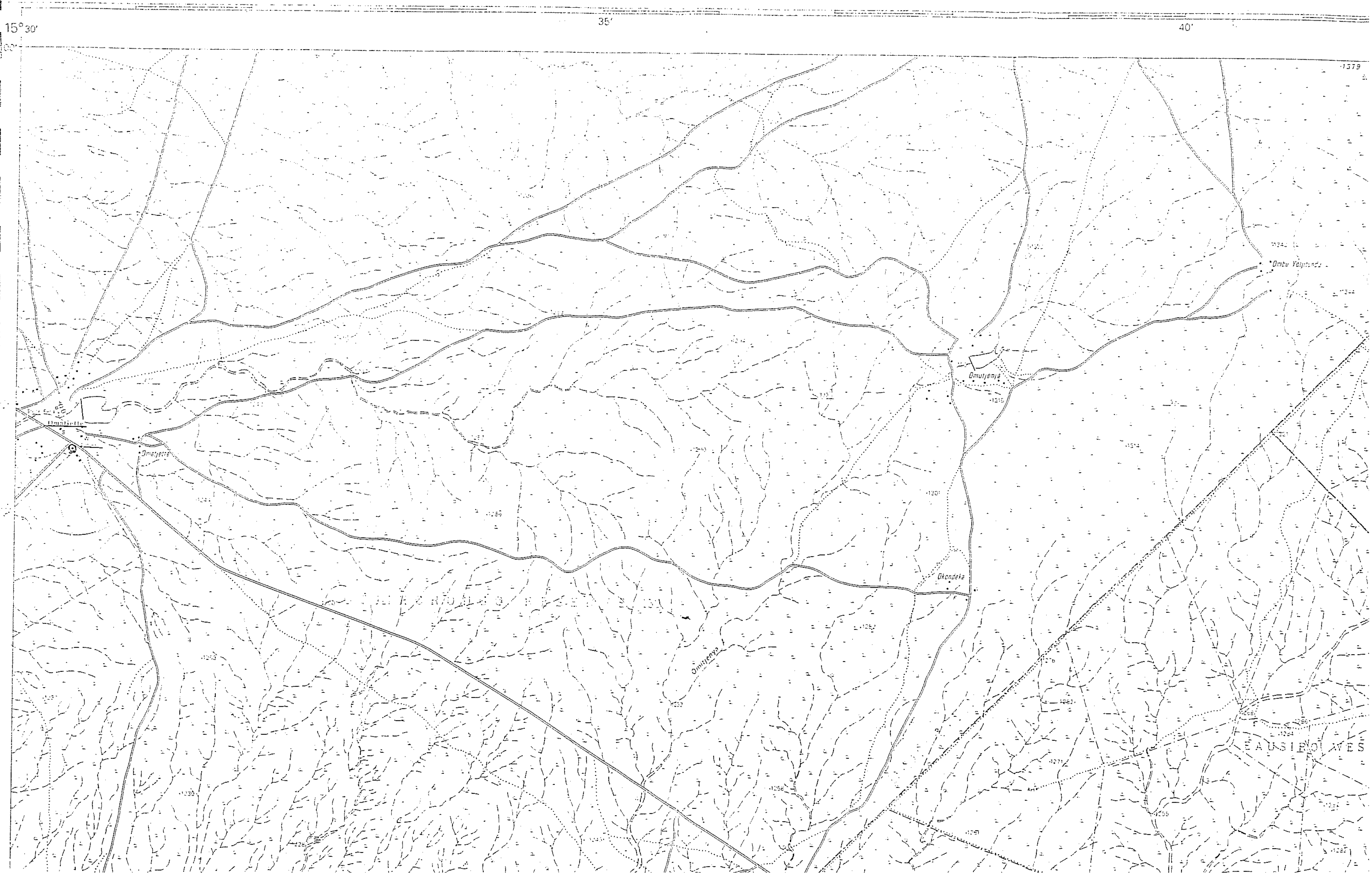
ETOSHA NATIONA
ERONGO
OKOMBAHE 139
OTJOHORONGO 760
Kamanjab
Khorixas
Fransfontein
Sesfontein
Omaruru
Karibib
Usakos
BRANDBERG
MESSUM CRATER
GOBOBOSEBBERGE
Kap Cross 143
Ogdon Rocks
Ambrose Bay
Toscanni
Doros Krater
White Lady
Uisberge
Okombahe
Omatjette
Otjikondo
Ohorongo Game Reserve
Kharokhaob Vlakte
Rössing-Uranium
Rock Bay
Jakkalsputs
Mile 108
Mile 72
Ugab Salt Works
Bocock's Bay
Horingbaai
Durissa Bay
Ugabmond
Huabmond
Torrabaai
Koigabmond

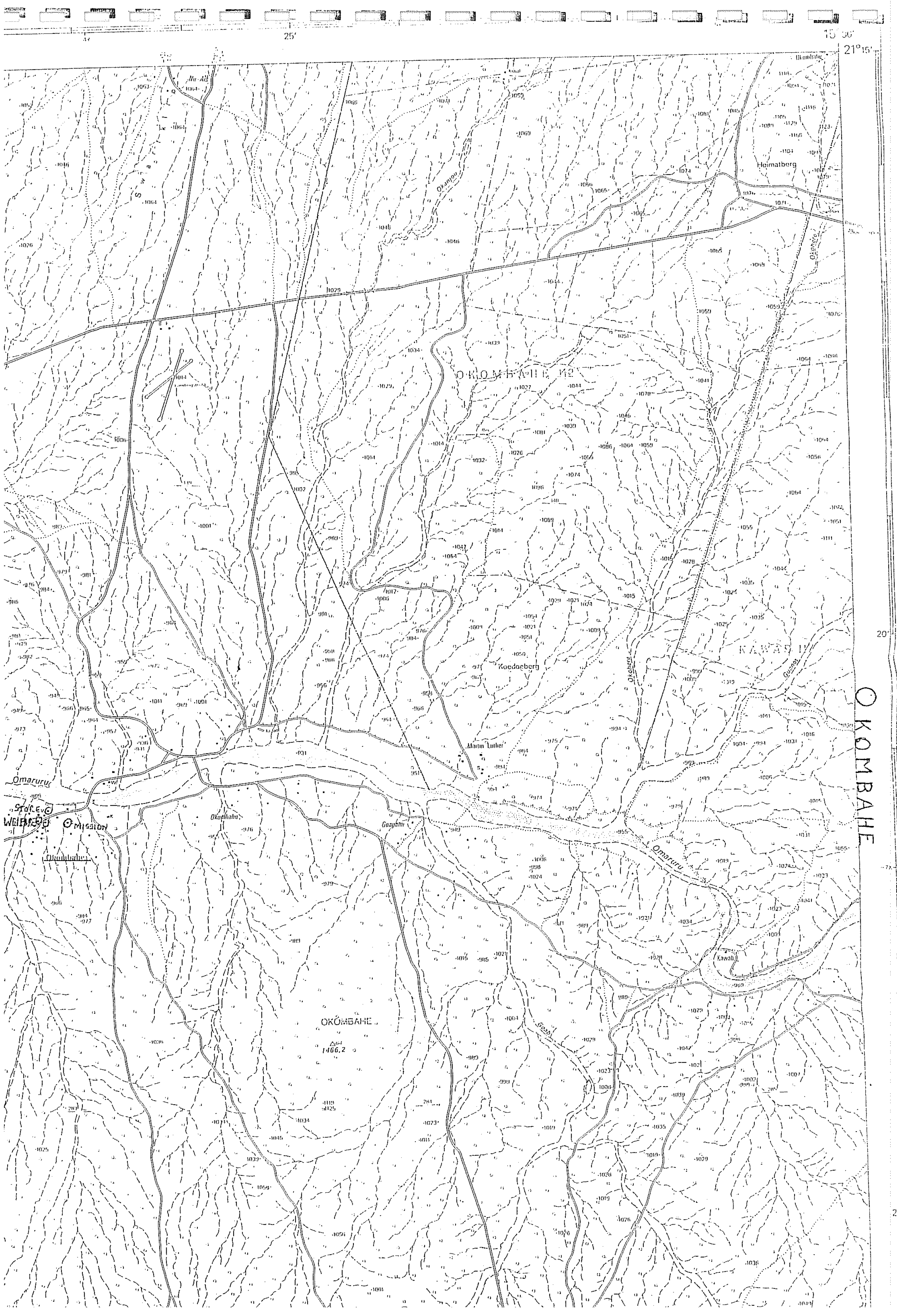
1:50 000 SOUTH WEST AFRICA
SUIDWES-AFRIKA

HEIGHTS IN METRES

2115BA OMATJETTE

HOOGTES IN METER



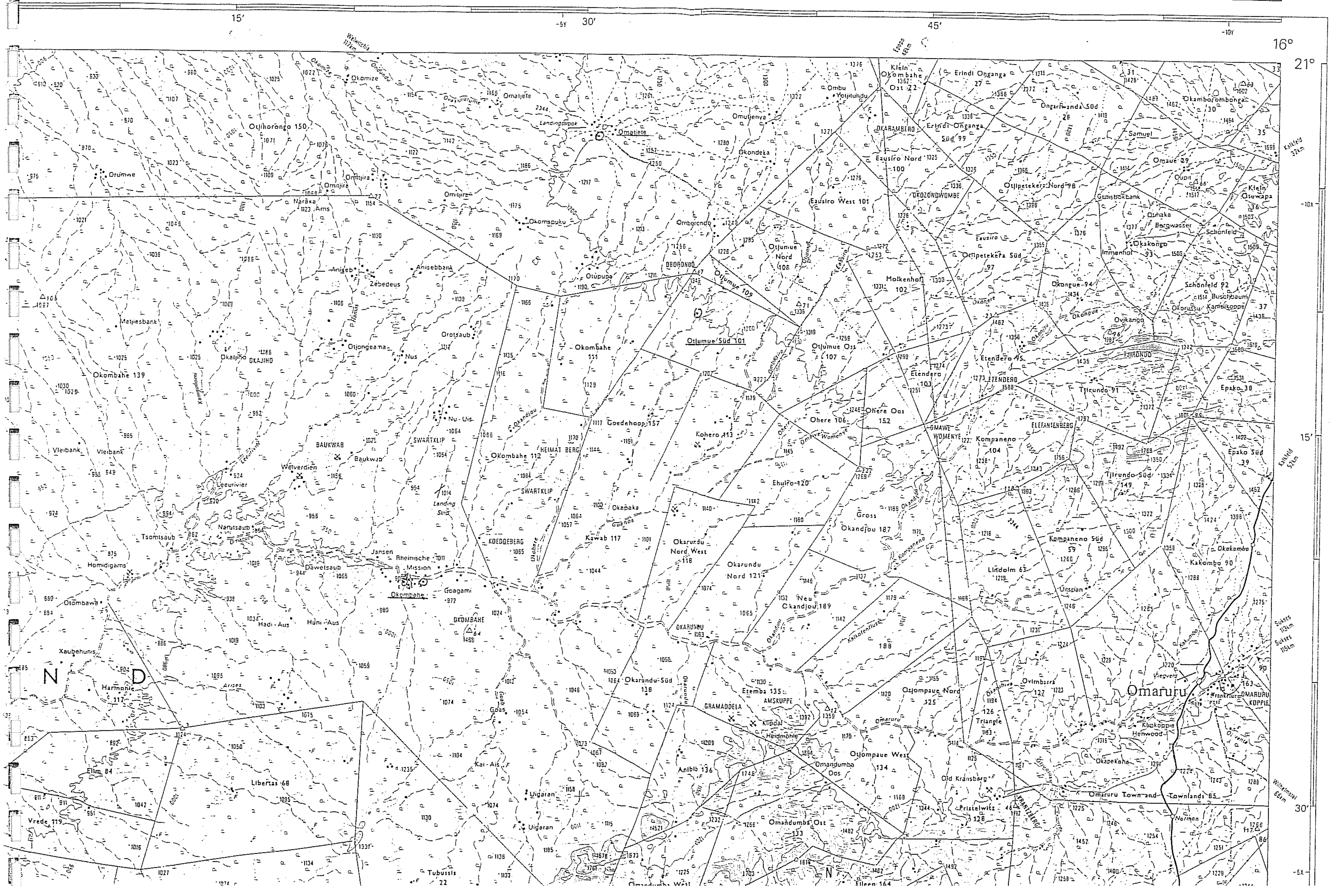

25'
15°30'
21°15'
Nu-Aib
Heimatberg
OKOMBAHE No
Koedoeberg
KAWAB II
Martin Luther
Omaruru
Mission
Okombahe
Goapanu
Omaruru
Kawab
OKOMBAHE
1466,2
20'
OKOMBAHE
25'

Refer to this map as SOUTH WEST AFRICA 1: 250 000 TOPOGRAPHICAL SHEET
Verwys na hierdie kaart as SUIDWES-AFRIKA 1: 250 000 TOPOGRAFIESE VEL

SECOND EDITION

2114 OMARURU

TWEEDE UITGAWE



Kontoertussenruimte 50 meter

1:250 000

10 20 30 Kilometer

5 10 15 Myl

...te to ground level in metres
...es is op grondhoogte in meter

...n Central meridian 15° east Bessel's spheroid
...ie Middelmeridiaan 15° oos Bessel se sferoïed

...outh West African co-ordinate system are indicated
...rt black ticks at 50 000 metre intervals, with
...ues in units of 10 000 metres in blue

Suidwes-Afrikaanse koördinaatstelsel word in die
...deur kort swart strepies 50 000 meter van mekaar
...rdes in eenhede van 10 000 meter in blou

REFERENCE — VERKLARING

REFERENCE		VERKLARING
Post offices, police stations and stores	•P •PS •W	Poskantore, polisiestasies en winkels
Schools, churches and hotels	•S •K •H	Skole, kerke en hotelle
Mission stations		Sendingstasies
Huts		Hutte
Trig. Beacons with heights and numbers		Trig. bakens met hoogtes en nommers
Perennial pans		Standhoudende panne
Non-perennial pans		Nie standhoudende panne
Dry pans		Droë panne
Pipelines and canals		Pyplyne en kanale
Perennial rivers		Standhoudende riviere
Non-perennial rivers		Nie standhoudende riviere
Marshes and vleis		Moerasse en vleie
Waterpoints	•F	Waterbronne
Cutlines		Kaplyne
Plantations and natural forests		Plantasies en natuurlike woude

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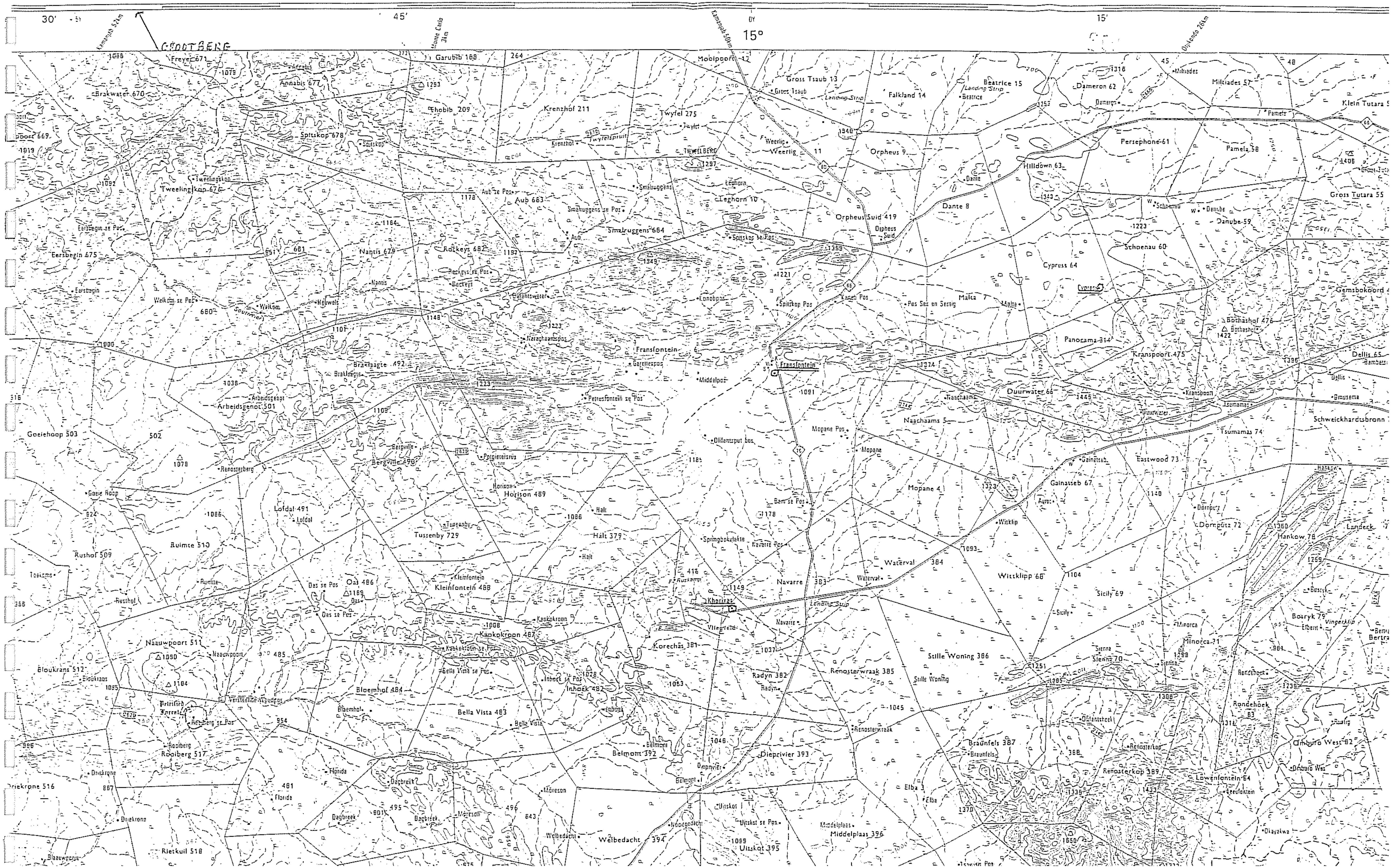
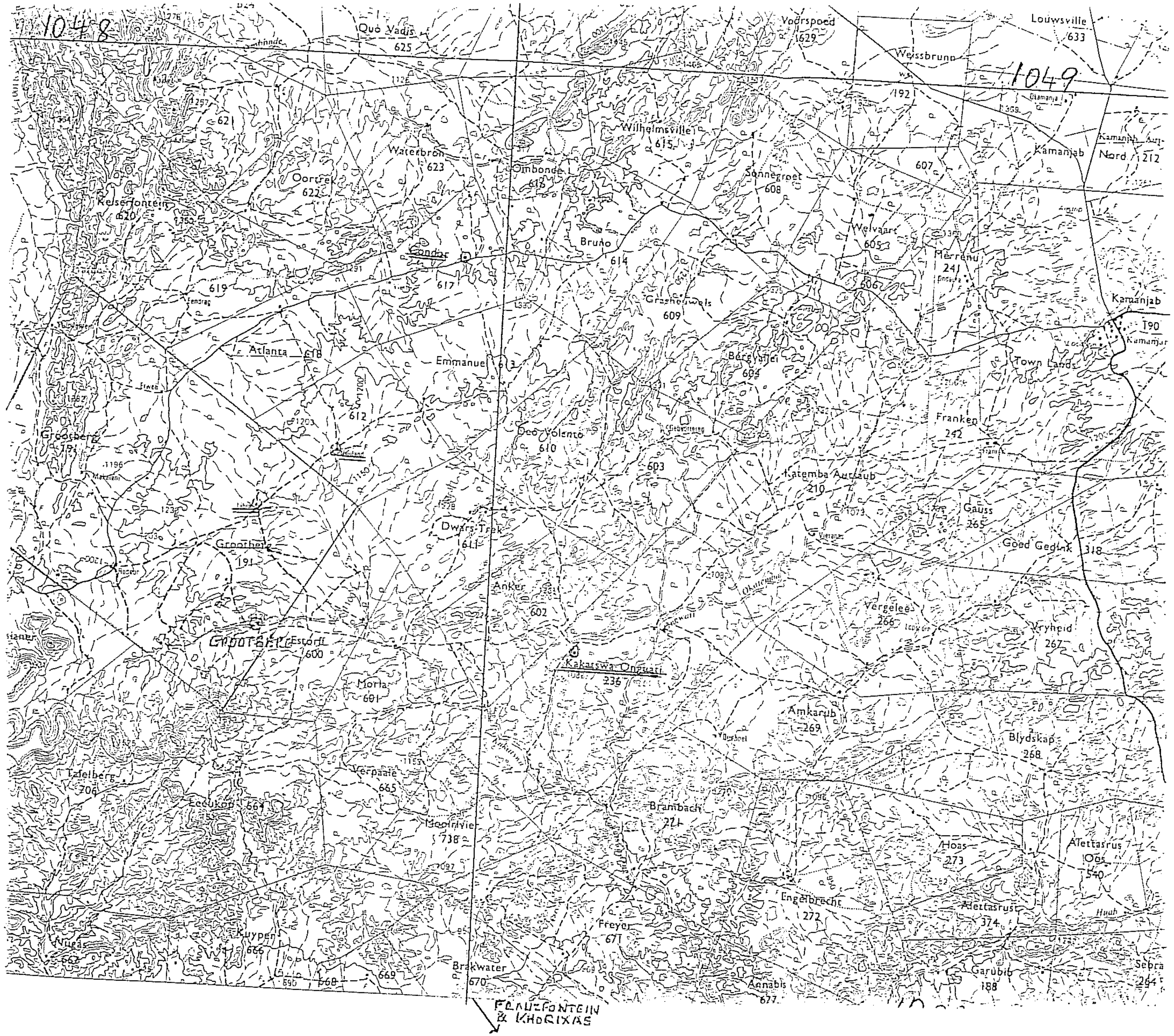
ATLANTIC OCEAN	2214 WALVISBAAI	2216 WINDHOEK

2114 OMARURU SECOND ED... TWEEDE UIT...

2014 FRANSFONTEIN





1048
Quo Vadis
625
Voorspoed
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Louwsville
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Weissbrunn
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Brambach
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Mooirivier
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Hoas
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Alettasrus
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Engelbrecht
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Alettasrust
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Kuypen
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Freyer
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Niueas
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Brakwater
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Annabis
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Garubib
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Sebra
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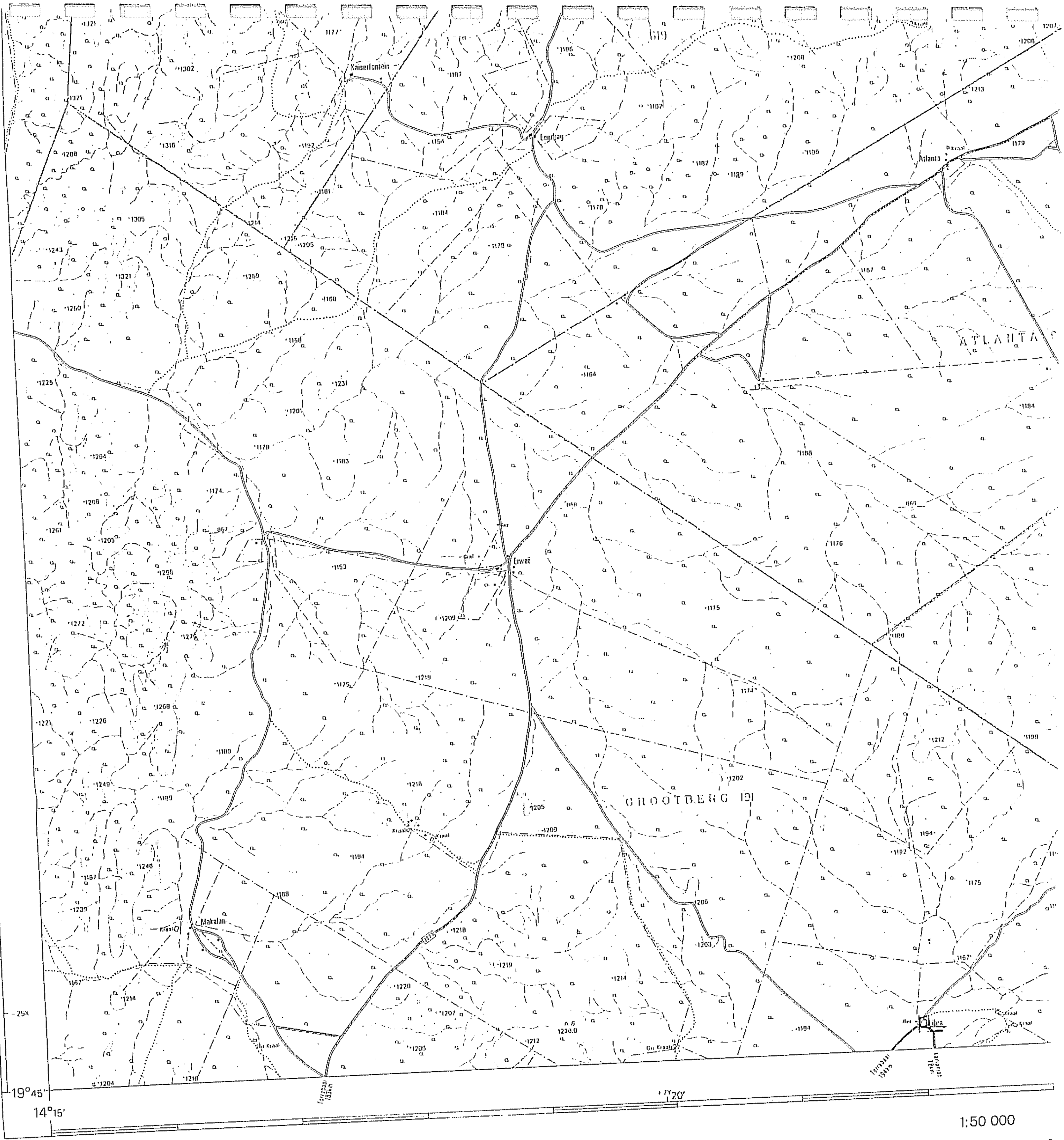
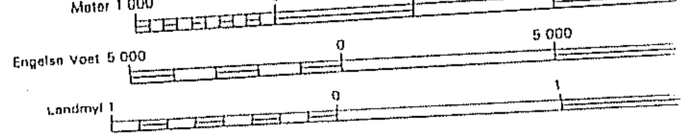
FRANZFONTEIN
& KHORIXAS



1:50 000



Lugfotografie 1974 (Taak No. 725/74). Opgemeet in 1978 en geteken in 1979 deur die Direkteur-generaal van Opmetings.
Air Photography 1974 (Job No. 725/74). Surveyed in 1978 and drawn in 1979 by the Director-General of Surveys.

VERKLARING	REFERENCE
Internasionale Grense	International Boundaries
Provinsiale Grense	Provincial Boundaries
Veelvoudige Spoorlyne	Multiple Track Railways
Enkelspoorlyne	Single Track Railways
Geëlektrifiseerde Spoorlyne	Electrified Railways
Smalspoorlyne	Narrow Gauge Railways
Diensspoorlyne	Service Railways
Hoofpaaie	Arterial Roads
Grootpaaie	Main Roads
Sekondêre Paaie	Secondary Roads
Ander Paaie	Other Roads
Dowwe Paaie en Voetpaaie	Tracks and Footpaths
Kraglyne	Power Lines
Telefoonlyne	Telephone Lines
Poskantore, Polisiestasies en -poste, Winkels, Hotelle, Skole en Plekke van Aanbidding	Post Offices, Police Stations and Posts, Stores, Hotels, Schools and Places of Worship
Vuurtorings en Seevaartligte	Lighthouses and Marine Lights
Seevaartbakens	Marine Beacons
Beheerdegebiedsgrense	Controlled Area Boundaries
Bantoe- en Kleurlinggebiedsgrense	Bantu and Coloured Area Boundaries

Die ruitlyne van die Suidwes-Afrikaanse Koördinaatstelsel word in die kantruimte aangetoon deur kort swart strepies, 10 000 meter van mekaar, met koördinaatwaardes in eenhede van 10 000 meter in blou.

Hoogtes is in meter op grondhoogte
Heights are in metres to ground level

Gauss se Konforme Projeksie Middelmeridiaan 15° Oos
Gauss Conform Projection, Central Meridian 15° East

INDEKS VAN VELLE INDEX TO

1914AC	1914AD	1914BC
1914CA	1914CB	1914D
1914CC	1914CD	1914

1914CD GROOTBERG-OOS

HEIGHTS IN METRES

Verwys na hierdie Kaart as SUIDWES-AFRIKA 1:50 000 Vel
Refer to this Map as SOUTH WEST AFRICA 1:50 000 Sheet

1914CD GROOTBERG-OOS
EERSTE UITGAWE FIRST EDITION