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MINISTRY OF AGRICULTURE, WATER AND RURAL DEVELOPMENT

DEPARTMENT OF WATER AFFAIRS

REPUBLIC OF NAMIBIA

REGIONAL MASTER WATER PLAN

FOR THE

OWAMBO REGION

THE PERMANENT SECRETARY
DEPARTMENT OF WATER AFFAIRS
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CONTENTS

PAGE

PAGE

PAGE

PAGE

PAGE

TABLES

PAGE

FIGURES

MAPS

ANNEXURES

MEANING OF PLACENAMES

Ambende	:	
Anamulenge	:	Mane of the donkey
Cunene	:	
Cuvelai	:	
Eenhana	:	
Ekuma	:	Wall
Elim	:	Place of the elephants
Endola	:	Big and deep, dry river
Engela	:	Wet place
Epato	:	
Etaka	:	Mine shaft
Etale	:	Dam
Eunda	:	To show
Iindangunge	:	Where the bulbs are dug
Mahanene	:	Plains
Nakayale	:	
Odila	:	River of the water duck (*Anas erythroshyncha)*
Ogongo	:	Fruit of the marula tree (*Sclerocarya birrea)*
Ohangwena	:	Grass (*Agrophyrum repens)*
Ohashiti	:	
Okahau	:	Calabash
Okalongo	:	A small piece of land
Okankolo	:	
Okatana	:	Calf
Okatope	:	Small well
Okongo	:	Holiday leave
Olifa	:	Leave (on holiday)
Olukonda	:	Scissors
Oluno	:	Thornbushes
Olushandja	:	Lucerne
Omafo	:	Tree leaves

Omahango	:	Pearl Millet
Omakango	:	Many water pans
Ombalantu	:	Palace
Omungwelume	:	
Omuntele	:	
Onaanda	:	Place where mean authills occur
Onambutu	:	Place with many edible roots
Onamundindi	:	Place with many wild geese
Onandjokwe	:	Dam where the ducks stay
Onathinge	:	Summer
Onayena	:	
Ondangwa	:	Here was a hole with honey
Ondjamba	:	Elephant
Ondobe	:	Pool of water
Ongandjera	:	Tribal area
Ongenga	:	On the bank of a dry river
Ongha	:	
Ongwediva	:	A water source where the tigers drank
Oniipa	:	Jackal berry (Jakkalsbessie) tree (*Diospyros mespiliformis*
Oshakati	:	In the middle
Oshana	:	Shallow ephemeral river course
Oshigambo	:	
Oshikango	:	Place where may water pans occur
Oshitayi	:	Branc of a tree
Oshivelo	:	Gate
Otjivalunda	:	
Ruacana	:	
Shalupumbu	:	
Tsandi	:	Garden

EXECUTIVE SUMMARY

The existing geographical and soci-economic conditions in Owambo relating to water resources, development potential, water consumption, future water demand and the requirements for the establishment of adequate water supply infrastructure, are elaborated upon in this Regional Master Water Plan.

This report is structured in such a way that a comprehensive overview of the contents of the report can briefly be obtained by reading the **Introduction** in **Chapter 1**, the **Recommendations** in **Chapter 11**, the **Conclusions** in **Section 10.2** and the proposed development programme and capital cost estimate in **TABLE 8.1**.

1. INTRODUCTION

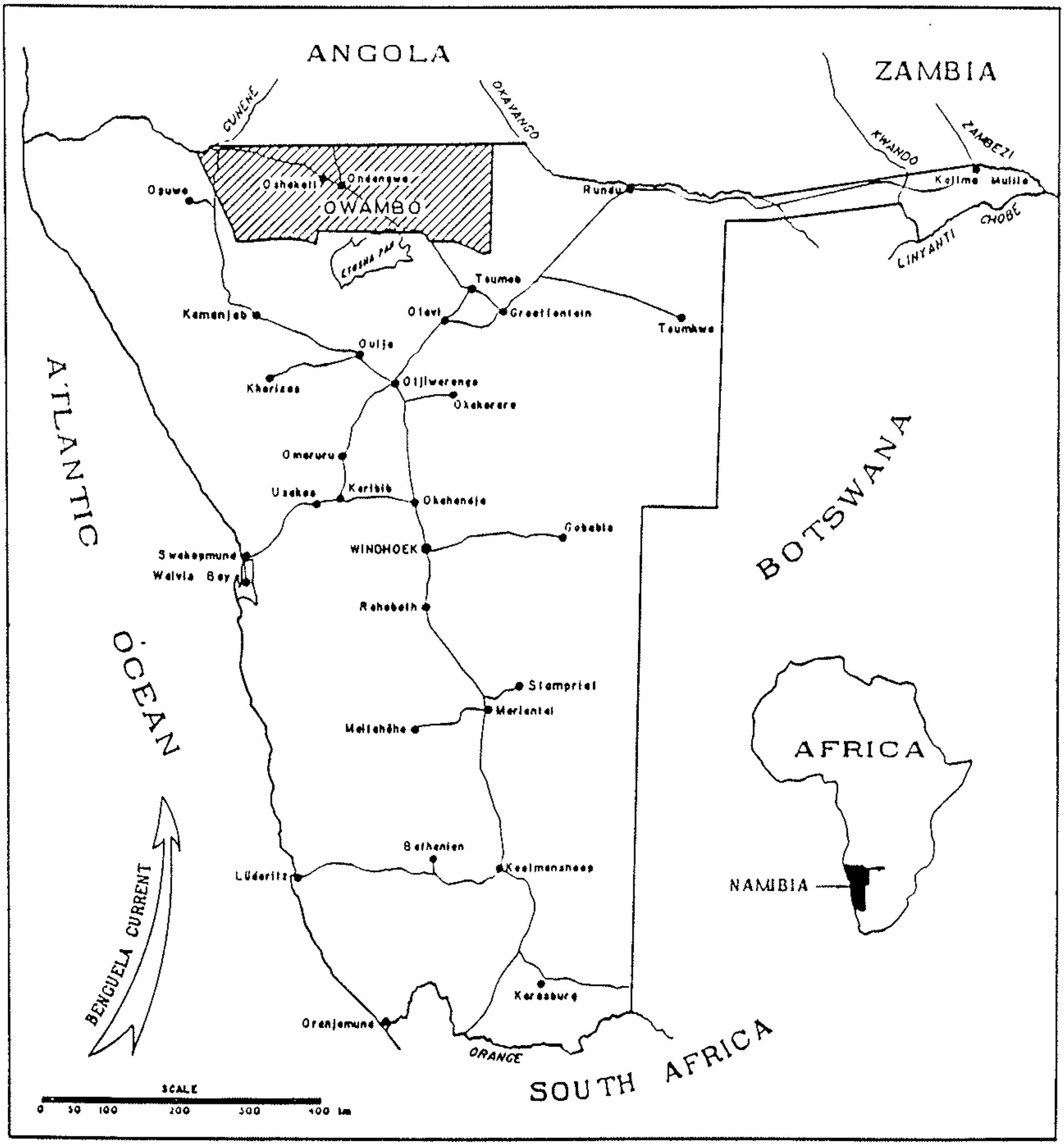
The availability of water in adequate quantities, of acceptable quality and at the right time is a prerequisite for all human activity. In an arid country like Namibia it is very important that water supply schemes should be established within the framework of a master water development plan which identifies the needs and provides guidelines for the implementation, programming and financing of the required water supply projects. The recommendations in this regional master water plan for Owambo are to serve this purpose.

The Owambo region, which is the most densely populated area in the country, is situated immediately to the south of the border with Angola. Refer to **MAP 1.1** on page 2 and **ANNEXURE 1** at the back of the report, which show the location of the important names and places mentioned in this report.

The people of Owambo originally obtained water purely by the utilization of ephemeral surface water, whenever available, or open wells. However, prolonged periods of drought and crop failure brought hardship and restricted development, which in turn adversely affected the social security of the local population. This necessitated the development of more reliable water sources.

The principle that Namibia has the right to use the perennial waters of the international Cunene River was accepted in 1926 when the First Water-use Agreement was signed between the Portuguese and South African Governments who respectively controlled Angola and Namibia at that time. However, the initial development of this water source was delayed for more than 40 years.

Since 1926 the development of water supplies in Owambo was very rudimentary, but in 1954 an intensive programme was launched to improve local surface water storage works and groundwater supplies in Owambo. One of the objectives with the construction of excavation and pumped storage dams was to bridge drought periods of up to two years by utilizing local runoff. Some measure of security was also provided through the construction of an unlined floodwater collecting canal between Ombalantu and Oshakati. These efforts only brought relief in the short term and it became clear that the unreliable ephemeral surface water supplies would never be able to support large scale expansion of the local economy on a sustained basis.



MAP 1.1 : LOCATION OF OWAMO

The random building of water schemes as the need arose, was also considered undesirable. By 1968 the foundation for the future development of the existing water supply infrastructure in Owambo was laid down by the recommendations made in the Master Plan for Water Development in Owambo **(Reference 1)**.

The master water development plan discussed the expected growth rate in water demand and made proposals for meeting the estimated water demand through the co-ordinated and formal establishment of the following water supply infrastructure:

- Extension of the system of canals and pipelines to feed water from the Calueque Dam in Angola into the interior of Owambo.
- Continued construction of storage dams which could be fed with water from local runoff or from the proposed water supply network.
- Drilling of additional boreholes in the eastern and western stock farming areas.
- The construction of wells and cisterns to serve rural schools and clinics.
- The development of irrigation schemes.

The priorities determined by the master water plan were to develop local water sources first and then to import water from the Cunene River. This principle still applies today.

At the time that the Master Water Plan was written, the Water Affairs Branch of the Administration for South West Africa had the total responsibility for water resource development. After reorganisation of the Administration in 1969 the Water Affairs Branch became part of the Department of Water Affairs in the Republic of South Africa. The responsibility for national, regional and local bulk water supply was entrusted to the new Directorate of Water Affairs, which later became the existing Namibian Department of Water Affairs. Responsibility for the development and operation of small, local water supply schemes in the rural areas reverted to the Department of Bantu-administration and later to the regional authority in Owambo, as it had been known at that time.

After completion of the National Master Water Plan for Namibia in 1974 **(Reference 2)** the 1968 Master Plan for Water Development in Owambo was also updated in the same year **(Reference 3)**. The National Master Water Plan recognised the following principles as far as Owambo is concerned:

- Owambo is a developing region which would experience an ever increasing water demand.

- Local water sources are insufficient to supply in the demand.
- Perennial water will have to be imported from the Cunene River via the Calueque Dam and supplied through a network of canals and pipelines.

In the 1974 update of the Owambo Master Water Plan special attention was given to the proposed construction of major regional bulk water supply networks. The most important of these were the following:

* An improved water supply link between Ombalantu and Oshakati.
* The upgrading of the pipeline between Oshakati and Ondangwa.
* New pipeline networks to the north of Ondangwa, to the south-east of Ondangwa and from Ombalantu into the area to the north of the Etosha National Park.
* An irrigation project to the east of Eunda.

The report also recommended that the extension of rural water supply should continue and central raw water purification works were proposed at Ombalantu and Ondangwa.

Since 1974 good progress has in general been made with infrastructural and socio-economic development in Owambo. Population growth, settlement trends and economic activity became more established. Bulk water schemes were constructed on a co-ordinated, regional basis to cater for the increasing demand at growth points and urban centres. However, on the eve of the independence of Namibia, it was considered appropriate to re-evaluate the existing water supply strategy for Owambo. The results of that study were envisaged to be presented in terms of a new Regional Master Water Plan for Owambo.

When considering the improvement of the regional water supply situation in Owambo, the following aspects are of fundamental importance:

1. To secure the necessary access to the Calueque Dam by ratification and honouring of existing agreements.
2. To upgrade critical bulk water supply lines by increasing their capacity.

3. To construct additional pipelines to introduce water for domestic use and stock watering purposes into the rural areas.
4. To embark upon small and large scale irrigation projects to support the cultivation of agricultural produce for local use and export.
5. To improve local rural water supply and sanitation facilities.
6. To formulate policies for public participation in water conservation, water scheme development and maintenance as well as the levy of appropriate water tariffs.
7. To programme the establishment of water supply projects according to water demand projections.
8. To ensure the availability of capital funds at the required time.

The purpose of this Regional Master Water Plan is therefore to document the available information on the natural resources and development potential in Owambo, to produce figures on the estimated water demand at various locations in the region and to make recommendations on a future water supply strategy. The proposals for the improvement and extension of the water supply infrastructure must also be seen as planning in very broad terms. Further adjustments would be required when detail project planning and design is done.

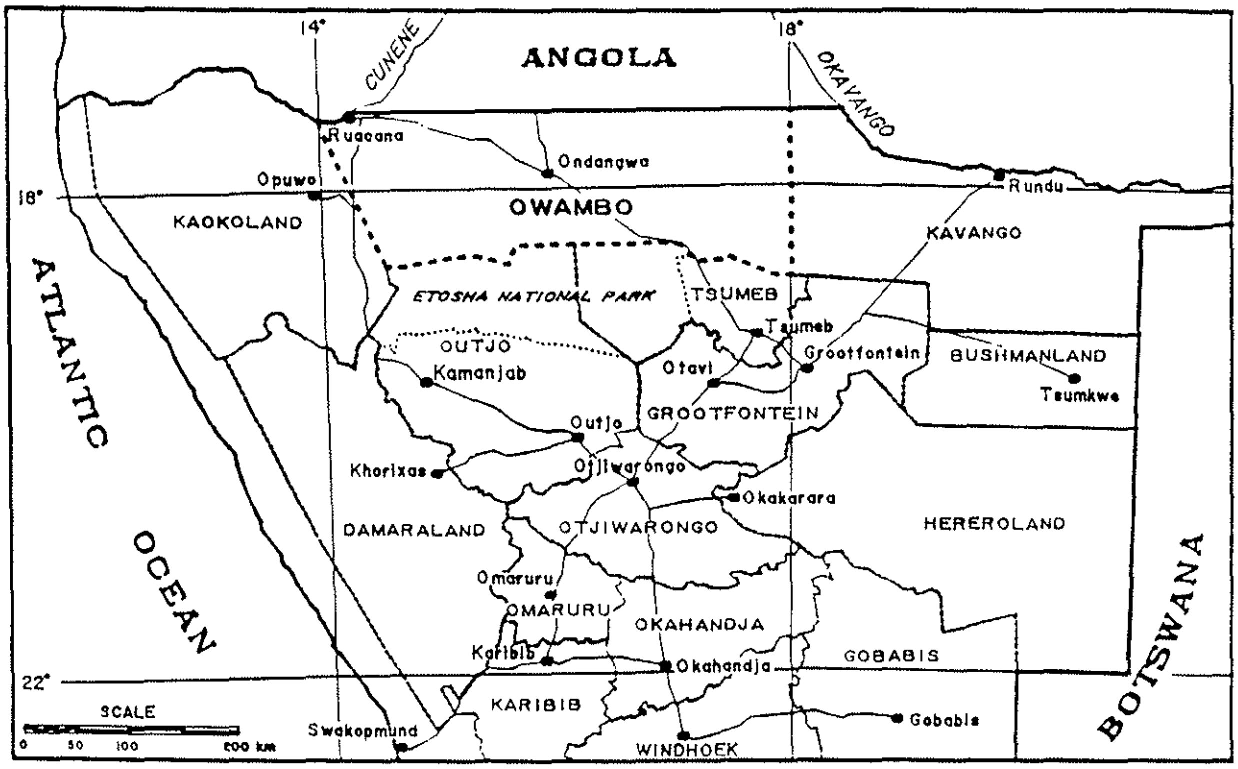
2. GEOGRAPHICAL CHARACTERISTICS

The provision of water in Owambo is intimately bound with the geographical nature of the region, which in many respects is quite unique. The various salient features which have a strong influence on development are described briefly. For more detail refer to **Reference 4.**

2.1 LOCATION

Owambo is situated in the north of Namibia and is centrally located between the Angolan border in the north, and the Tsumeb and Outjo Districts in the south, the Kaokoland region in the west and the Kavango region in the east. Refer to **MAP 2.1** on page 6 for orientation. This advantageous location may have a significant bearing on regional trade and the local economy in an independent Namibia.

The Owambo region is more or less trapezoidal in shape and covers an area of 51 800 km². It is approximately 120 km wide from north to south and stretches almost 425 km from Ruacana in the west to the 18° longitude line in the east. Owambo constitutes 6,3% of the total land area of Namibia. Seen in broad terms, it is estimated that 36 500 km² of Owambo is suitable for crop cultivation and stock farming, 9 500 km² for forestry, 2 000 km² for irrigation and 3 800 km² is unsuitable for agricultural development due to salt pans, rocky and mountainous terrain, or utilization for infrastructural purposes.

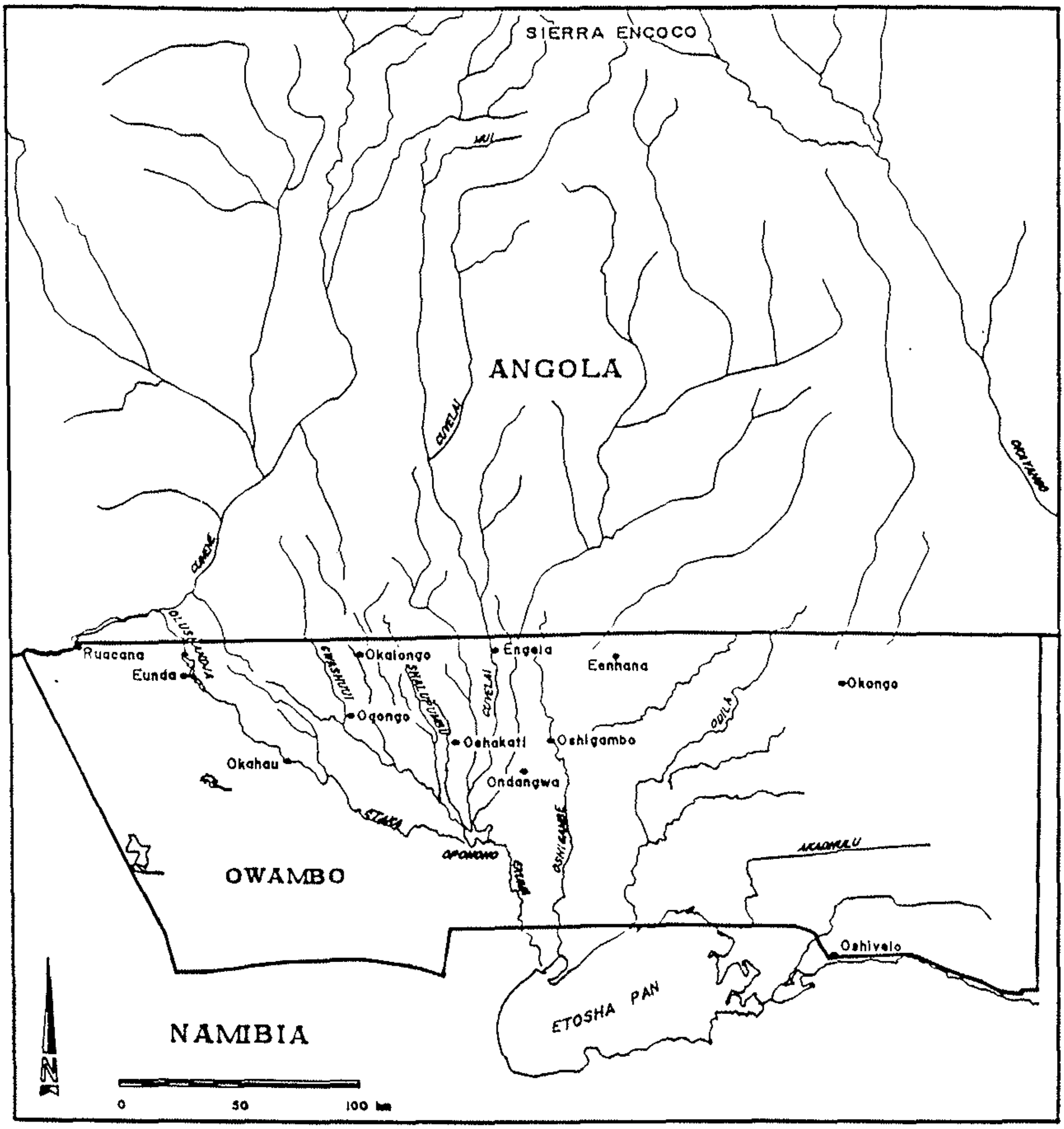


MAP 2.1: OWAMBO IN RELATION TO NEIGHBOURING REGIONS

2.2 TOPOGRAPHY

The topography in Owambo is characterized by an extremely flat plain which forms part of the Etosha Depression and gradually descends like a shallow trough from north to south towards the Etosha Pan. Refer to **MAP 2.2** on page 7. The gradient of the plain is approximately 1:2 500 between the Angolan border and Ondangwa and 1:5 000 to 1:10 000 further south to the Etosha Pan. The elevation of the plain is between 1 090 m and 1 150 m above mean sea level (AMSL).

The only exception to the flat topography is found in the western area where the land rises gently to the foothills of the Kaokoland mountain ranges, where some hills reach 1 400 m AMSL. This is also in contrast to the rugged hills and the escarp along the deep valley which has been carved into the north-western fringe of the plains by the Cunene River. The elevation below the Ruacana Falls, which has a height of about 130 m, is 750 m AMSL.



MAP 2.2 : DRAINAGE PATTERN

Influenced by the flatness of the terrain, the sandy nature of the soil and the ephemeral flow in the water courses, the drainage system is generally poorly developed, except for the Cunene River valley. However, five marked drainage patterns can be distinguished. In the south-east the water courses flow from east to west and turn southwards towards the Etosha Pan. In the north-east a few flow paths are traceable on the sandy surface, but their definition is poor and they cannot really be seen as water courses. In the central area there are numerous interconnected ephemeral pans and shallow water courses which run from the north in a south-easterly direction towards the Etosha Pan. In the extreme north-western corner the water courses empty into the Cunene River, which flows in a south-easterly direction from the central highlands of Angola and turns in a westerly direction downstream of the Ruacana Falls. In the west, in spite of the steeper gradient of the land between the border with Kaokoland and the Oshana Etaka, no continuous water courses are found and the runoff disappears into the sand or collects in a large number of small pans.

The Cuvelai is the most important drainage system which carries water from Angola through most of Owambo to Lake Oponono. The Cuvelai rises south of the Sierra Encoco in Angola and is perennial up to the village of Evale. Approximately 200 km north of the border the Cuvelai ramifies into a delta, which is almost 70 km wide where it crosses the border into Owambo. These wide, grassed water courses or flood channels are called oshanas. In some cases continuous flow paths can be traced over long distances and form the major oshanas.

The most prominent oshanas of the Cuvelai are the Oshana Gwashuui which goes past Ogongo, the Oshana Shalupumbu which runs past Okalongo, the Oshana Cuvelai passing Oshakati and the Oshana Oshigambe at Oshigambo. Another interesting oshana is the Oshana Etaka. The runoff in this oshana mainly originates from local rainfall and the watershed of the Etaka lies just to the east of Eunda. The northerly course, known as the Oshana Olushandja, drains towards the Cunene River and the south-easterly course runs into Lake Oponono. From Lake Oponono the water of the Cuvelai and the Etaka is carried by the Oshana Ekuma into the Etosha Pan. The most significant oshana in the north-east is the Oshana Odila. An extensive zone of permanent sand dunes is found in the south-eastern area and dry water courses occur in the troughs between the dunes. The remaining part of this area is dotted with numerous small pans and little runoff occurs, even after heavy rainfall.

The absence of deep river valleys in the flat, sandy plains makes it practically impossible to develop any major surface water storage works to supply Owambo with an assured source of water.

2.3 CLIMATE

2.3.1 General

Meteorological information gathered at the third order meteorological station at Ondangwa is considered representative for the whole region and is used to indicate the climatological conditions to be expected in Owambo. Also refer to **Reference 5** for more detail.

Owambo can be classified as a warm steppe region with a Köppen classification of **BShgw**. The interpretation of this classification is as follows:

Climate = Bshgw

where

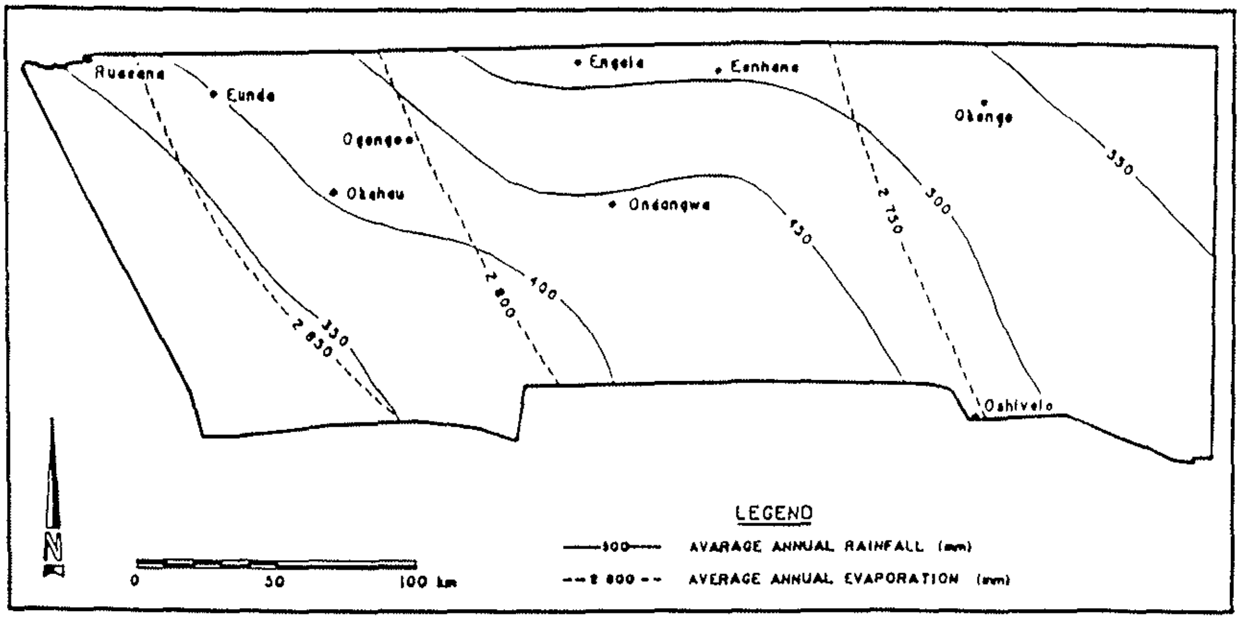
B = Dry region with a rainfall deficiency
S = Steppe or semi-desert
h = Annual mean temperature above 18°C
g = Month with maximum temperature in early summer
w = Rainfall during summer.

2.3.2 Rainfall

Owambo experiences seasonal rainfall by means of thunderstorms in the summer months between October and April. More than 70% of the rainfall occurs between January and March. The rainfall in the dry season during the rest of the year constitutes less than 1% of the total annual rainfall.

The mean annual rainfall varies between 600 mm in the east and 300 mm in the west.

According to a 79 year raintall record the region has a relatively high average mean annual raintall of 480 mm in comparison to the 250 mm for the rest of Namibia, but the erratic nature of the rains has an important influence on the hydrological regime. The absolute maximum and minimum rainfall recorded was 982 mm in 1916/17 and 184 mm in 1928/89. Refer to **MAP 2.3**.



MAP 2.3 : RAINFALL AND EVAPORATION

The variability of the seasonal precipitation is an important detrimental agricultural factor and ranges between an average deviation of 30% from the mean rainfall in the east to 50% of the mean rainfall in the west. Typical monthly distributions of rainfall in a dry, an average and a wet season is presented in **FIGURE 2.1** on page 11.

The overall mean distribution of average rainfall during the rainy season, at a number of locations in Owambo, is given in **TABLE 2.1** on page 11.

2.3.3 Sunshine

The duration of sunshine is mainly determined by latitude and frequency of cloudiness. The average annual sunshine in Owambo is 9 hours per day, but may be as little as 7 hour per day in January as a result of more cloudy conditions during the summer rainfall season.

The relatively high average number of sunshine hours per day in Owambo is an important aspect concerning small scale utilization of solar power for rural water supply systems.

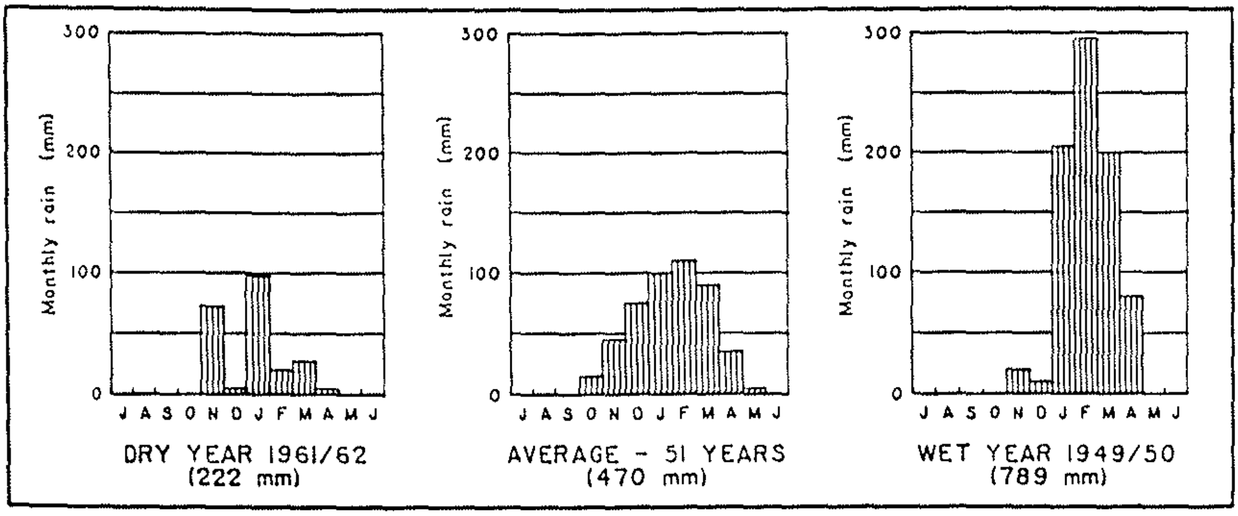


FIGURE 2.1 : TYPICAL MONTHLY RAINFALL DISTRIBUTIONS

TABLE 2.1 : MONTHLY DISTRIBUTION OF RAINFALL

LOCATION	MONTHLY DISTRIBUTION OF RAINFALL AS A PERCENTAGE OF THE MEAN ANNUAL RAINFALL						
	OCT	NOV	DEC	JAN	FEB	MAR	APR
Oshigambo	2,5	12,6	10,3	29,9	23,2	20,3	7,1
Ondangwa	2,5	10,8	11,3	25,1	23,1	20,6	6,5
Ombalantu	1,8	9,5	10,9	22,5	24,7	25,2	5,4
OVERALL MEAN	2,4	10,5	10,6	24,3	23,9	22,6	5,7

2.3.4 Temperature

Summers in Owambo are very hot. The average annual daily temperature is 23 °C. October and November, prior to the onset of the rainy season, are the hottest months. The average daily maximum temperature in October is 35,5 °C. Winter days are mild, but cold at night. The coldest month in winter is July and the average daily minimum temperature is 6 °C. The absolute maximum and minimum temperatures ever measured to date were 40 °C and -3 °C. The incidence of frost is insignificant and can be ignored as a factor in crop production.

Soil temperature, which has an important influence on evapotranspiration and vegetation growth, varies between 20 °C and 32 °C, depending on the season, soil type, and depth of measurement. These high soil temperatures pose a problem for crop growth.

The relative humidity in Owambo varies according to the season and the time of day, but on average it may be as low as 17% in September at 12h00 and as high as 80% in March at 08h00. The low humidity and high temperature create difficult conditions for germination and crop establishment at the onset of the rainy season.

2.3.5 Wind

Owambo experiences no wind and calm conditions for almost 60% of the time during the year. There are no prevailing winds, although the wind seems to blow mostly from the east when it does. Strong winds are rare, but may occur before and during thunderstorms. Wind is not an important factor as far as soil cultivation and possible windblown soil erosion is concerned.

The availability of wind seems to be reliable enough to drive windmills for borehole water abstraction.

2.3.6 Evaporation

Evaporation of water from open water surfaces like pans and storage dams in Owambo is enhanced by the low relative humidity, high daily temperature and wind. The potential average annual evaporation in the region is less than 2600 mm. Refer to **MAP 2.3** on page 10. The mean annual evaporation as measured with a standard A-pan evaporimeter at Ondangwa is 2 485 mm. The expected maximum monthly potential evaporation is the highest in October (276 mm) and the lowest in June (148 mm). Refer to **TABLE 2.2** on page 13 for more evaporation statistics.

TABLE 2.2 : MEAN EVAPORATION AT ONDANGWA

MONTH	EVAPORATION (mm)	STANDARD DEVIATION (mm)
January	220,6	40,8
February	185,6	38,9
March	203,2	37,2
April	165,6	20,4
May	172,6	23,9
June	147,8	14,8
July	164,5	27,2
August	195,8	23,4
September	223,3	46,0
October	267,7	52,4
November	265,4	38,9
December	263,6	25,3

2.4 GEOLOGY

2.4.1 General

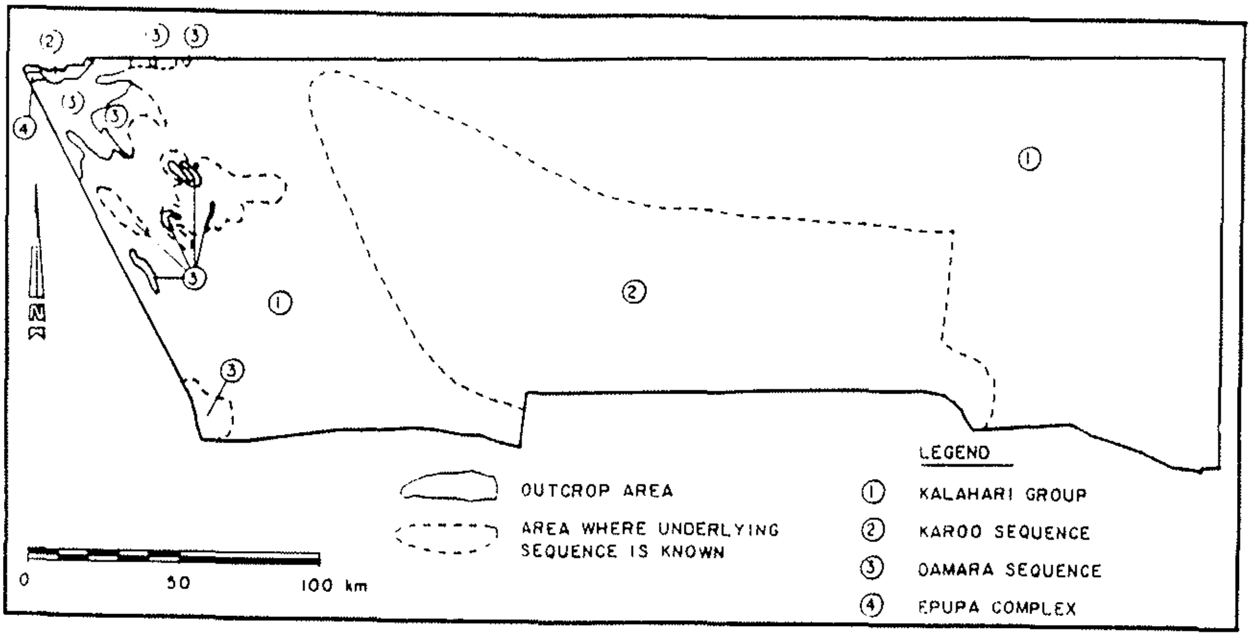
Although the unconsolidated to poorly consolidated beds of the Kalahari Group covers most of the region, the overall geology of Owambo is much more complex than normally anticipated. **References 6 & 7** provide more information on the geology, mineral resources, mining potential and the economic aspects of the geology. Refer to **TABLE 2.3** on page 14 for the lithostratigraphy of Owambo and **MAP 2.4** on page 15 for a simplified geological map.

2.4.2 Lithostratigraphy

Due to the thickness of the Kalahari beds, the basement geology of central and eastern Owambo is not known in any detail, but the bedrock of the Etosha Basin most probably comprises the very old Archaic Complex, the dish shaped Damara Sequence, which outcrops on the western edge of the basin, and the younger Karoo Sequence which outcrops in the Ruacana area.

TABLE 2.3: LITHOSTRATIGRAPHY OF OWAMBO

ISOTOPIC AGE (Ma)			LITHOSTRATIGRAPHIC UNIT			LITHOLOGY
			GROUP	SUB-GROUP	FORMATION	
TERTIARY TO QUARTERNARY	32-39		Kalahari		Andoni	Greyish-green sandy clay or clayey sand
					Olukonda	Redish-brown calcareous sandstone
					Beiseb	Reddish, gritty, conglomeratic sandstone
CARBONIFEROUS TO JURASSIC	180	KAROO SEQUENCE				
					Omingonde	Red mudstone, siltsone, grit, sandstone, conglomerate
	500		Ecca		Dwyka	Tillite, bouldershale, shale, sandstone, limestone
NAMIBIUM		DAMARA SEQUENCE	Mulden		Owambo	Shale, sandstone, dolomite, limestone, siltstone
			Otavi	Undifferentiated		Dolomite, limestone, chert, shale, mixtite, quartzite, iron formation
	720 900		Nosib			
	920				Varianto	Quartzite, shale, ferruginous mixtite, iron formation
VAALIUM	2100	EPUPA COMPLEX				Orhtogneiss, granite, metasedimentary rock



MAP 2.4 : SIMPLIFIED GEOLOGY

The successive layers of sands, sandy clays, sandstones and conglomerates of the Kalahari Group are up to 500 m thick and of Tertiary to Quaternary age (30 to 40 million years). In the central part of Owambo the basal portion of this succession consists of the conglomeratic sandstone of the Beiseb Formation, between 15 m and 30 m thick. The basal unit is overlain by the poorly consolidated calcareous sandstone of the Olukonda Formation, reaching a thickness of more than 120 m. Above the reddish basal layers, a marked change in the lithology of the remaining upper portion of the succession occurs in the Andoni Formation. The formation comprises sandy clay and clayey sands which probably indicate a change in climatic conditions during the time of deposition. The clayey material was probably transported and deposited by endoreic rivers and streams while the deposition of windblown sand also took place at the same time. The alluvial plain has subsequently been much altered by aeolian reworking of the surface deposits and all that remains of the ancient drainage system are numerous locally depressed oshanas as described in **Section 2.2.**

The contact between the poorly consolidated Kalahari Group and the rather well-bedded underlying Omingonde Formation of the Karoo Sequence can easily be recognised in borehole core, while the tillite, shale, sandstone and limestone of the Dwyka Formation of the Karoo Sequence are exposed over a distance of some 35 km along the Cunene valley.

The rough and hilly terrain at several places along the western border of Owambo is formed by outcrops of phyllite, quartzite, conglomerate, dolomite, limestone and shale of the Mulden and Otavi Groups of the Damara Sequence. The Nosib Group is exposed as a narrow band between outcrops of the Otavi Group and the Dwyka Formation in the Ruacana area.

The Epupa Complex, which consists of a succession of metamorphosed volcanic and sedimentary rocks, is the oldest in geological terms and covers an area of 5 to 10 km^2 at Ruacana on the Angolan border.

2.4.3 Economic Mineral Potential

Soda occurs in a number of pans in southern Owambo. The most important of these are Otjivalunda (400 ha), Otjivalunda East (400 ha), Ongandjera (60 ha) and Ongandjera East (30 ha). The salts are mainly trona, thenardite, burkeite and table salt. In the past the Wambo exploited the salt in the Otjivalunda pans for trade in northern Namibia. Only the Otjivalunda salt pans were extensively investigated and a summary of the results is given in **TABLE 2.4.** Very little is known about the Ongandjera Pans, but a 0,92 m thick layer of trona and thenardite was found in a few exploration pits.

TABLE 2.4 : SODA DEPOSITS OF THE OTJIVALUNDA PANS

PAN	AVERAGE THICKNESS OF DEPOSITS (m)	ESTIMATED RESERVES (t)	COMPOSITION OF TOTAL DEPOSIT (%)		
			TRONA	THENARDITE	OTHER
Otjivalunda	0,60	2 300 000	15	80	5
Otjivalunda East	0,64	4 100 000	30	65	5

Groundwater found in boreholes just north of the Etosha Pan has a very high percentage of dissolved solids and at places the salt content is three times higher than that of the ocean. With the relatively low rainfall and high evaporation it is thought that brine could be pumped into some of the pans for salt production, but the economic viability of salt mining still has to be investigated.

Between 1960 and 1963 extensive geophysical and geochemical surveys were carried out in the search for oil in the area to the west and north of the Etosha Pan. Although no indication of petroleum was found, exploration boreholes revealed that sufficient thicknesses of source and reservoir rocks may exist in places, with the necessary trap-structures to concentrate hydrocarbons. The evidence does not warrant particular optimism, but the potential cannot be ignored and recently a Taiwanese petroleum company (Overseas Petroleum Investment Corporation (OPIC)) obtained a concession to explore for oil in an area between the Atlantic coast, the Angolan border, the Botswana border and the 20° latitude line. This area includes Owambo as a whole.

Exploration for coal was first undertaken in Owambo in 1922. The exploration for oil confirmed the presence of coal which was found in boreholes at a depth of more than 300 metres below surface. However, it is of low quality and the material is better described as bituminous shale. It therefore seems unlikely to be of economic value.

Calcrete is widely distributed over Owambo and is locally used in the building of roads. Due to the variation in calcrete development, the selection of material for a specific use should only be carried out by an expert. Calcrete is not suitable for use as aggregate in concrete.

Concrete aggregates and resilient stone for tarred roads can only be obtained in the western area where outcrops of granite, dolomite and quartzite occur.

Two sources of suitable brick clays have been found in Owambo. Large quantities of sandy clay from the Kalahari deposits available in the oshanas are suitable for local brick manufacturing. Excellent bricks can also be made from a mixture of Nosib shale and montmorrilonitic Dwyka shale which occur in the Ruacana area. It is estimated that deposits to manufacture in excess of 100 million bricks have been identified, but further work needs to be done on the viability of the establishment of a brick industry to provide bricks for housing projects.

Although rocks of the Damara Sequence, which are known to contain limestone and metalliferous deposits like copper, lead and zinc, occur in the north-western area of Owambo, the presence, quality and quantity of such mineral resources still remain to be determined.

From the above it seems that no information is available to predict the development of a major water consuming mining operation or industry in the near future.

2.4.4 Hydrogeology

Groundwater in Owambo is hosted in rocks of two geological formations, viz.

1. **The Kalahari Group**
2. **The Damara Sequence.**

The most prominent of these are the recent **Kalahari Group** sediments in the Etosha Depression. The groundwater in the Cuvelai Drainage Basin occurs in two aquifers. Firstly there is the deep regional aquifer containing saline water and secondly a discontinuous perched aquifer where lenses of fresh water overlie less permeable alluvial horizons or layers of salty water. Saline water of the so-called brine lake area is more or less confined to the central Etosha Depression, but in eastern Owambo, on the eastern fringe of the brine lake area, the deep Kalahari sands contain potable water. Artesian and sub-artesian potable water also occurs on the south-eastern fringe of the brine lake area in the vicinity of Oshivelo. Potable water is also found in a perched water table in this area. In a north-westerly direction from Oshivelo the artesian water becomes very saline and unsuitable for consumption.

The other geohydrological environment mentioned is in western Owambo where groundwater occurs in the joints, faults and solution cavities of the hard rock aquifers of the **Damara Sequence.** However, kartstification of the dolomites is insignificant due to low rainfall in the west.

The potential of the groundwater sources in Owambo will be discussed in **Chapter 3.**

2.5 PHYSIOGRAPHY

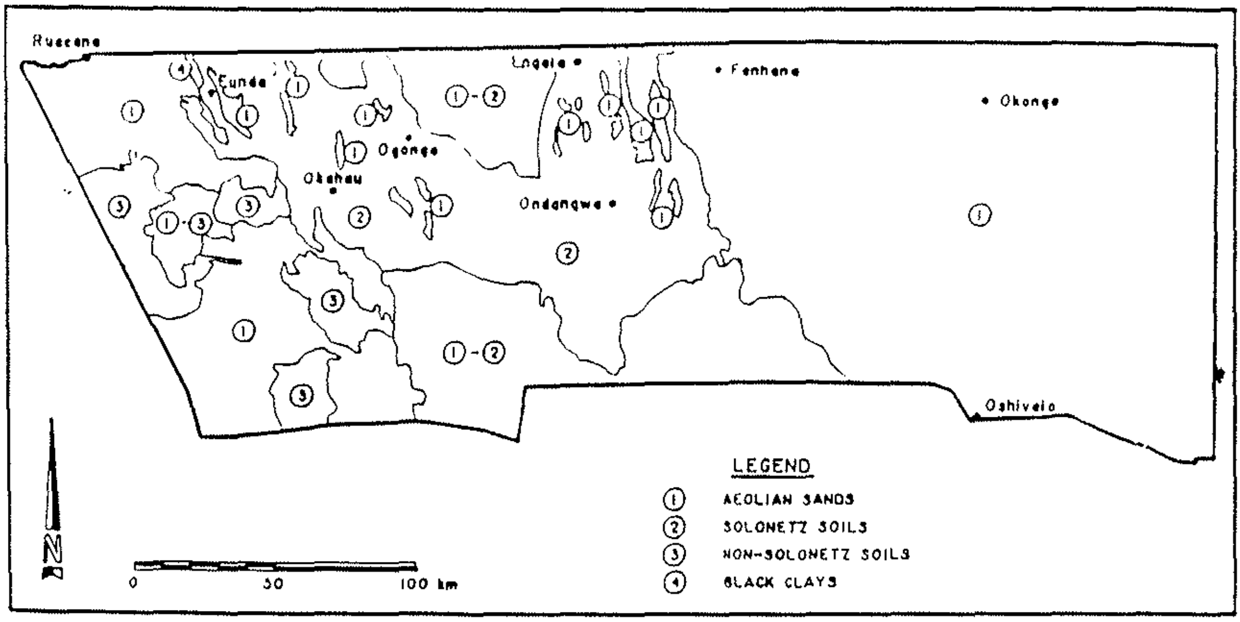
Considerable investigations into the physiography of Owambo were conducted in the past **(References 8, 9, 10, 11 & 12)**. Extensive reconnaissance soil surveys were done in Namibia between 1965 and 1976, as well as subsequent, more detailed work in Owambo between 1970 and 1971. Aerial photo-interpretation techniques relating to localized, more intensive patterning, were used. Major objectives of these studies were to determine the occurrence of potentially irrigable soils and the grazing potential of the vegetation. Some of the most important aspects are discussed briefly.

2.5.1 Soil

Geological origin, landform and climate have a pronounced influence on the development, character and eventual utilization of soils. The common parent material of the alluvial plain in Owambo is a remarkably uniform, relatively unwithered, medium-textured sand. The sands vary essentially only by virtue of their colloid content, influencing colour and structure, their salinity and grading. Extensive sand mantles of aeolian origin also occur in the eastern and western areas. The soil surveys indicated a quite intensive patterning which complicated classification of the soils, but they can broadly be classified into four groups. Refer to **MAP 2.5** on page 20 for orientation. The soil groups are:

1. **Aeolian Sands**
2. **Solonetz Soils**
3. **Non-solonetz Soils**
4. **Black Clays**.

The **Aeolian Sands** are present on the fringe of the central alluvial depression. The clay content is relatively low, varying between 2% and 8%. These soils are also generally non-saline. Although much more complex in distribution and classification, it can generally be stated that grey sands cover the whole of the eastern area, while red and brown sands are characteristic in the gentle relief of the western area of Owambo. There are also sands, enriched with locally derived material, in narrow lenses in the higher lying areas between the oshanas.



MAP 2.5 : SIMPLIFIED SOIL DISTRIBUTION

The **Solonetz Soils** are medium textured and cover virtually the whole central alluvial plain which is characterized by a bleached (white) surface. There is also a definite transition between the upper and a lower, more compacted solonetz horizon having low permeability and high sodium activity. This profile is typical of soils in flat areas with saline parent material and poor drainage. The upper layers of these soils are shallow, but cultivation is practised on the higher lying areas between the oshanas.

The **Non-solonetz Soils** occur in the western area bordering the Kaokoveld and are associated with calcrete. The soil is typically a brown sandy loam, non-saline, non-sonic and inherently fertile.

Black Clays occur in scattered locations all over Owambo and are associated with the beds of the oshanas and pans. The clays are highly expansive and usually non-saline and non-sodic, but salinity may increase with depth.

2.5.2 Vegetation

The vegetation in Owambo can be broadly classified into five groups. Refer to **MAP 2.6** on page 22. These are:

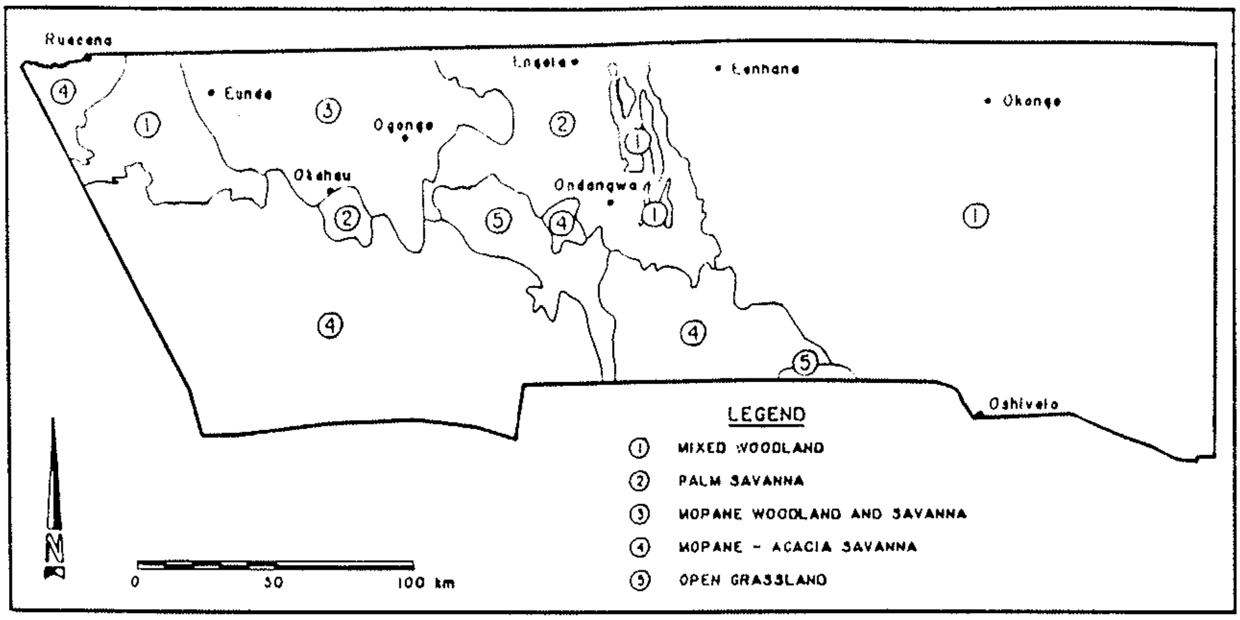
1. **Mixed Woodland**
2. **Palm Savanna**
3. **Mopane Woodland and Savanna**
4. **Open Grassland**
5. **Mopane-acacia Savanna**

The **Mixed Woodland** areas, associated with aeolian sands, are located in the whole area to the east of the Cuvelai Drainage Basin and in the west in the Ruacana area. Vaalboom and wild seringa are the main species while dolfhout, kiaat and manketti occur to a lesser extent. The grass cover is moderate, but in the eastern area the grass tends to be less palatable than elsewhere.

The **Palm Savanna,** associated with secondary growth of acacia and mopane shrub, mainly occurs in the central-northern area. Scattered stands of these plant communities on the perimeters of the oshanas are a typical feature of the landscape. The grass cover is generally poor.

The **Mopane Woodland** and **Savanna** vegetation group is associated with solonetz soils and is characteristic of the central north-western area of the Cuvelai Drainage Basin, extending across the Etaka. Maroela, palms, boabab and manketti also occur in isolated, but extensive communities within the mopane woodland. To a large extent this area has been denuded of vegetation, except for fruit trees, due to the use of timber for palisades and firewood, overgrazing and the clearing of land for cultivation. The grass cover is moderate, consisting of various perennial and annual grasses.

Open Grassland occurs in the environs of Lake Oponono. Trees and shrub are absent and the area is seasonally inundated. The grass cover is good, but utilization is restricted due to seasonal inundation and moderate nutritional values.



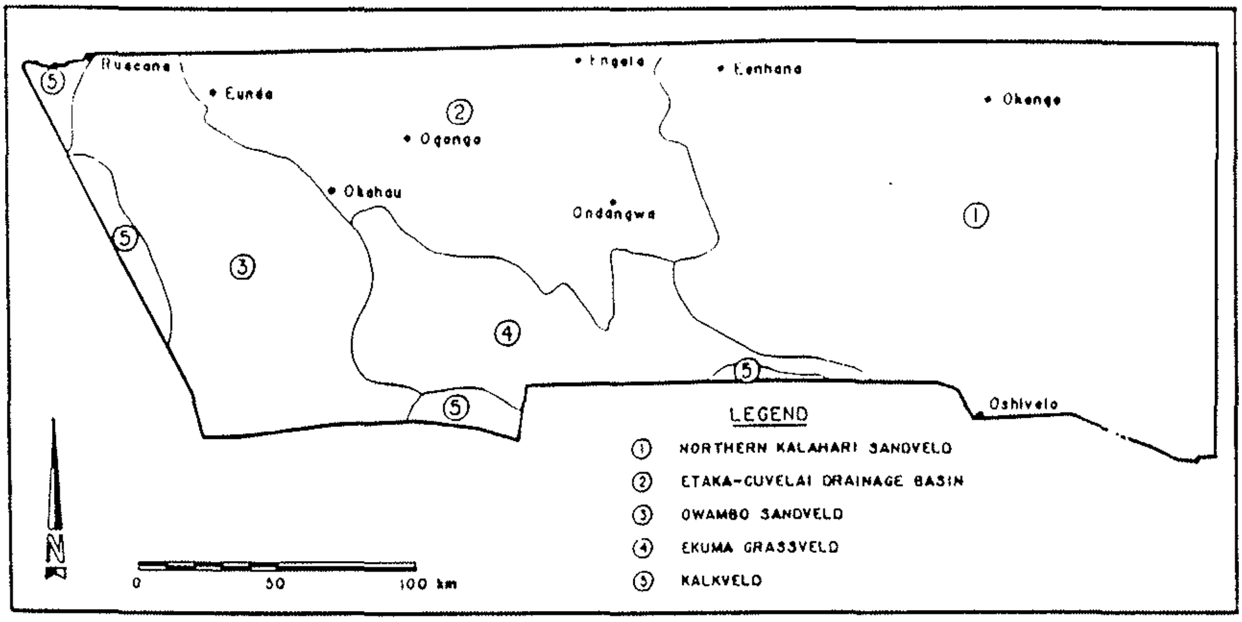
MAP 2.6 : VEGETATION

Mopani-acacia Savanna with various mopane and acacia species covers most of the central area to the north and north-west of the Etosha National Park. The landscape is characterised largely by grass flats with some shrub along the Ekuma, progressing to bush and tree-bush towards the east and west. Grass cover is sparse and of low nutritive value, except perhaps in the west where sweet veld is encountered.

2.5.3 Physiographic Regions

Owambo can be divided into five major physiographic regions as shown on **MAP 2.7** on page 23. They are the:

1. **Northern Kalahari Sandveld**
2. **Etaka-Cuvelai Drainage Basin**
3. **Owambo Sandveld**
4. **Ekuma Grassveld**
5. **Kalkveld**



MAP 2.7 : PHYSIOGRAPHIC REGIONS

The **Northern Kalahari Sandveld** predominates the east of Owambo and mainly constitutes an aeolian sand mantle covering an underlying land form consisting of tertiary calcretes and sediments. Prior to deposition the sands were most probably eroded and partially reworked by wind and water. This resulted in the creation of flat plains and seif dunes. The sand is up to 50 m deep. Mixed woodland vegetation occurs.

The **Etaka-Cuvelai Drainage Basin** is located in central Owambo and is covered by alluvia deposited by the ancient Cunene and attendant drainage systems. There is an abrupt transition between the upper, coarse to medium sand surface and the more dense, less permeable lower layer. The relief of the area is flat and monotonous. The palm savanna vegetation group is characteristic in the region.

The **Owambo Sandveld** lies in the west of the region and is covered by fine to medium textured aeolian sands which have a slightly higher clay content than the sand in other areas. Generally the landscape has a gentle, undulating character, with mopane woodland and savanna vegetation.

The Ekuma Grassveld in central Owambo is covered by a uniformly textured mild to strongly saline sandy loam, overlain by aeolian or fluviatile sand. The landscape is extremely flat, being interrupted by occasional pans. Open grassland and mopane-acacia savanna is the predominant vegetation classes.

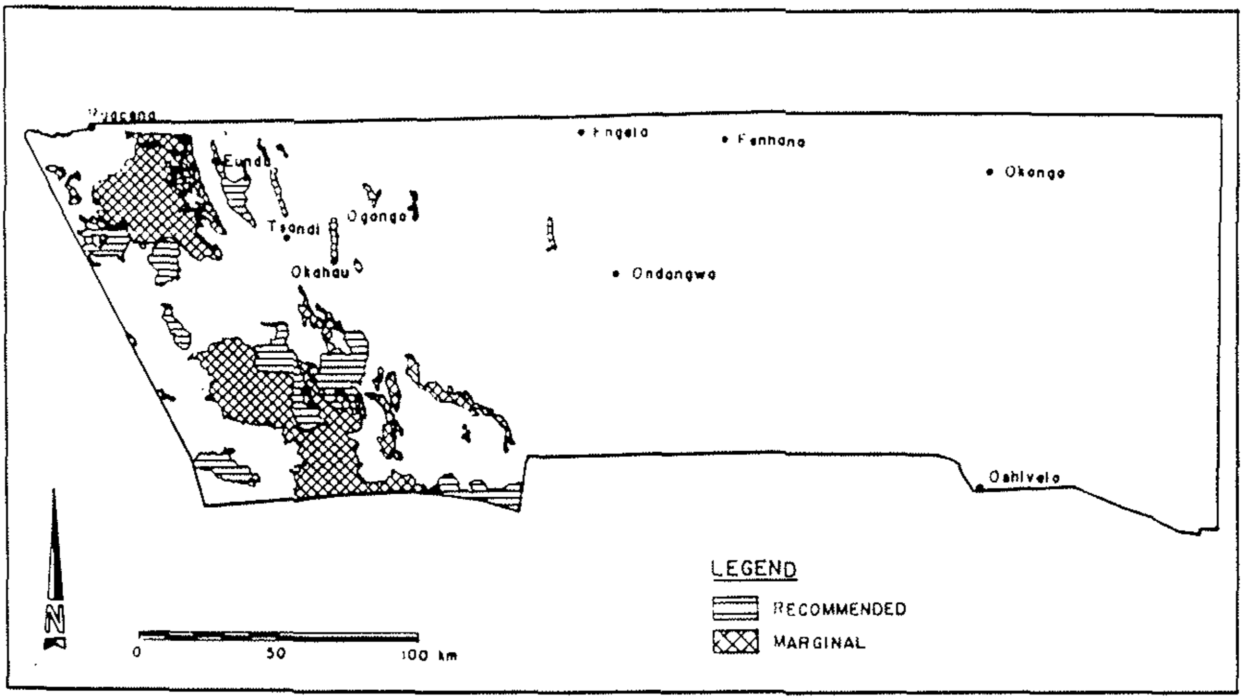
The **Kalkveld** covers a very small area adjacent to the western boundary of Owambo. The soil is derived from tertiary calcrete or its erosion products. The terrain is gently undulating with suppressed and diffuse drainage. Minor pans, low lying areas and endoreic, shallow drainage lines are a prominent feature. The vegetation type is mopane-acacia savanna.

2.5.4 Irrigable Soils

According to soil surveys the Owambo sandveld is the only physiographic region in Owambo which has recommendable irrigable soils. The irrigation potential is, however, uniformly marginal over the whole area. The soils are generally weakly self mulching sandy loams or sandy clay loams in slight depressions of the flat plains commanded by the 1150 m AMSL contour. There were more than 150 000 ha of these soils identified, but the recommended soils are distributed in patches over the region and in some cases are very remote from a perennial water source like the Cunene River. It was estimated that only 40% of these areas would be suitable for irrigation and even much smaller areas were considered highly recommendable for irrigation. Refer to **MAP 2.8.** on page 25.

The sandy soils in Owambo have rather low water retaining capacities, infiltration is rapid and salinity problems can be expected. Unless suitable soil compaction techniques are developed through research, it must be assumed that these soils can only be irrigated by sprinkler systems. Sound irrigation management would therefore be required.

In the Etaka-Cuvelai region slightly elevated discontinuous landforms of well drained sandy material occur. They appear to be fluviatile levees deposited by the Cunene River and that aeolian action also contributed soil material. Although the higher lying levees have a moderate to high irrigation potential, the whole area has not been recommended suitable for irrigation during previous soil studies. These soils are located in long lenses along the drainage pattern and can be irrigated from existing canals.



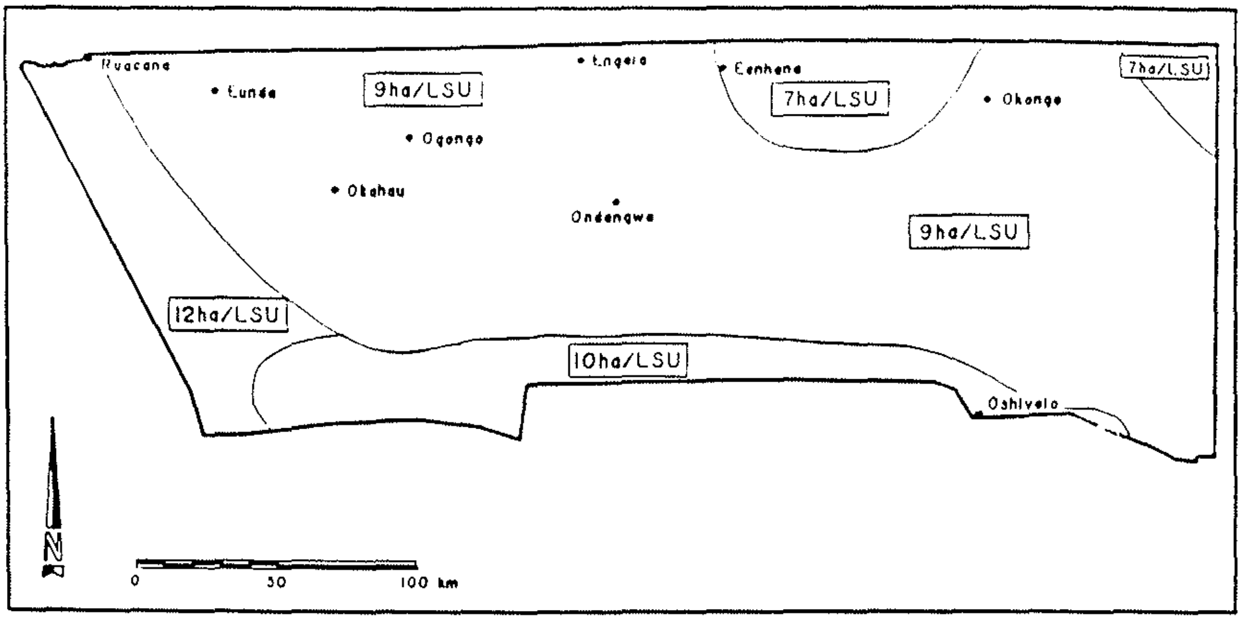
MAP 2.8 : IRRIGABLE SOILS

Due to the superficial nature of the large scale soil surveys which were done previously, and the fact that the grey and red gradational soils which are preferentially utilized for dryland crop cultivation by the Wambo can be recommended for irrigation without reserve, it is indicated that much more detailed studies will have to be undertaken to identify specific areas with soils suitable for further irrigation project development.

2.5.5 Grazing Capacity

The potential for grazing as derived from soil and vegetation studies seems to be generally moderate to low, except for a relatively small area to the west, located within the kalkveld physiographic region. Refer to **MAP 2.9** on page 26 for the grazing capacity as determined in 1968.

Related to previous agro-ecological studies the grazing capacity possibly ranges between 12 ha per large stock unit (LSU) for the low potential areas to 7 ha/LSU in the high potential areas. It is also known that the nutritional value of the grazing decreases during the dry season and that supplementation of fodder is desirable.



MAP 2.9 : ORIGINAL GRAZING CAPACITY

Although the grazing capacities were considered conservative during the initial studies, various adverse factors have contributed to poor grazing management which has resulted in a deterioration of the soil and vegetation cover. It is estimated that the grazing capacity has on average been reduced by 5 ha/LSU, e.g. an original capacity of 10 ha/LSU has deteriorated to 15 ha/LSU. This needs to be rectified urgently to prevent dust bowl conditions from developing.

3. WATER RESOURCES

3.1 GENERAL

In order to utilize water resources effectively it is important to know their magnitude and distribution. This would facilitate the provision of adequate water supplies to demand centres, but then the water must also be used judiciously and conserved wherever possible. If these objectives can be achieved, the available water sources could make a substantial contribution to development and growth of the economy in Owambo.

From the discussion in **Chapter** 2 it is clear that Owambo has direct access to three types of natural water resources. They are:

1. **Perennial Surface Water**
2. **Ephemeral Surface Water**
3. **Groundwater**

The Okavango River may in the distant future also be utilized as a source for the importation of perennial water to the eastern areas of Owambo, but due to the availability of groundwater sources and the fact that the east is considered to be a stock farming area, the Okavango River as a water source for Owambo will not be discussed further in this report.

3.2 THE PERENNIAL CUNENE RIVER

3.2.1 Hydrology

The Cunene River which rises in the Sierra Encoco mountain range in Angola near the town of Huambo, flows in a southerly and south-westerly direction up to the Ruacana Falls. From there it follows a generally westerly direction until it spills into the Atlantic Ocean.

The Cunene catchment covers 106 500 km^2 of which 14 100 km^2 or 13% is situated in the north of Namibia. The rainfall in the catchment decreases from 1 300 mm/a in the headwaters to practically zero at the mouth of the river. Contrary to this, the nett evaporation from open surfaces increases from 300 mm/a in the upper catchment to 2 600 mm/a in the Owambo area. The insignificant contribution that the catchment area in Namibia makes, is reflected by the fact that the mean annual runoff (MAR) of 5 500 Mm^3/a at Ruacana is the same as at the coast and that the median annual runoff decreases from 4 800 Mm^3/a to 4 700 Mm^3/a respectively at the sites mentioned.

The topography of the drainage basin can be divided into three distinct parts. The upper part of the catchment drains mainly hilly and mountainous areas in Angola where the tributaries are well defined channels with perennial water and rapids. The middle part comprises flat plains where the tributaries are ephemeral, the river has a shallow slope and the runoff contribution is considerably reduced. The lower part of the river cuts through a rugged mountainous area where local runoff is extremely erratic and where the river runs in a steep gorge with waterfalls and rapids (Ruacana, Epupa, Marienfluss). The importance of this last section of the Cunene for hydro-electric power development, its significance to supply in the future energy demand in Namibia, as well as the potential to provide water for Owambo in particular, is accentuated by the development which has already taken place at Ruacana and Calueque.

3.2.2 Background to Existing Development

The importance of the Cunene as a major water source was already noted by the early pioneers and the Ruacana Falls were often used as a landmark in the exploration of the area. The Border Agreement which was signed on 30 December 1886 between the Governments of Germany and Portugal aimed **inter alia** at securing a firm basis for so-called peaceful co-operation in the opening of Africa for the promotion of civilization and trade.

In 1915 German South West Africa was occupied by the Union of South Africa and was declared a Class C mandate by the League of Nations in 1920. The Union of South Africa was appointed the Mandatory and became responsible for the administration of The Territory of South West Africa.

Due to the ambiguity of the general terms of the Border Agreement between the German and Portuguese Governments, a second Border Agreement was reached between the Governments of Portugal and the Union of South Africa on 22 June 1926. According to one of the articles of the Agreement a part of the international border between the Territory and Angola was defined as the middle of the Cunene River, from the Atlantic Ocean to the Ruacana Falls. The border was subsequently demarcated and is recognized internationally as the border between the two countries. In terms of this definition the international status of the Cunene River and the right of both countries to use water from the river was confirmed. Of interest is that a 30 km stretch of river between the Ruacana Falls and the 14° longitude line also forms part of the border between Owambo and Angola.

By virtue of being contiguous to both Angola and Namibia along its length from its mouth to Ruacana, and by virtue of its flowing through the two countries successively, the beneficial use of the waters of the Cunene River cannot be denied to any of those countries, and to Owambo in particular.

With the subsequent signing of a Water-use Agreement on 1 July 1926 the premise was accepted that the floodwaters from the Cunene River Drainage Basin formerly flowed into Owambo, but that the inflow has considerably decreased due to the siltation of the old river courses. It was therefore agreed that the diversion of water from the Cunene for humanitarian reasons and the benefit of Namibia could be allowed under certain conditions. After the Union of South Africa became a Republic in May 1961, further Water-use Agreements were signed by the respective governments in 1964 and 1969. These Agreements **inter alia** made provision for joint development of the water sources of the Cunene and led to the construction of the flood regulation dam at Gove in Angola, the hydro-electric power station at Ruacana and the Calueque Dam from where initially 6 m^3/s or about 190 Mm^3 of water could annually be diverted to Namibia. See **FIGURE 3.1** on page 30 for an artist's impression of the project which was proposed. **(Reference 12).**

A Permanent Joint Technical Commission (JPTC) was also established in terms of the 1969 Agreement, but formal activities were discontinued in the early seventies. Informal contact was resumed in 1984, but the formal establishment of a JPTC between Namibia and Angola according to the provisions in the 1969 Water-use Agreement is very important to ensure that the interests of both countries are accommodated as far as further co-operation on the Cunene River development is concerned.

3.2.3 Existing Development

The hydrology of the Cunene River catchment and future development possibilities were investigated under the provisions of the 1964 Water-use Agreement. A total of 17 possible dam sites were subsequently identified in addition to the Matala Dam which already existed at that time. The proposed dam sites can be seen in **ANNEXURE 2**. After more detailed investigations had been completed, the 1969 Water-use Agreement was concluded to provide for the implementation of the proposals for the development of three sites, namely at Gove, Calueque and Ruacana. All three projects were jointly financed by the Portuguese and South African Governments. The first of these projects to be completed was the Gove Dam in Angola.

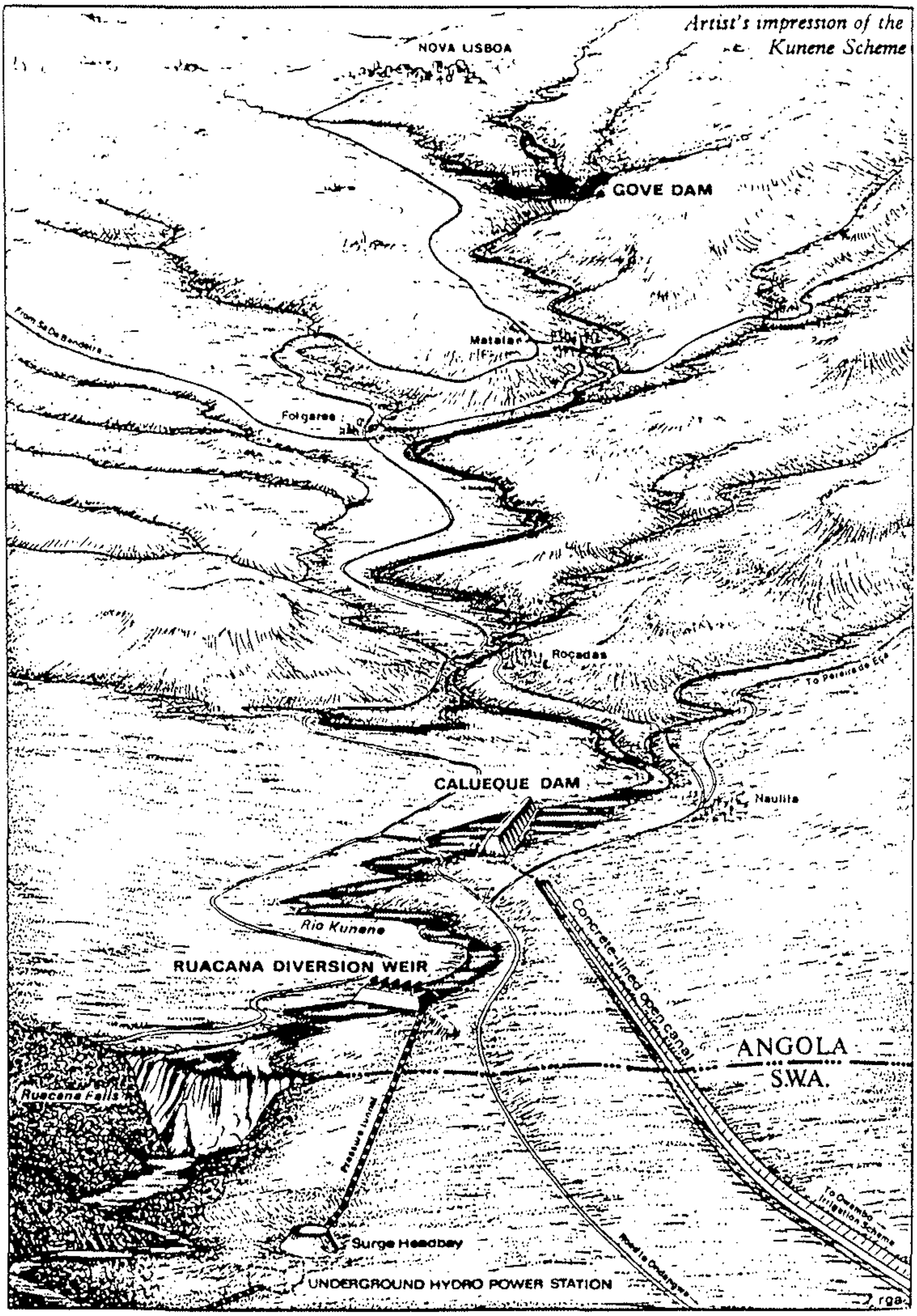


FIGURE 3.1 : PROPOSED CUNENE DEVELOPMENT

The purpose of the Gove Dam was to regulate the monthly flow of the Cunene for optimal power generation at Ruacana. Both Gove and Matala could also generate hydro-electric power for consumption in Angola. A summary of the dimensions of the Gove and Matala dams appears in **TABLE 3.1**.

TABLE 3.1 : SUMMARY OF PHYSICAL DIMENSIONS OF THE DAMS AT MATALA AND GOVE

INFORMATION	UNIT	DAM	
		MATALA	GOVE
Completion date	-	1954	1973
Wall type	-	Concrete Gravity	Earthfill Gravity
Height	(m)	16	58
Crest length	(m)	1 035	1 111
Volume of wall	(m^3)	-	4 537 000
Full supply volume	(m^3)	78 000 000	2 574 000 000
Max capacity of spillway	(m^3/s)	-	500

The construction of the diversion weir and hydro-electric power station at Ruacana commenced in 1971 and the work was completed in 1978. The Ruacana Diversion Weir lies in Angola, immediately upstream of the Ruacana Falls. The purpose of the weir, which has a full supply capacity of 26 Mm^3, is to divert water to the intake works of the power station and to balance daily peak water demands for power generation.

The power station which was built in Owambo on the Namibian side of the border, has three turbines and a total generating capacity of 240 MW under optimal conditions. The optimal flow rate through each turbine is 70 m^3/s and the maximum electricity generated is 700 GWh/a per turbine or an average of 1 260 GWh/a in total. Refer to **FIGURE 3.2** on page 32 for a diagrammatic representation of the layout at Ruacana.

The purpose of the Calueque Dam was to regulate the weekly flow of the Cunene to optimize power generation at Ruacana and to divert water at a rate of 6 m^3/s into Namibia. Construction on the Calueque Dam commenced in 1974, but the dam was never finished due to the deteriorating war situation in the area at that time. The contractor left the site in May 1976 after which a construction team of the Department of Water Affairs took over. This team also had to leave the site with only 2 to 3 months of work left. Only the northern embankment and the installation of 8 of the 10 sluice gates still had to be completed. During an air attack on the South African Defence Force in 1988 some damage was caused to the main concrete section of the dam, housing the pumpstation, and the pipeline to Owambo.

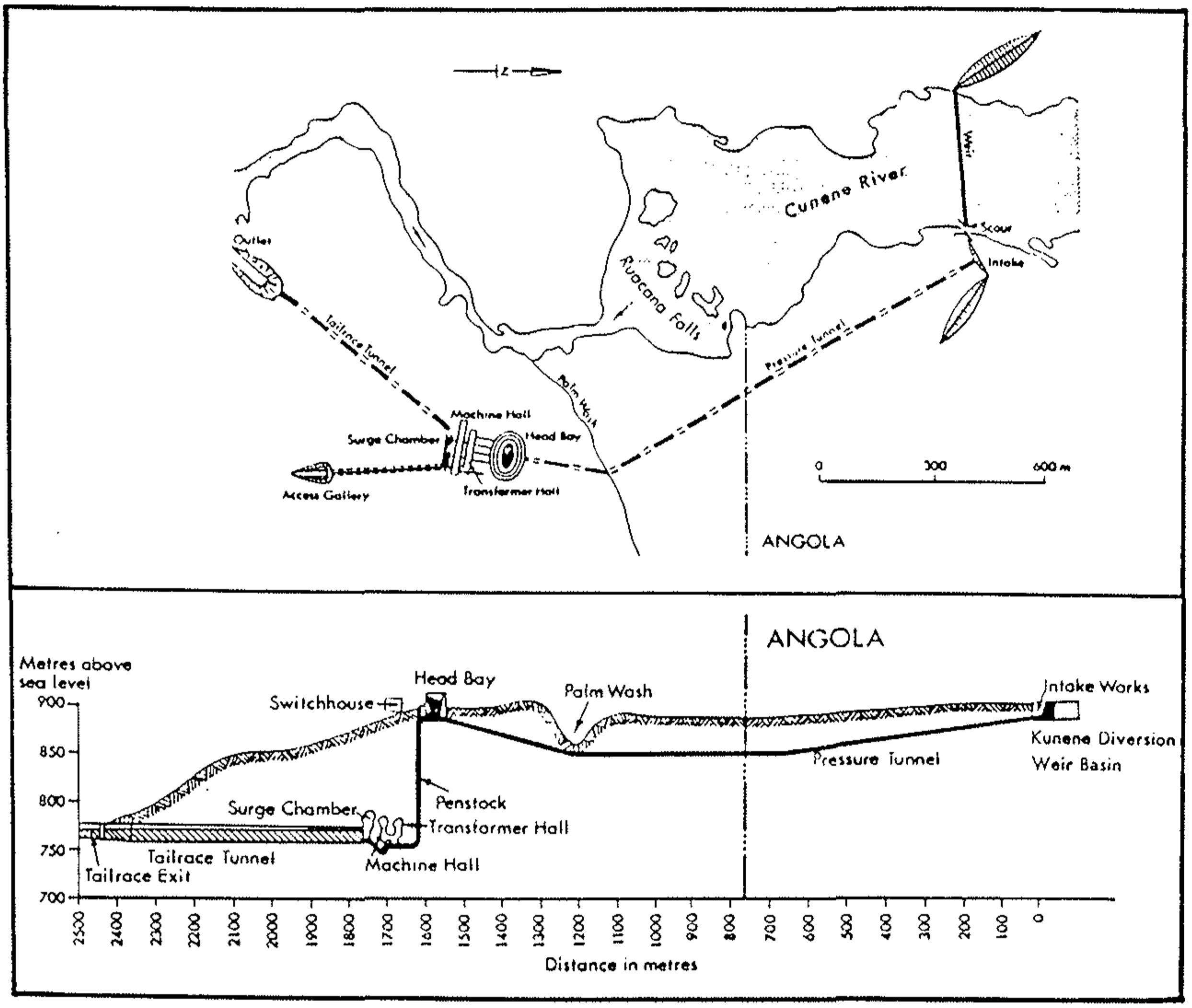


FIGURE 3.2 : LAYOUT AT RUACANA

In order to supply water from Calueque the water must be elevated about 18 m over the watershed between the Cunene and the Oshana Etaka, depending on the water level in the Cunene. Two pumpsets with a capacity of 3 m^3/s each were originally installed.

The pumping main is a 2 437 m long, 1 658 mm diameter steel pipeline leading into a 21 km long trapezoidal canal lined with concrete blocks. The canal has a nominal design capacity of 6 m^3/s, but a freeboard to accommodate 10 m^3/s up to a bifurcation, 14 km from the end of the pipeline and 2 km to the south of the border between Angola and Namibia. From the bifurcation to the Olushandja Dam the canal has a capacity of 3,2 m^3/s. The design pumping head at Calueque is between 25 and 35 m, depending on the water level in the dam and the number of pumps in operation.

The fluctuating security situation in the area necessitated the removal and replacement of the pumpsets from time to time in the past. However, the need to maintain the supply of water into Owambo remained a critical factor and remedial measures had to be implemented. Provision was therefore made to supply water from the Ruacana Falls into Owambo. Water can be pumped from the headbay at the intake of the power station or from the tailrace which is at river level downstream of the Ruacana Falls. Although provision was made to pump at a rate of 0,6 m^3/s, the pumping cost is in excess of R0,10 /m^3 in comparison to a cost of only R0,01 /m^3 at a much higher pumping rate of 3,5 m^3/s which is possible from Calueque with the existing pump configuration. The reason for this is that the difference in elevation between the plains of Owambo and Ruacana is 304 m at the headbay and 434 m at the tailrace. The corresponding pumping heads vary between 350 m and 480 m depending on pumping rates. It is therefore of vital economic and strategic importance to secure access to the pumping facilities at Calueque through further negotiations with the Government of Angola. This will ensure the pumping of water on a permanent basis to satisfy the long term water demand in Owambo.

Consideration must also be given to the completion of the earth embankment, reparation of the concrete works and upgrading of the pump capacity at Calueque. In a recent study of the hydro-electric power potential of the Cunene River **(Reference 14)** it was shown that the contribution of Calueque Dam as a flow regulating facility for the hydro-electric power station at Ruacana is of minor significance. In a storage-draft analysis for Calueque Dam it was shown that the 95% safe yield of the dam is 135 Mm^3/a. **(See Reference 13).** Although this is more than the annual pumping capacity of the existing pumpsets and enough to supply in the short term water demand of Owambo, it can be argued that because of the regulation of the flow in the Cunene from the Gove Dam, it is not really necessary to have a storage dam at Calueque. If the embankment and sluice gates of the Calueque Dam cannot be completed the pump water level would be reduced to the river level and it would therefore not be possible to divert 6 m^3/s with the existing pumpsets into Owambo. The upgrading of the pumping capacity and the repair of the damaged pumpstation seems much less expensive than repairing the embankment which is estimated at R30 million in order to raise the water level of the Cunene. The increase in pumping cost and the cost of additional pumps are factors to be considered in an economic analysis in order to determine the feasibility of repairing the Calueque Dam as a whole, or maintaining the present situation. In spite of the fact that there would seem to be no economical justification for repairing the dam there still is the engineering aesthetic point of view. An incomplete structure which was the result of an international agreement does not create a good impression, while tourist and recreational facilities in the north of Namibia and the south of Angola can be greatly improved by the dam. The dam may also serve as a major source of fish protein for the local population in an area where the people are known fish-eaters. The future of Calueque Dam may eventually depend on policy decisions, taking all factors into account.

The main purpose of the Olushandja Dam was to store a reserve supply of perennial water from the Calueque Dam closer to the consumer points in Owambo in order to accommodate peak demand and the expected variable water demand generated by possible irrigation projects.

The Olushandja Dam is unique because it was built across the watershed that separates the Oshana Olushandja and the Oshana Etaka. The dam basin was created by building an embankment on either side of the watershed in each of the oshanas. The full supply capacity of the dam is 42,5 Mm^3. Due to the extremely flat terrain, the maximum depth of the dam is only 4 m. The embankments in the oshanas are 19 km apart and the total surface area of the water is 19 km^2. The dam receives inflow via the canal from the Calueque Dam and a storage-draft analysis was carried out, considering inflow from Calueque through the canal. Three different pumping rates over a 20 hour production day were taken into account and from the results it was clear that on average only 7,7% of the water pumped to Olushandja would eventually be used effectively. For more detail on this analysis refer to **TABLE 3.2.** on page 35.

TABLE 3.2 : YIELD OF THE OLUSHANDJA DAM

PUMPING RATE FROM THE CUNENE RIVER (m^3/s)	VOLUME OF WATER (Mm^3/a)	95 % ASSURED YIELD (Mm^3/a)
1,8	47,30	3,60
3,5	91,98	7,02
6,0	157,68	12,07

The Olushandja Dam was damaged during the war, but aspects like the feasibility to utilize the dam and to repair it or to reduce its size must be investigated before a final decision can be taken on its future incorporation into the water supply system in Owambo.

3.2.4 Future Development

The initial investigations and studies to determine the potential of the Cunene River were done in terms of the provisions in the 1964 Water-use Agreement mentioned earlier. According to those studies the Cunene River had a total hydro-electric potential of 2 385 MW of which 270 MW or 1 300 GWh/a could be developed in the upper Cunene catchment and 2 115 MW or 10 000 GWh/a in the lower Cunene River downstream of Ruacana. It was originally proposed to develop the total electricity generating capacity by building 18 power schemes, but these plans never materialized fully due to the international situation and the fact that the original estimated power consumption in Namibia did not increase as anticipated.

In the Master Water Plan for Namibia **(Reference 2)** it was proposed to develop a Western Water Carrier from the Cunene River and an Eastern Water Carrier from the Kavango River. The development of the so-called Eastern National Water Carrier (ENWC) went ahead, but the feasibility of the Western Water Carrier came into question due to the cost implications, the fact that the ENWC can provide the water demand in Namibia well into the next century and the reservation of Cunene water for Owambo. In view of these developments it is proposed that the Cunene River be utilized to supply in the regional water demand in Owambo, and perhaps the Kaokoveld when necessary, as well as to develop the hydro-electric potential of the lower Cunene River to supply cheap power to Namibia and its neighbours.

The recent study on the hydro-electric potential of the lower Cunene River **(Reference 14)** contained a proposal to develop a new hydropower scheme at Epupa, some 110 km north-west of Ruacana on the Cunene River near the Epupa Falls. This facility could have a 130 m high dam wall, a storage capacity of 5 000 Mm^3, a maximum available head of 165 m for power generation, two turbines with a total generating capacity of 324 MW and an average output of 1 650 GWh/a.

From this preliminary information it is clear that the strategic and economic importance of an additional hydropower facility on the Cunene is vital for the future of Namibia and further feasibility studies should continue.

3.3 EPHEMERAL WATER SOURCES

The oshanas in central Owambo are mainly flooded by waters originating in the Cuvelai catchment area in Angola. Local downpours also make a contribution, specifically in the eastern area which is not tied to the catchment area in Angola, but run-off is rather insignificant due to the sandy nature of the soil.

The floods in central Owambo are known as the Efundja and usually occur in February. The oshanas may remain filled with water until June. After heavy downpours, and especially when the Efundja occurs, vast areas are flooded so that the elevated land between oshanas stands out as islands.

It is very difficult to measure the floods in the oshanas in order to obtain an indication of the potential of this ephemeral water resource. This fact can be understood if the flood mechanism is made clear. At low flood levels the floodwaters may be contained in a specific oshana, but at higher flood levels during the occurance of the Efundja, the water spills into adjacent oshanas and pans. The whole area becomes inundated and thus there is no point in having a measuring instrument in a specific oshana. The measurement of flow in the Cuvelai has therefore been discontinued completely.

The frequency of flow in the oshanas is erratic. In **TABLE 3.3** the occurrence and magnitude of the flow in the Oshana Cuvelai at Oshakati over a period of 27 years from 1940 to 1967 is given. Prior to 1955 the flow was only estimated, but for the remaining years actual measurements were attempted (**Reference 1**).

TABLE 3.3 : THE EFUNDJA AT OSHAKATI FROM 1940 TO 1967

ARBITARY FLOW DESCRIPTION	MAGNITUDE (m^3)	NUMBER OF OCCURRENCES OVER 27 YEARS
No flow	0	10
Very Weak	100 000	2
Weak	500 000	3
Normal	5 000 000	4
Good	15 000 000	3
Very Good	50 000 000	3
Exceptional	100 000 000	2

From **TABLE 3.3** it is evident that in 10 out of 27 or 37% of the seasons no flow occurred in the oshana at Oshakati. In the years that a flow of up to 500 000 m^3/a was measured it can be assumed that floods were caused by local runoff. Only 45% of the time the flow in the Oshana Cuvelai was sufficient to serve as a reliable water source for Oshakati. Due to the ephemeral nature and irregular occurrence of the Efundja as well as the large variation in and distribution of local rainfall, the water in the oshanas cannot be considered as a reliable long term water source for Owambo.

To utilize the runoff in the oshanas, dams have been excavated in the oshanas. These excavation dams are open on at least one side so that water from a local oshana or pan can fill the excavation. The depth of the excavation dams is limited by the local saline water table. In some areas it is as shallow as 2 m, but generally more favourable sites were sought and depths of 5 m have been attained. Because of this precaution, relatively little salt penetration into the dams has occurred. The slopes of the sides of the dams were generally 1:2 or 1:3, depending on the local soil conditions. Dams which supplied water for human consumption were fenced in. Unfenced dams had a slope of 1:6 to allow direct access for stock to drink. Dam sizes were chosen to provide a 2 year supply of water, including evaporation losses. See **FIGURE 3.3** on page 38.

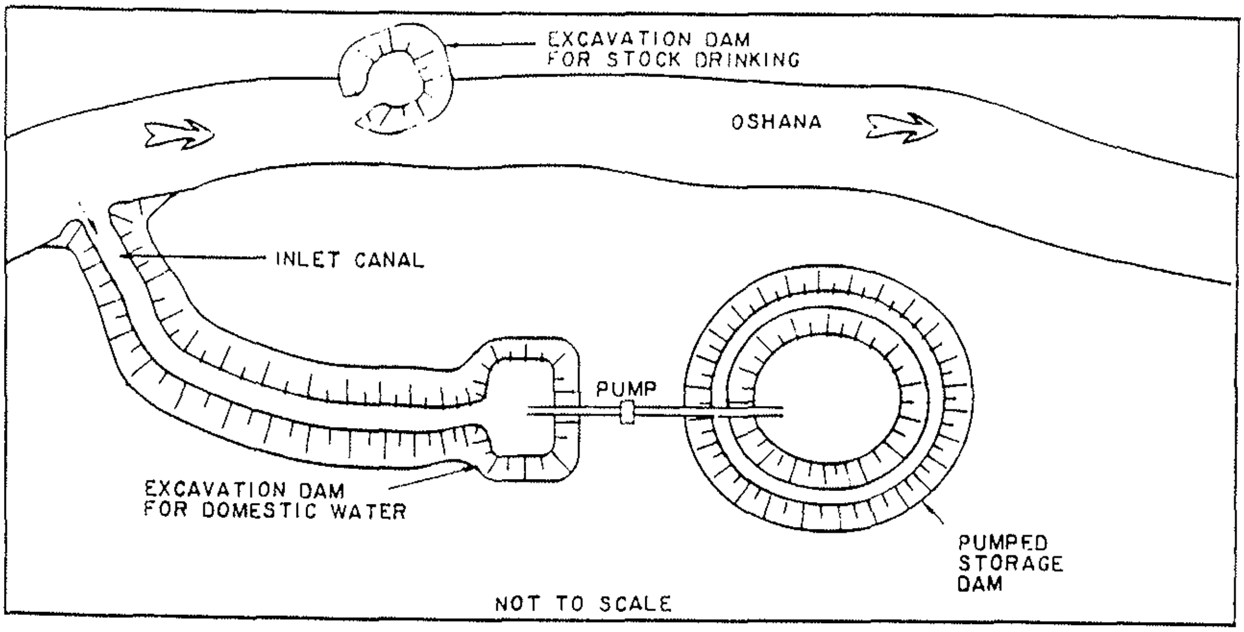


FIGURE 3.3 : TYPICAL EXCAVATION DAM LAYOUT

In order to store more water as water demands increased the excavation dams had to be increased in size. Due to the saline water table, an increase in water volume could only be achieved by increasing the surface area of an excavation dam. The high evaporation losses did not make such a solution viable and the concept of pumped storage dams were introduced. A pumped storage dam was excavated from ground level to the saline water table and had an embankment raised several metres above ground level. Water depths of up to 10 m have thus been obtained. Water was pumped from a sump dam, excavated adjacent to the storage dam. The sump dam was connected by means of an unlined canal to a local oshana. The runoff in the oshana was in this way diverted to the sump dam from where it was pumped into the pumped storage dam. Seepage through the compacted clayey sand of the storage dam embankments has proved to be insignificant. Wave erosion was prevented by using precast concrete slabs on the upper slopes of the dams. For a section through a pumped storage dam facility refer to **FIGURE 3.4.** on page 39.

Clear water was provided at many of the dams by using a simple sand filter construction, leading to a well fitted with a hand pump. The fine local sands have a low permeability and the sand filters did not always perform satisfactorily. At each of 17 pump storage dams a complete filter plant was built to supply purified water to hospitals, schools and community centres, but the problems experienced with the local fine sand resulted in the introduction of simple purification works. The process involved coagulation and pre-settling in sedimentation tanks. The clear water was chlorinated and stored in a reservoir or, where necessary, in elevated tanks. Presently only 3 of these purification works are still in operation as the only sources of purified water. Refer to **FIGURE 3.5** on page 40 for the configuration of a typical water purification works.

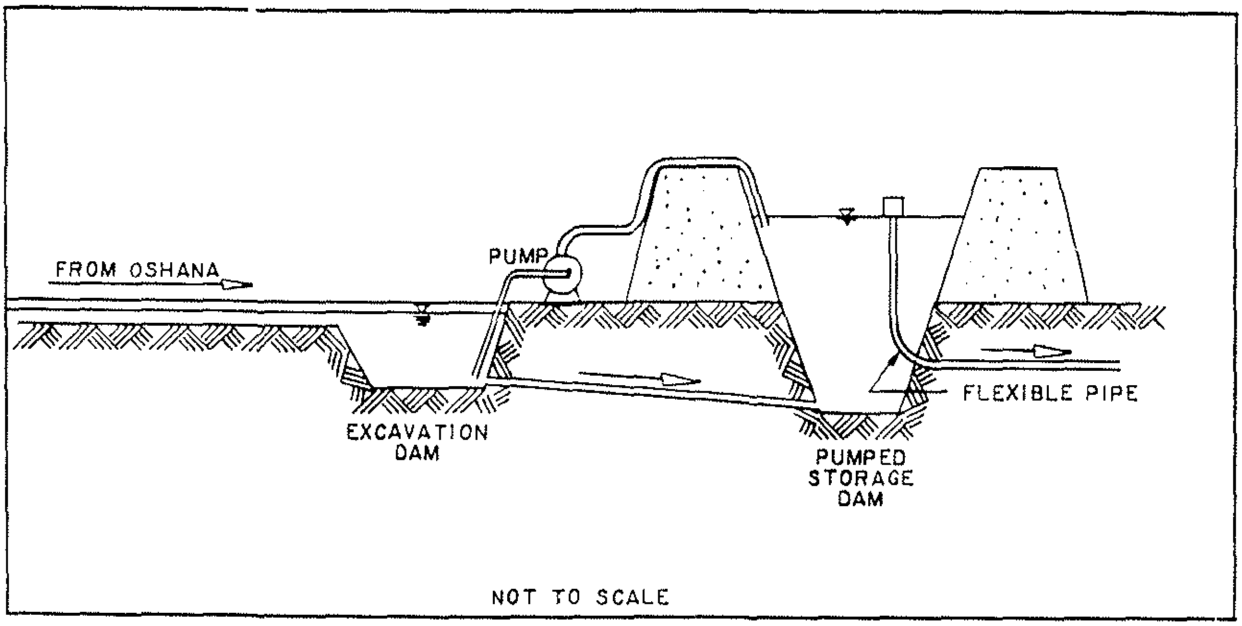


FIGURE 3.4 : SECTION THROUGH A PUMPED STORAGE FACILITY

The construction of excavation and pumped storage dams commenced in 1954 and lasted until the mid 1960's. During that period a total of more than 300 dams were constructed, of which 180 had a capacity of 6 000 m^3 or more. **TABLE 3.4** on page 40 provides more information on the larger dams in Owambo. Also refer to **ANNEXURE 4** for the approximate location of these dams.

During road construction in Owambo the creation of additional surface water storage dams was made possible through the advantageous siting of borrow pits next to oshanas and the construction of causeways which could dam the oshanas. The capacities of these dams are small, but an extreme example is at Oshakati where a storage capacity of 3 Mm^3 was obtained. In 1968 the total storage capacity of excavation dams was estimated at 7 Mm^3. The excavation and pumped storage dams supplied water to communities spread all over Owambo, but further construction of these dams was discontinued due to the relatively high unit cost of the water and the importation of piped water from the Cunene River.

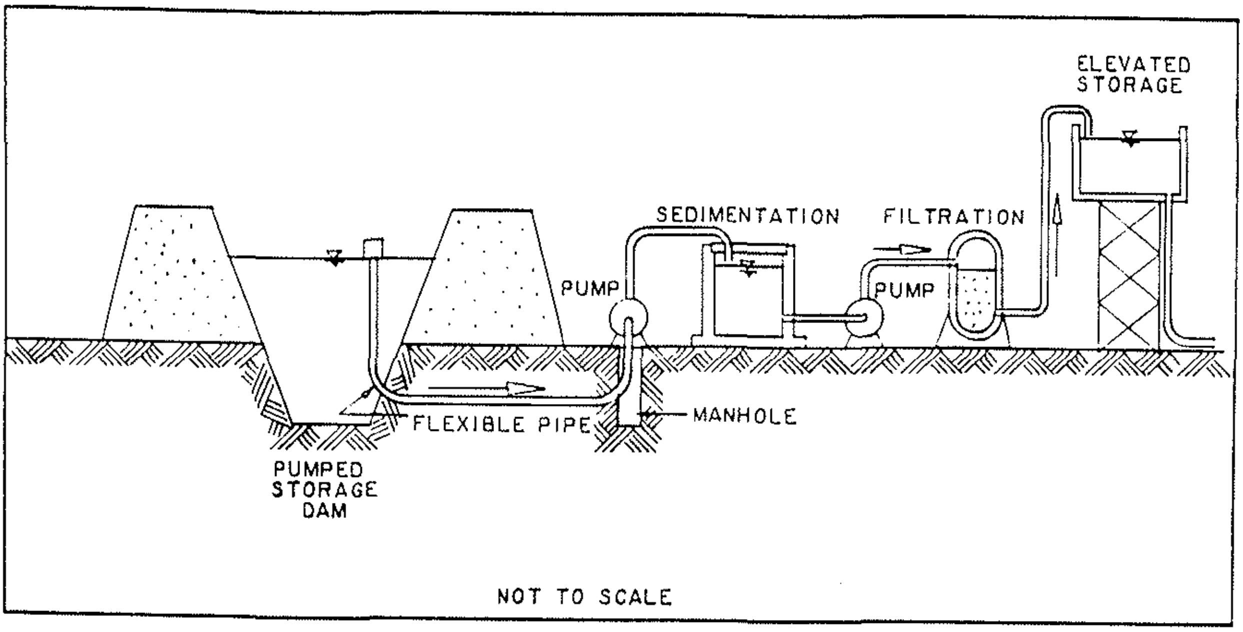


FIGURE 3.5 : TYPICAL PUMPED STORAGE PURIFICATION WORKS

TABLE 3.4 : DAMS WITH CAPACITIES LARGER THAN 6 000 m^3 CONSTRUCTED BETWEEN 1954 AND 1968 IN OWAMBO

TYPE OF DAM	NUMBER
Excavation dam	87
Pumped storage dam without filter station	86
Pumped storage dam with filter station	17
TOTAL	**180**

Despite the limitations and shortcomings in reliability, water from the ephemeral oshanas must be considered as an important source for rural water supply in the future. Piped water from the Cunene River is expensive and it will not only take time and money to expand the pipeline network to the outlying rural areas, but the water will most probably be required for urban development and organised agricultural activities.

Little or no work has been done to maintain the majority of the excavation and pumped storage dams. None of the handpumps at filter wells are in a working condition. It is therefore recommended that an investigation be carried out to determine what amount of siltation has taken place in the dams over the years, to establish the current condition of the handpumps and sandfilters and what needs to be done to utilize these facilities optimally. The collection of rainwater from the roofs of buildings into tanks should also receive attention. These investigations should lead to a programme of dam rehabilitation and the construction of handpump systems and other facilities to provide water for human and stock consumption.

Priority should be given to the rehabilitation of dams in the remote areas where piped water is not available. The local population must be fully involved in the determination of needs, the reconstruction work, as well as the operation and maintenance of these facilities.

3.4 GROUNDWATER RESOURCES

3.4.1 General

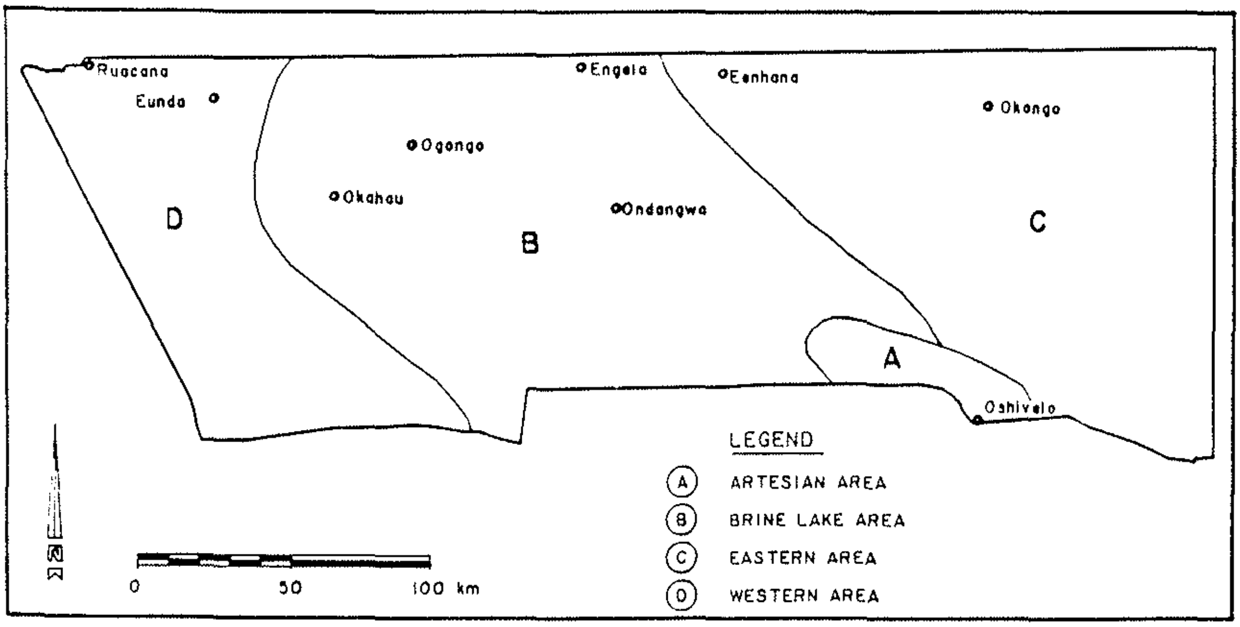
The location, quality and quantity of groundwater in any region must be known before it can be utilized to its full potential. The geohydrological environments with which the occurrence of groundwater in Owambo is associated, were briefly discussed in **Section 2.4.4.**

The first groundwater investigations in Owambo were undertaken in the densely populated central area in 1927. Further drilling was done in 1948, 1953 and 1962 to establish the occurrence of groundwater in other areas in Owambo. By 1968 some 250 boreholes had been sunk and a picture of the groundwater situation emerged. Most of the boreholes were drilled 50 to 150 m deep, but some were up to 250 m deep and five were up to 650 m deep in an effort to locate possible aquifers in the bedrock beneath the

Kalahari sediments. From the drilling results it could be concluded that groundwater in Owambo occurs in four major areas. These are:

1. **The Brine Lake Area**
2. **The Eastern Area**
3. **The Artesian Area**
4. **The Western Area**

Also refer to **MAP 3.1** for more information on the location of the groundwater sources.



MAP 3.1 MAJOR GROUNDWATER AREAS

3.4.2 The Brine Lake Area

The underground Brine Lake occurs in the centrally located Cuvelai Drainage Basin. The groundwater of the deeper, regional aquifer was found to be unsuitable for consumption due to very high concentrations of total dissolved solids. The concentrations may vary between 3 000 mg/ℓ and 33 000 mg/ℓ, but in some boreholes the salinity was three times higher than that of sea water. Due to these conditions further drilling and test pumping was abandoned and the potential of the brine lake has never been determined.

The possibility to desalinate the saline water has been raised, but the high cost and advanced nature of the technology involved make it too complicated for implementation in both the rural and urban areas. A proposal to mix the saline water with Cunene River water also seems possible, but may be impractical. Refer to **FIGURE 3.6** on page 44 for an indication of the possibilities for mixing fresh, imported Cunene water with saline groundwater water in such a way that a Namibian Standard Group B water is still obtained. If borehole water with a salinity of 5 000 mg/ℓ is mixed with Cunene water, which normally has a salinity of less than 100 mg/ℓ, 76 m^3 of saline water could be mixed with every 100 m^3 of sweet water and still yield a Group B water.

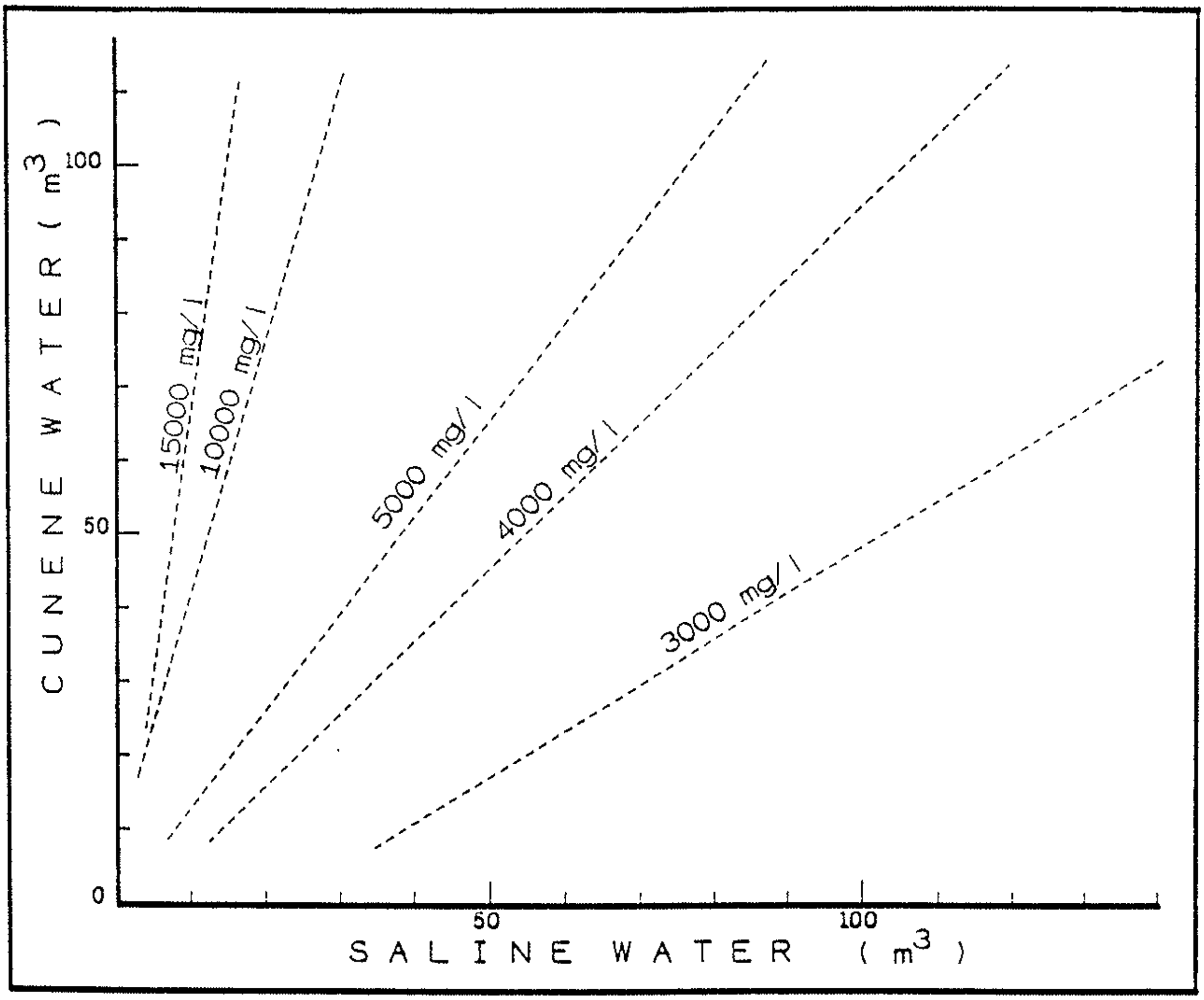


FIGURE 3.6 : MIXING OF CUNENE AND SALINE WATER

The perched aquifer in the brine lake area contains potable water at depths of between 5 and 20 m. The more shallow water was utilized by the rural population in the past, but the deeper water required more sophisticated methods of development and was therefore not utilized to such a large extent.

The shallow potable water is still abstracted through open wells and the drawing of water with buckets. Water supply based on these waterholes, which can be seen all over central Owambo in the oshanas near villages, is fraught with problems. Due to the sandy nature of the soil, the sides of the waterholes collapse, necessitating laborious re-excavation. The fine sands also affect permeability and the wells are often not located optimally. New wells must be dug as the water table recedes and potable water is displaced by more saline water. The way in which wells are operated also poses health hazards because humans and animals have access to the open water.

Properly designed, optimally located wells or shallow boreholes with handpumps could be a solution to many of the existing problems and should be investigated further. The potential of the potable groundwater in the brine lake area must be developed for water supply in the outlying rural areas.

3.4.3 The Eastern Area

Boreholes in the eastern area, that is to the east of the brine lake, have generally been 85% successful with yields in the order of 2 to 5 m^3/h at depths of 70 to 90 m. The water is potable and the concentration of total dissolved solids in the water is about 500 mg/ℓ. Few boreholes have failed on account of high salinity or weak yields.

Due to the depth of the water table and absence of electricity, windmills or diesel driven pumpsets will have to be used to abstract the water in this area. The implementation of solar power needs to be investigated, but the technology may be too advanced and expensive. The inaccessibility of the groundwater is also reflected in the low population density and the distribution of settlements around the few pans in the area.

It seems that the groundwater sources in the east are sufficient to support rural stock farming, but extensive geohydrological investigations and drilling are required before any conclusions can be made on the availability of the groundwater to sustain large scale urban development.

3.4.4 The Artesian Area

Artesian conditions exist in boreholes in the vicinity of Oshivelo in south-eastern Owambo. A raised water table is also found in the same area.

Water is abstracted from artesian aquifers in the vicinity of Oshivelo and Miershoop in Owambo, as well as at tourist facilities and stock farms in the north of the Tsumeb District. The salinity of the water in the artesian aquifer increases from Oshivelo in a north-westerly direction towards the brine lake area. The water in the perched aquifer is potable. The yield of boreholes in the artesian aquifer varies between 20 and 100 m^3/h. Boreholes penetrate the perched aquifer at 10 to 20 m below surface and yield up to 15 m^3/h.

Very little is known of the seemingly good groundwater potential indicated by the strong yields from boreholes in the area. The Geohydrology Division of the Department has embarked upon a comprehensive programme of investigations, drilling and pumptesting to determine the potential of the groundwater sources in an area to the north-west of Tsumeb because it is believed that water from the Otavi mountains in the Karst area percolates towards the north and north-west.

3.4.5 The Western Area

In this area which lies to the west of the Brine Lake, drilling results have been rather variable in respect of both yield and salinity. Some boreholes yield between 2 and 5 m^3/h, but 50% or more are rather weak. The water table is relatively shallow at depths of 10 to 30 m, but increases to 50 m in the Ruacana area. The salinity varies between 400 mg/ℓ in the north-west and 1 000 mg/ℓ in the south-west, but in the central western area the concentration of total dissolved solids may be as high as 5 000 mg/ℓ, rendering the water barely usable for stock drinking.

3.4.6 Groundwater Quality

The chemical quality of groundwater is determined by the abundance of rainfall, the topography and the chemical composition of the geological formations through which the groundwater percolates before it accumulates in an aquifer. The groundwater in arid regions tends to contain higher concentrations of dissolved salts which may be unhealthy for humans and animals. The corrosivity of such waters may also cause damage to water supply equipment.

The more important criteria for the potability of groundwater for human or stock consumption are the concentration of fluorides, nitrates, sulphates, the total dissolved solids, expressed in terms of conductivity, and the total hardness.

The chemical and physical guidelines for drinking water in Namibia are based on the guidelines of the World Health Organization (WHO) as well as on results of local research and experience. The approved Namibian Drinking Water Quality Guidelines (NDWQG) have been adjusted, within proven safe health margins, to suit local conditions and to avoid expensive water treatment facilities, particularly for isolated local water schemes serving small rural communities. Refer to **TABLE 3.5** for the quality guidelines of some of the more important determinants of the NDWQG.

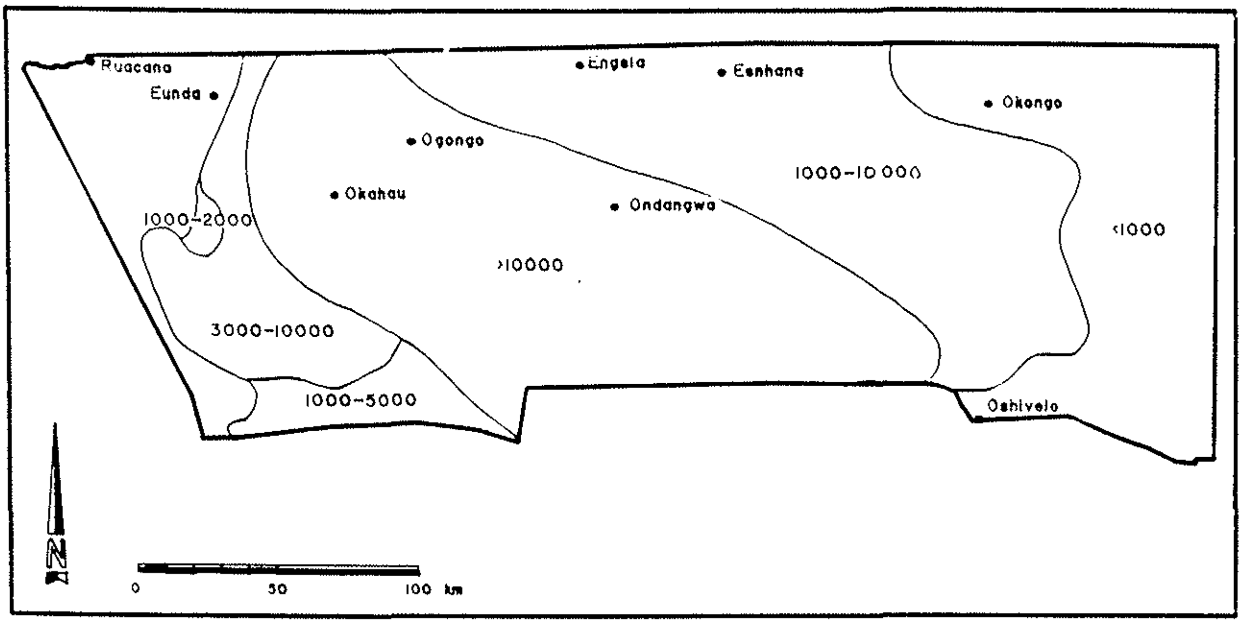
TABLE 3.5 SOME DETERMINANTS OF THE NDWQG

DETER-MINANT	UNIT	LIMITS			
		GROUP A	GROUP B	GROUP C	GROUP D
		EXCELLENT	GOOD	LOW HEALTH RISK	HIGHER HEALTH RISK
Conductivity	mS/m	150	300	400	400
TDS*	mg/ℓ	1 050	2 100	2 800	2 800
Sulphate	mg/ℓ SO_4	200	600	1 200	1 200
Nitrate	mg/ℓ N	10	20	40	40
Fluoride	mg/ℓ F	1,5	2,0	3,0	3,0

* Total Dissolved Solids

The National Institute for Water Research of the Scientific and Industrial Research Council (CSIR) in the Republic of South Africa conducted an investigation into the quality of groundwater in Namibia and produced comprehensive groundwater quality maps in 1982.

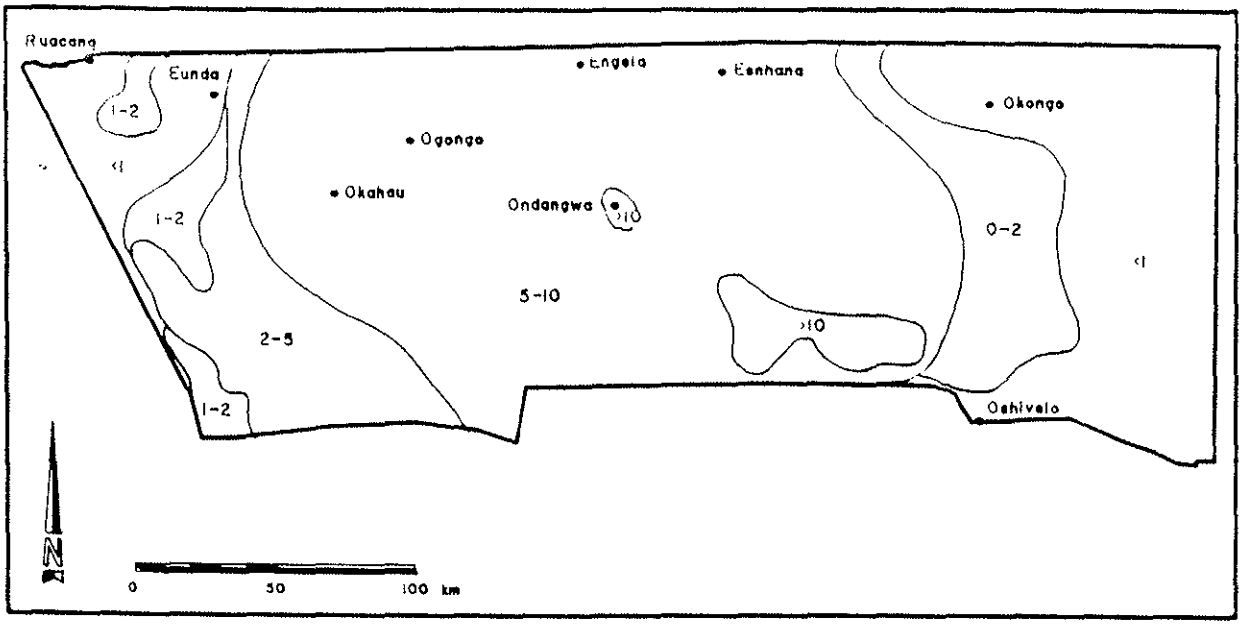
The quality of the groundwater in Owambo is generally very poor with high concentrations of total dissolved solids, especially in central Owambo. Refer to **MAP 3.2** for the distribution of the concentrations total dissolved solids in the groundwater in Owambo.



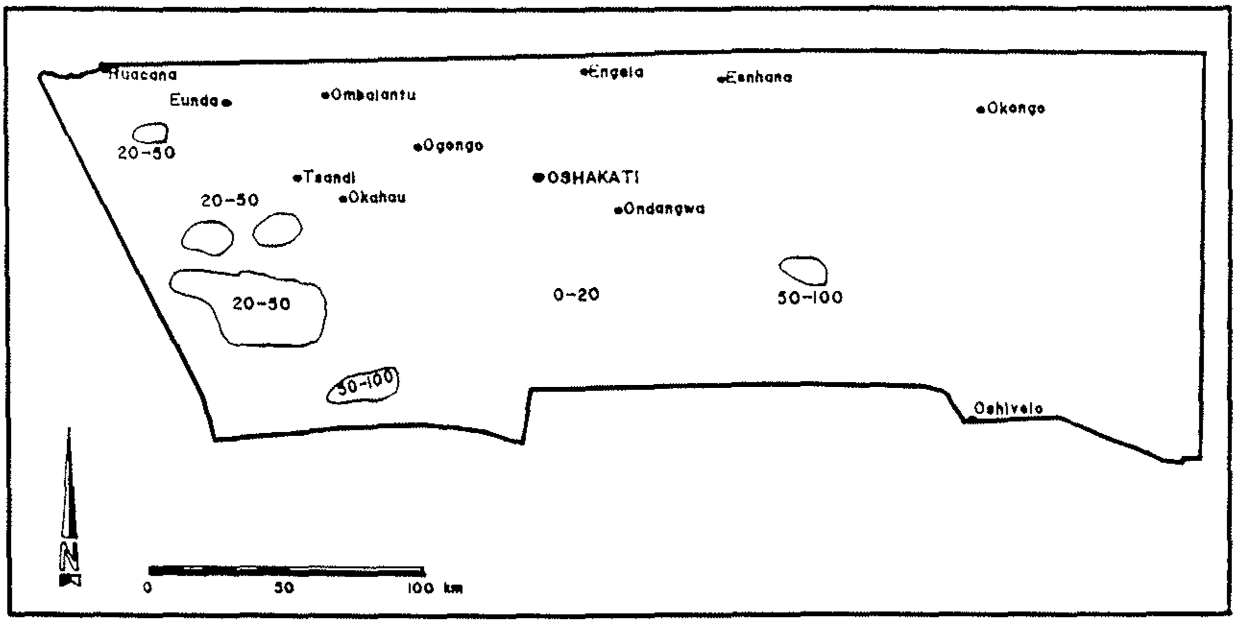
MAP 3.2 : DISTRIBUTION OF TOTAL DISSOLVED SOLIDS CONCENTRATIONS

MAPS 3.3 and **3.4** on page 47 and **MAP 3.5** on page 48 respectively shows the distribution of the concentrations of fluorides, nitrates and sulphates in the groundwater in Owambo. **MAP 3.6** on page 48 shows the distribution of water quality groups, according to the NDWQG.

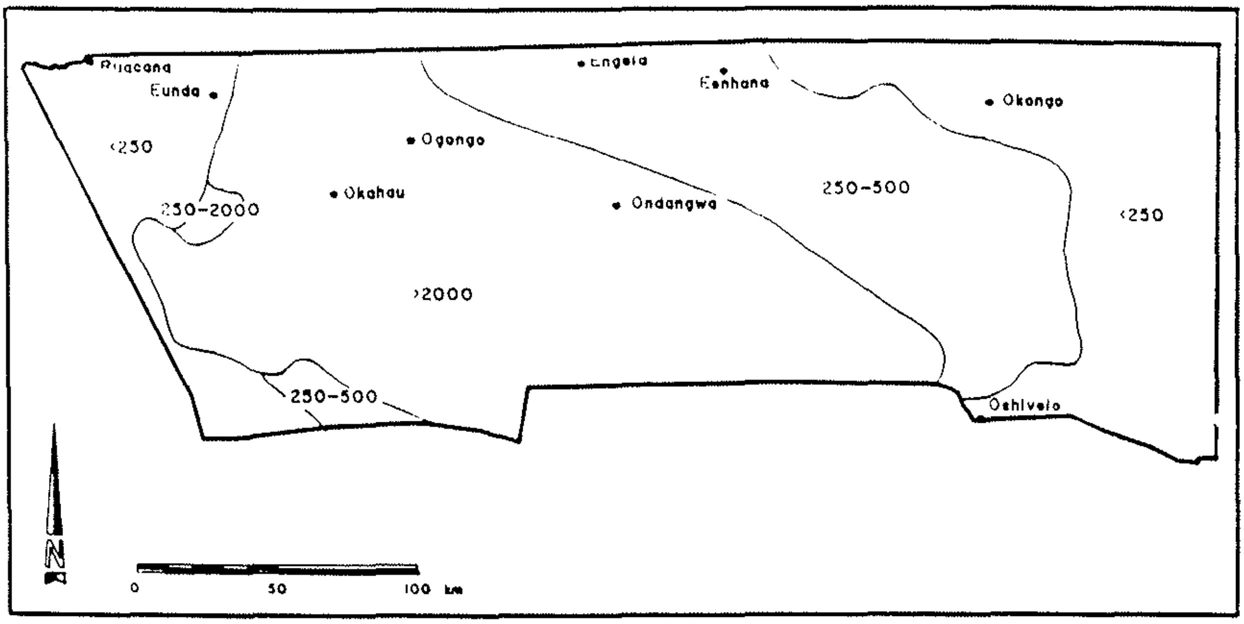
The microbiological guidelines for drinking Water in Namibia area also based on those of the WHO, but groundwater usually only needs disinfection before consumption. However, water from a large number of open wells also need purification due to contamination from humans and animals having direct access to the water.



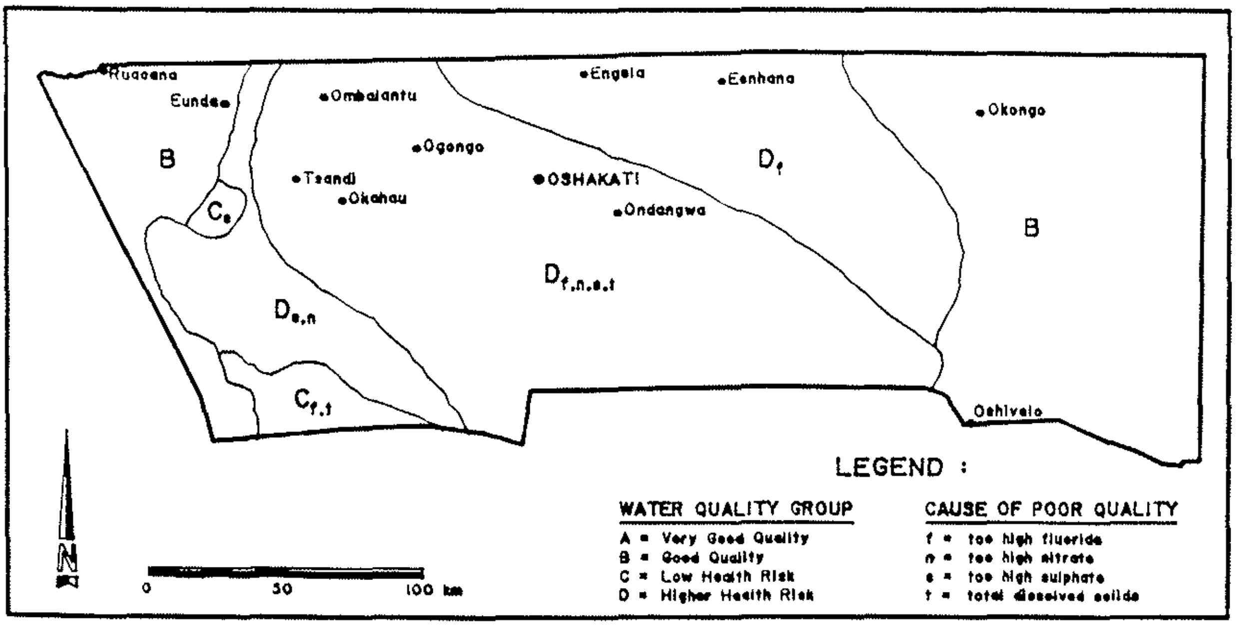
MAP 3.3 : DISTRIBUTION OF FLUORIDE CONCENTRATIONS



MAP 3.4 : DISTRIBUTION OF NITRATE CONCENTRATIONS



MAP 3.5 : DISTRIBUTION OF SULPHATE CONCENTRATIONS



MAP 3.6 : DISTRIBUTION OF WATER QUALITY GROUPS

3.5 CONCLUSION

From the discussion on the available water sources it can be seen that the perennial water of the Cunene will in future be the basis for sustained development in Owambo. However, the importance of local ephemeral surface water, as well as the development of wells and boreholes to supply in the rural water demand, cannot be neglected.
It is therefore important that the existing Agreements on the Cunene River Development be ratified by the Governments of Angola and Namibia. The repair of damaged infrastructure should receive immediate attention to ensure a continued supply of water to Owambo. Further feasibility studies on the augmentation and extension of the bulk regional water supply system as well as the development of the proposed Epupa hydro-electric power scheme should also be undertaken.

The possibility to repair excavation dams for stock drinking purposes should be attended to. It is also suggested that wells tapping the perched aquifer in the central area should be improved by utilizing better technology.

The provision of additional boreholes for new settlements and stock drinking facilities in eastern, southern and western Owambo is also required to accommodate development in areas with stock farming potential, but the co-operation and support of the local population should always be secured to ensure the success of the rural water supply network.

The investigations into the groundwater potential in the Artesian Area may lead to more bulk water supply options and should be continued.

4. SOCIO-ECONOMIC DEVELOPMENT

4.1 GENERAL

The water requirements in a region are determined by various socio-economic factors like the size of the population, settlement trends, social structure, land tenure, infrastructural development and the strength of the regional economy as far as trade, industry, mining and agriculture is concerned. Another important aspect is the degree of success of

Government policies which could direct or support socio-economic activities. These factors will therefore be considered briefly.

Numerous reports in which development plans for Owambo are put forward, have been prepared since 1963 **(References 1, 2, 3, 15, 17, 18 & 19)**. Although these plans led to considerable development, many recommendations remain to be implemented, depending on their feasibility and whether if they are still applicable. However, it is reasonable to assume that the new Government of Namibia will most probably have its own views on a future development strategy for Owambo and previous priorities could therefore be adjusted accordingly.

In the absence of new guidelines, it was considered appropriate to examine the present socio-economic situation and to base projections on future development on those proposals which could be justified within the framework of the new political dispensation in Namibia.

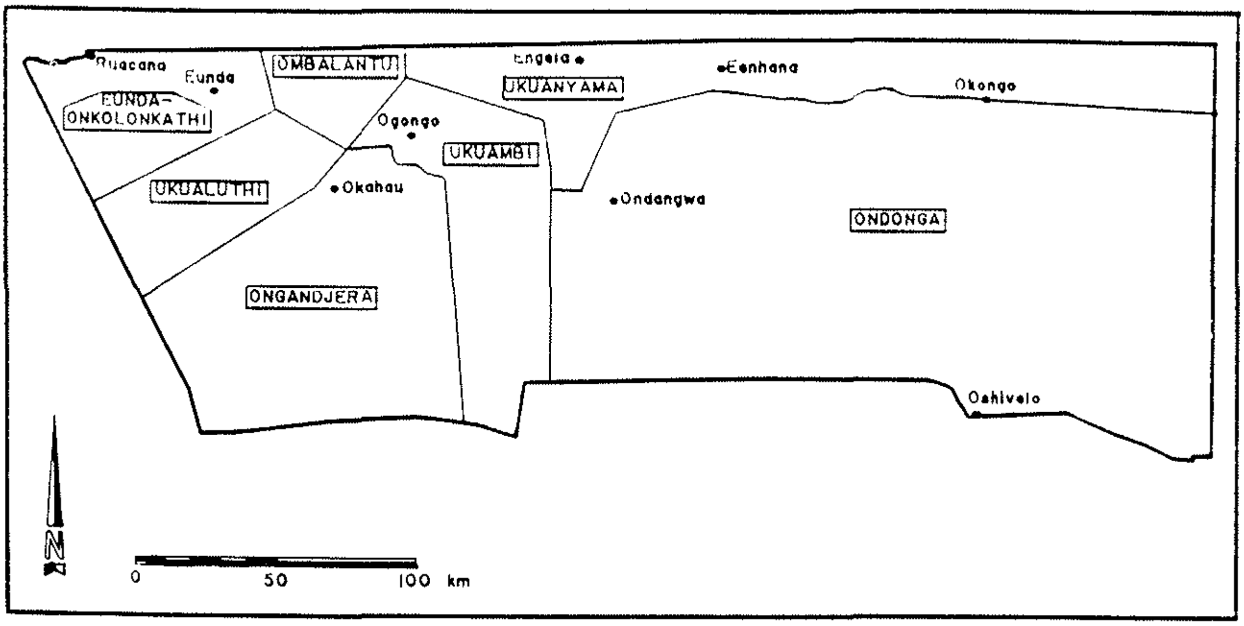
4.2 HISTORICAL BACKGROUND

The forebears of the present Wambo people were the Ajamba who migrated from the great lakes of Eastern Africa in the sixteenth century and eventually settled in an area between the Kavango River, the Etosha Pan and the Cunene River **(References 20, 21 & 22)**.

According to folklore the Wambo migrated in a south-westerly direction until they reached the Okavango River. They crossed the river and followed a branch of a "big river" that flowed south into the Etosha Pan. On the way they encountered a number of small pans and settled at one called Oshimolo. The new settlers lived mainly from fishing and crop cultivation as well as some cattle farming, but after a quarrel over fishing rights, groups of people started to break away, each under its own leader. All of these groups settled on the plains to the north of Etosha and thirteen different tribes were formed, each with its own territory and dialect. The establishment of the international border between Angola and Namibia separated the Wambo into eight tribes in northern Namibia and three tribes in southern Angola.

MAP 4.1. on page 52 shows the names of the Wambo tribes and the tribal boundaries.

can be seen on The Kwanyama tribe is bisected by the border while the Eunda and Nkolonkathi share the same tribal area.



MAP 4.1 : WAMBO TRIBAL AREAS

The first recorded contact between the Wambo and Europeans occurred in 1851. From April 1884 tot July 1915 Namibia was administered as a Protectorate of the German Empire, but Owambo was not placed under direct administration and remained politically independent in practice. Very little development took place in Owambo prior to and during this administration, except for the establishment of a number of mission stations since 1870. Commissioners with limited judicial and administrative functions were appointed for Owambo after the Military Administration took over in 1915. After the Union of South Africa was appointed the Mandatory of the Territory of South West Africa in December 1920, the Military Administration was replaced in 1924 by the South West Africa Administration who made the first definitive attempts to develop the infrastructure and to improve conditions in Owambo.

In 1964 recommendations by the Commission of Enquiry into South West African Affairs (The Odendaal Report) led to the administration and development of Owambo as a so-called "Homeland" with a separate regional authority responsible for "own" affairs like health care, education, agriculture and rural water supply (**Reference 16**). This was achieved in October 1968 when Owambo became a self-governing territory with its own Legislative Council.

Due to the international implications and the technical nature of the bulk water supply situation in Owambo, regional and urban water supply became the responsibility of the central government Department of Water Affairs. The status of the Owambo Regional Authority has changed with independence, but since 1968 it has attended to the development of the region through development plans and strategies which, seen in retrospect, may not have been as successful as was anticipated. This situation stands to be rectified and could have a significant impact upon the future water demand in Owambo.

4.3 SOCIO-POLITICAL STRUCTURE AND LAND TENURE

4.3.1 Social Structure

The traditional social structure of the Wambo is based on the concept of matrilineal descent. Kinship is determined through the mother and consequently children are affiliated to the lineage and clan of the mother only (**References 21 & 23**).

The most important matrilineal kinship groups are the clan and the lineage. A tribe has a number of clans and the people in a clan observe the rule of clan exogamy and does not intermarry. They also demonstrate their kinship by using classificatory kinship terminology like "sister", "father" and "grandmother", depicting persons at certain generation levels.

The clan function of property control is performed within the lineage. A man's possessions are transmitted to the eldest son of his eldest sister when he dies, but never to his own children because they belong to the clan of the mother. This ensures that wealth remains within the clan. A man can, during his lifetime, donate his cattle to his own children, provided that they are not lineage cattle. A woman possesses rights over the produce of her lands, and on her death, her personal belongings pass to her daughters.

In any matrilineal society, persons of authority are men who stand in a matrilineal relationship to their kinsmen. It is therefore the mother's brother who occupies the most important position in relation to her children. The sons are heirs-to-be of their maternal uncle, they accept his authority and reside with him after getting married. However, in Owambo a young man does not stay with his relatives after marriage any more, but establishes his own household at a new locality. As a result of this, members of matrilineage are geographically dispersed and kinship bonds are weakened.

4.3.2 Tribal Organization

The tribal organization is headed by a hereditary chief who is succeeded matrilineally within the ruling family. His heir is the next ranking brother or eldest sister's eldest son, but not his own children because they are members of a different matriclan.

In the tribal administration the chief is assisted by a council of headmen. A senior headman is in charge of a district and sub-headmen are appointed over a ward in a tribal area. This decentralization of political authority to the wider community coincides with the breach of contact between persons of authority and their matrilineal heirs, caused by the changing rule of residence mentioned earlier. From this it is clear that the matrilineal nature of the Wambo society is gradually breaking down under the influence of factors like land pressure, relocation, education, religion and new concepts in public administration.

4.3.3 Land Tenure

The ownership of land is vested in the chief or headman who grants life interests of a usufructuary nature to individual members of the tribe in respect of specific pieces of land for agricultural purposes. The tribal area is divided into districts which are allocated to senior headmen. The assignment of land carries lifelong rights of utilization by the senior headmen, but not personal ownership. After his death, the land reverts back to the chief or an elected headman, who is free to decide on its re-allocation.

Districts are divided into wards which are sold to sub-headmen, but a sub-headman is not permitted to buy more than one ward. After his death, the land reverts back to the senior headman.

A ward is subdivided into village sites, each with its own piece of arable land and sold to village-heads, but the village reverts back to the sub-headman if the village-head dies. The heir of the deceased may buy the village back, but the price of sites remain the same, regardless of the length of time they were actually occupied or any improvements made.

With these restrictions on land holding and the fact that land never becomes the private property of tribal functionaries and their families, the Wambo does not practise a feudal system of land ownership. Private ownership of land is non-existent and land is communally owned. Non-arable land is reserved for grazing on a communal basis. Similarly, anyone is allowed to use the produce of the bush, but cutting of fruit-bearing trees is prohibited since they are considered communal property.

4.4 INFRASTRUCTURE

4.4.1 General

The infrastructure in the central area is reasonably well-developed in contrast to the poor infrastructure in the outlying rural areas. The most important towns, growth points and villages, roads and airfields, as discussed in the following paragraphs, are indicated on **ANNEXURE 1. ANNEXURE 3** shows the bulk water supply infrastructure in greater detail.

4.4.2 Water Supply Network

The strategic importance of the bulk water supply network can easily be seen in the way it is directed from the perennial Cunene River to the areas with high population concentrations. The existing bulk water supply network consists of a system of concrete and earth canals, pipelines of different materials, capacities and diameters as well as a number of pumpstations, pumped storage dams and purification works. These will be discussed in detail in **Chapter 5.**

Rural water supply is at present the responsibility of the regional authority and certain aspects concerning the improvement of these facilities will also be discussed.

4.4.3 Roads

The backbone of the Owambo road system is the tarred trunk road (Route B1) between Oshivelo and Oshikango and the tarred main road (Route C46) between Ondangwa and Ruacana. There is 400 km of tarred roads and 1300 km of gravel district roads which link the larger centres inside and outside Owambo with each other.

4.4.4 Airfields

Besides the airports with paved runways at Nkongo, Ondangwa, Oshakati, Oshivelo and Ruacana there are landing strips with gravel runways at Ogongo, Okankolo, Ombalantu and Eenhana. This facilitates communication and emergency services between the different centres.

4.4.5 Electricity

The towns which are supplied with power by the South West Africa Water and Electricity Corporation (SWAWEK) are Oshivelo, Ondangwa, Oshakati and Ruacana. There are plans to extend a 33 kV power line between Oshakati and Ogongo. Other major centres like Mahanene, Ombalantu, Ogongo, Okahau, Engela, Oshigambo and Ongha have their own diesel powered generators for electricity supply. There is a 330 Kv powerline from Ruacana to the rest of the country, a 66 kV line between Ruacana and the Calueque Dam, as well as a 132 kV line between Tsumeb and Okatopi and from there a 66 kV line to Oshakati, but only 66 kV is supplied through the line. As central Owambo is so densely populated a regional, rural electricity supply network may be viable and should be investigated.

4.4.6 Communication Services

Owambo has two major post offices located at Ondangwa and Oshakati as well as five minor post offices at Ruacana, Ombalantu, Tsandi, Okahau and Oshikango. Postal agencies provide services at Ekwafo, Oyovu, Onandjaba, Omungwelume and Ukwambi. There is also one mobile post office.

Manual telephone exchanges which provide communication links between centres in Owambo, the rest of the country and internationally, exist at Ruacana, Tsandi, Olifa, Okahau, Ombalantu, Oshakati, Ondangwa and Oshikango.

There is an FM radio and television station at Oshakati which provides a radio service to the whole of Owambo and a television service in a radius of 60 km around Oshakati.

4.4.7 Urban Development

Development of urban centres like towns, growth points, villages and small community settlements resulted from the concentration of the rural population around places where amenities such as churches, hospitals, clinics, schools, post offices and businesses were established. Rapid urbanization is a well-known characteristic of a developing country.

As far as water supply is concerned the Department of Water Affairs divides settlements into four groups. These are a

1. **Community**
2. **Village**
3. **Growth Point**
4. **Town**

A community consists of a number of families at a small settlement like a kraal. A village is a small community which has at least some form of state provided amenity like a school, a clinic, or a water supply scheme. A growth point is a properly planned village. A town is a growth point that has grown to such an extent that some form of local authority like a management board or municipality is required.

In order to cope with the growing urbanization of the population, several tribal centres and larger settlements were planned as towns, growth points and villages to serve as future service centres. The most likely places to develop further are shown in **TABLE 4.1**. The pre-independence administration in Owambo provided the information on the existing situation as far as population and status of the places are concerned.

TABLE 4.1 : MAJOR CENTRES IN OWAMBO

PLACE OR AREA	ESTIMATED POPULATION IN 1990	STATUS	
		PRESENT DEFINITION	FUTURE DEVELOPMENT
Oshakati-Ongwediva	65 000	Major urban area	Town
Ondangwa-Oluno	15 000	Tribal urban centre	Town
Oniipa	7 000	Settlement	Town
Omafo-Engela	4 000	Settlement	Growth Point
Ohangwena	3 500	Tribal Centre	Growth Point
Ruacana	3 500	Settlement	Village
Anumulenge	3 000	Settlement	Village
Nkongo (Okongo)	3 000	Settlement	Growth Point
Oshigambo	3 000	Settlement	Growth Point
Eenhana	3 000	Settlement	Town
Okahau (Ongandjera)	3 000	Tribal centre	Town
Ombalantu	2 000	Tribal centre	Growth Point
Ongha	2 000	Settlement	Town
Oshikuku	2 000	Settlement	Growth Point
Elim	1 500	Tribal centre	Village
Okalongo	1 500	Settlement	Village
Omungwelume	1 500	Settlement	Village
Onayena	1 500	Settlement	Town
Tsandi	1 500	Tribal centre	Village
Okankolo	1 500	Settlement	Growth Point
Onesi	1 000	Tribal centre	Village
Onaanda	1 000	Settlement	Village
Oshivelo	1 000	Settlement	Village
TOTAL	**131 000**		

A significant phenomenon associated with rapid urbanization is the inability to provide enough properly planned housing facilities. The consequence is the disorderly erection of shanties by squatters. During the past decade little planned development took place to accommodate squatters, since the emphasis has shifted from housing projects to the provision of organized stands and basic services. The random erection of shanty houses resulted in extremely densely populated areas with little service infrastructure. Measures to relieve the disorderly and unhygienic conditions in squatter communities are presently being undertaken. This involves the limitation of the number of dwellings to not more than 80/ha, the supply of at least one watering point per 20 dwellings, a pit latrine for every four dwellings as well as the upgrading of streets to minimum standards.

4.4.8 Sewage

The towns which have a limited water borne sewage system and oxidation dams are Okahau (Ongandjera), Oshikuku, Onayena, Nkongo, Ogongo, Tsandi, Ombalantu and Ohangwena. Ruacana, Oshakati, Ongwediva and Ondangwa all have larger sewage systems. While provision for sanitation has been made for the various squatter communities, the development of more small sanitation systems would also need to be investigated in future to prevent pollution and health risks.

4.4.9 Schools

Owambo has a three level school system, namely Primary Schools with sub-standard A, sub-standard B and standard 1, Junior Secondary Schools with standards 2 to 5 and Senior Secondary Schools with standards 6 to 10. There are 404 schools, 2 training colleges, 2 technical schools, a night school and a hospital school in Owambo. TABLE 4.2 shows the steady increase in the number of schools and pupils over the past 15 years.

TABLE 4.2: NUMBER OF SCHOOLS, PUPILS AND AVERAGE SCHOOL SIZE

YEAR	NUMBER OF SCHOOLS	NUMBER OF PUPILS	AVERAGE NUMBER OF PUPILS PER SCHOOL
1972	254	64 072	252
1976	338	84 781	251
1981	539	112 804	257
1983	492	144 339	293
1984	513	158 339	309
1987	511	189 492	371

The Directorate of Education of the Administration in Owambo is working towards a system where the average school size will be 750 pupils. To attain this, some of the smaller schools may have to be consolidated and others will have to be enlarged.

4.4.10 Hospitals and Clinics

There are a total of 12 hospitals and 65 clinics in Owambo. **TABLE 4.3** shows the hospitals and clinics with overnight facilities.

TABLE 4.3: HOSPITALS AND CLINICS WITH BEDS

HOSPITALS	RESPONSIBLE AUTHORITY	NUMBER OF BEDS
Oshakati	Administration for Owambos	800
Onakayale	Administration for Owambos	106
Tsandi	Administration for Owambos	60
Okahau	Administration for Owambos	60
Ombalantu	Administration for Owambos	90
Onandjokwe	Lutheran Mission	450
Engela	Lutheran Mission	202
Eenhana	Lutheran Mission	93
Okongo	Lutheran Mission	38
Elim	Lutheran Mission	30
Okatana	Roman Catholic Church	53
Oskikuku	Roman Catholic Church	350
SUBTOTAL		**2 372**
CLINICS	**RESPONSIBILITY AUTHORITY**	**NUMBER OF BEDS**
Endola	Administration for Owambos	4
Eunda	Administration for Owambos	4
Ohangwena	Administration for Owambos	4
Okalongo	Administration for Owambos	4
Omungwelume	Administration for Owambos	4
Onaanda	Administration for Owambos	4
Onayena	Administration for Owambos	4
Oshigambo	Administration for Owambos	4
	Administration for Owambos	4
	Administration for Owambos	4
	Administration for Owambos	4
SUBTOTAL		**32**
GRAND TOTAL		**2 404**

4.5 POPULATION

4.5.1 General

According to the 1970 and 1981 census figures (**References 24 & 25**) the Wambo population in Namibia grew from 352 600 people in 1970 at an average rate of 3,34%/a to an estimated 506 100 in 1981. Considering that the total number of people resident in Namibia in 1981 was 1 033 200, it is clear that the Wambo people represents about 50% of the total population of the country. All the estimated population figures used in this report will have to be confirmed by a proper population census, but will be accepted for planning purposes.

4.5.2 Population Statistics

TABLES 4.4 and **4.5** show the numbers and growth rates for the Wambos resident inside and outside Owambo, as well as the other people living in Owambo.

TABLE 4.4: WAMBO POPULATION GROWTH

RESIDENCY	POPULATION		AVERAGE GROWTH (%/a)
	1970	1981	
Wambo in Owambo	300 000	446 850	3,69
Wambo outside Owambo	52 000	59 250	1,09
TOTAL WAMBO POPULATION	352 000	506 100	3,34

TABLE 4.5 : POPULATION GROWTH IN OWAMBO

GROUP	POPULATION		AVERAGE GROWTH (%/a)
	1970	1981	
Wambo in Owambo	300 000	446 850	3,69
Other people in Owambo	5 500	5 150	-0,57
TOTAL WAMBO POPULATION	305 500	452 000	3,63

From the figures in **TABLES 4.4** and **4.5** it can be seen that the population growth of the Wambo people is typical of a developing country like Namibia. Between 1970 and 1981 the average growth of the Wambo in Owambo was relatively high at 3,69%/a. The average growth in the total Wambo population in the country during the same period was 3,63%/a, while the average growth rate for the total population in Owambo was 3,2%/a. Also of importance is the relatively small number of other people in Owambo and the fact that their numbers decreased between 1970 and 1981. About 11,7% of the Wambo people resided outside Owambo and the fact that most of the women stayed behind in Owambo is reflected in **TABLE 4.4** by the much lower rate of increase of 1,09%/a in the Wambo population outside Owambo.

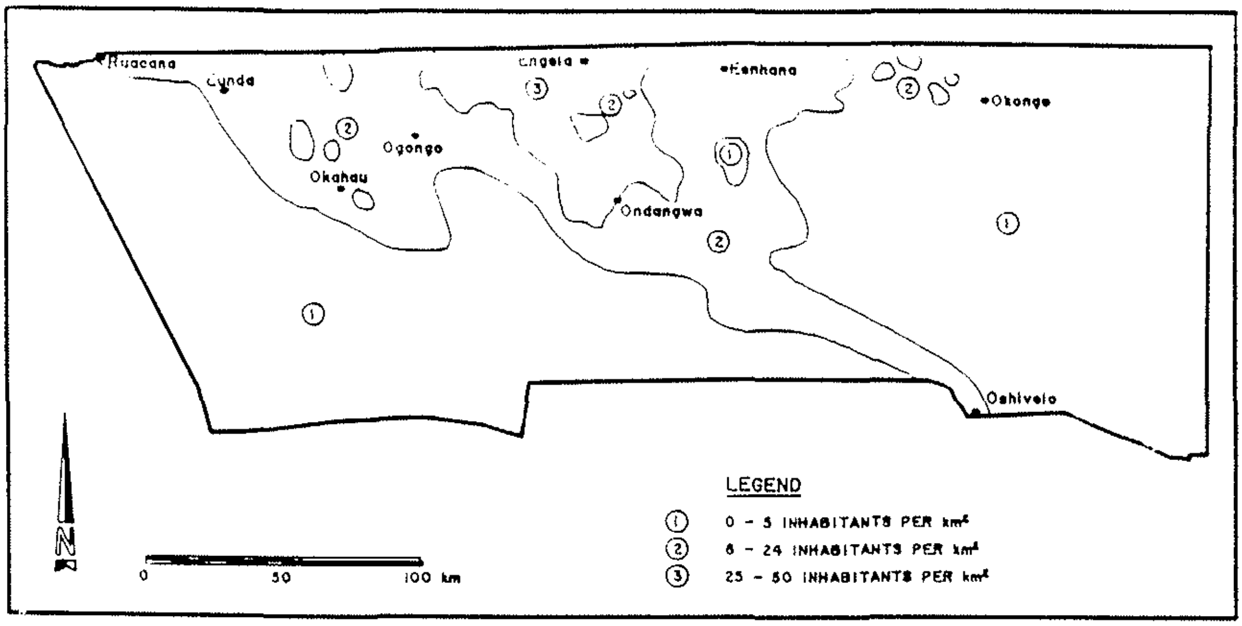
An abbreviated representation of the age distribution and activities of the Wambo in Owambo, according to the 1981 census, is shown in **TABLE 4.6.**

TABLE 4.6: AGE DISTRIBUTION IN 1981

AGE GROUP	SEX		TOTAL	% OF TOTAL
	MALE	FEMALE		
1 - 19	125 740	128 920	254 660	57,0
20 - 59	62 300	90 760	153 060	34,2
60 +	19 010	20 120	39 130	8,8
TOTAL	207 050	239 800	446 850	100,0

The information in **TABLE 4.6** confirms the effects of the rapid increase in Wambo population. About 57% of the people are less than 19 years of age and of school going age. Only about 34% of the population is in the working group between the ages of 20 and 59. The difference between the number of males and females in that age group in Owambo is a significant indication that many men work outside Owambo, usually in the industrial, mining or agricultural sectors elsewhere in Namibia. The people in the older than 60 years age group is relatively small in number and represent the retired people who are dependent on their families or the State for health care and social support.

Although not shown in **TABLE 4.6** the 1981 census figures indicate that about 19% of the total Wambo population in Owambo are of childbearing age, i.e. between 15 and 40 years of age. The birth rate is 22,5 per 1 000 people and 2,25% of the population is younger than 1 year of age. More than 44% or 198 000 people are younger than 15 years of age.



MAP 4.2 : POPULATION DENSITY

In Owambo two types of population migration can be distinguished. Firstly, there is the rural population migrating to the urban areas in Owambo and secondly there is the people migrating from Owambo to the rest of the country. **(Reference 26).**

Little is known about urbanization trends in Owambo, but urbanization is a global phenomenon which seems to be very rapid in developing countries like Namibia.

However, from the 1981 census it is known that the average growth rate of the population in the towns outside Owambo was about 4,5%/a and if the average rate of increase of 3%/a in the population in Namibia between 1970 and 1981 is considered, then it can be argued that the expected rate of urbanization had been at least 1,5%/a in those towns. This average must be used with caution because specific development at a certain place may attract more people and stimulate urbanization. This can be illustrated by the results of a socio-economic survey **(Reference 27)** carried out in 1985 in the Oshakati-Ongwediva-Ondangwa-Olunu area. It was found that the average increase in the population in these urban areas was 20%/a between 1975 and 1985. This very high rate of urbanization is an indication that special conditions like the availability of schools, hospitals, housing, shops, jobs and better infrastructure facilities like water, electricity and roads could have attracted people from the outlying rural areas. The security situation also had an effect, but is something of the past, except for people moving from the war torn southern parts of Angola into Namibia.

Recently, especially after the Ondangwa-Oshivelo pipeline and main tarred road were completed, people started to settle in the less densely populated areas along this new south-eastern infrastructure axis between the major centres at Ondangwa and Tsumeb. Added attractions were the availability of relatively good grazing and land to build new settlements. In the past, this area could only be utilized during the rainy season when open water was available in pans. Since then the availability of water which is transported with vehicles over long distances from the pipeline, has led to more permanent settlement. This serves as a further example of how development of infrastructure can affect settlement trends and may indicate that similar conditions can be created when the south-western and central-eastern areas are developed.

In order to determine population migration trends it will be assumed in this report that the rate of urbanization as a result of people emigrating from Owambo to other areas in Namibia, was at least 1,5%/a between 1981 and 1990. This means that the Wambo population residing outside Owambo in 1990 is estimated at at least 13,4% of the total Wambo population. These figures will be used further in this report.

4.5.4 Estimated Present Wambo Population

In the absence of any recent census statistics it is very difficult to estimate the population growth in Owambo since 1981. The change in the political situation and the fact that influx control was abolished in 1981, may have had a significant impact on the migration of people from Owambo to the rest of the country. However, the available parameters will be discussed and used to project the 1981 population figures for the total Wambo population. When the future water demand in Owambo is estimated, aspects like settlement trends and population distribution will be taken into account.

The Population Division of the United Nations estimates that the population growth rate in

Africa will decrease from 4,7%/a in 1975 to 2,5%/a in 2025 due to better education, land pressure, urbanization, a higher standard of living and family planning. These figures indicate an average decrease of 0,044%/a in the population growth rate during the 50 years between 1975 and 2025. If this prediction is applied to the Wambo population the growth rate would reduce from 3,34%/a in 1981 to 2,5%/a in 2025, representing an average decrease of 0,02%/a in the 44 year period under consideration.

In order to determine the present size of the Wambo population in Namibia the average growth rate of 3,34%/a between 1970 and 1981 is decreased with 0,02%/a until 1990. According to these assumptions the present Wambo population in Namibia is estimated to increase from 506 100 in 1981 to 675 000 people in 1990. According to this estimate the average growth rate over the past 9 years was 3,25%/a.

The Statistics Division of the former Department of Economic Affairs is of the opinion that the high population growth rate in Namibia will remain at not less than 3%/a in the long term, which leads to an estimate of 660 300 people in 1990. This conservative figure will not be used for further calculations since it is unacceptable to assume that the population growth would suddenly have decreased from 3,34%/a in 1981 to 3%/a between 1981 and 1990.

According to the estimation **Section 4.5.3**, 13,4% of the Wambo population will reside outside Owambo in 1990. This means that 90 500 Wambo live outside Owambo and 584 500 Wambo in Owambo. As far as the "other" people in Owambo are concerned, it will be assumed that they increased at about 2,6 %/a from 5 150 in 1981 to 6 500 in 1990.

In **TABLE 4.1** on page 58 it is shown that the estimated number of Wambo and other people living in the major urbanized centres amount to about 131 000. This means that 22% of the people in Owambo are urbanized and that at least 460 000 people live in the rural environment. Refer to **TABLE 4.8** and **4.9** on page 67 for a summary of the results according to the above assumptions.

TABLE 4.8 : ESTIMATED WAMBO POPULATION IN NAMIBIA

YEAR	WAMBO POPULATION		
	IN WAMBO	OUTSIDE OWAMBO	TOTAL
1981 1990	446 850 584 500	59 250 90 500	506 100 675 000

TABLE 4.9 : ESTIMATED POPULATION DISTRIBUTION IN OWAMBO

YEAR	POPULATION IN OWAMBO				
	URBANIZED			RURAL	TOTAL
	WAMBO	OTHER	TOTAL	WAMBO	
1981 1990	20 250 124 500	5 150 6 500	25 400 131 000	426 600 460 000	452 000 591 000

From the estimated figures in **TABLES 4.8** and **4.9** it can be calculated that between 1981 and 1990:

1. The total Wambo population increased at an average of 3,25 %/a from 506 100 to 675 000.
2. The Wambo in Owambo increased at an average of only 3 %/a from 446 850 to 584 500 due to emigration from Owambo.
3. The total population in Owambo increased at an average of 3 %/a from 452 000 to 591 000.
4. Urbanization in Owambo proceeded at an average of 20 %/a from 25 400 to 131 000.
5. The Wambo outside Owambo increased at an average of 4,8 %/a from 59 250 to 90 500 due to the effect of emigration from Owambo.
6. The "other" people in Owambo increased at an average of 2,6 %/a from 5 150 to 6 500.
7. The urbanized people in Owambo represents 22% of the total population in Owambo.
8. The Wambo residing outside Owambo is 13,4% of the total Wambo population.

4.5.5 Estimated Future Population in Owambo

A planning horizon of 30 years from 1990 to 2020 is considered to estimate the future population in Owambo. The following assumptions are used:

1. The average growth rate of the total Wambo population will decrease by 0,02 %/a from 3,25 %/a in 1990 to about 2,5 %/a in 2020.
2. The "other" people in Owambo will increase at 2,6 %/a from 1990 to 2020.
3. The percentage of the total Wambo population which will live outside Owambo, will increase from 13,4% of the total Wambo population in 1990 by 1,5 %/a to about 21% of the total Wambo population in 2020.
4. The urbanized people in Owambo will increase by 3 %/a from 22% of the total population in Owambo in 1990 to about 53% of the total population in Owambo in 2020. It is expected that the rural population in Owambo would rather urbanize in Owambo than outside the region and therefore the estimated rate of urbanization is taken at double the expected rate for people urbanizing outside Owambo.

Refer to **TABLE 4.10** as well as **TABLE 4.11** and **FIGURE 4.1** on page 69 for the results of the estimates according to the above-mentioned assumptions.

TABLE 4.10 : ESTIMATED FUTURE WAMBO POPULATION IN NAMIBIA

YEAR	WAMBO POPULATION		
	IN OWAMBO	OUTSIDE OWAMBO	TOTAL
1990	584 500	90 500	675 000
1995	675 300	113 900	789 200
2000	774 700	142 600	917 300
2005	881 800	177 500	1 059 300
2010	996 600	219 500	1 216 100
2015	1 117 900	269 800	1 387 700
2020	1 244 200	329 700	1 573 900

TABLE 4.11 : ESTIMATED FUTURE POPULATION DISTRIBUTION IN OWAMBO

YEAR	POPULATION IN OWAMBO				
	URBANIZED			RURAL	TOTAL
	WAMBO	OTHER	TOTAL	WAMBO	
1990	124 500	6 500	131 000	460 000	591 000
1995	166 700	7 400	174 100	508 600	682 700
2000	223 100	8 400	231 500	551 600	783 100
2005	296 000	9 500	305 500	585 800	891 300
2010	389 500	10 800	400 300	607 100	1 007 400
2015	508 300	12 300	520 600	609 600	1 130 200
2020	657 800	14 100	671 900	586 400	1 258 300

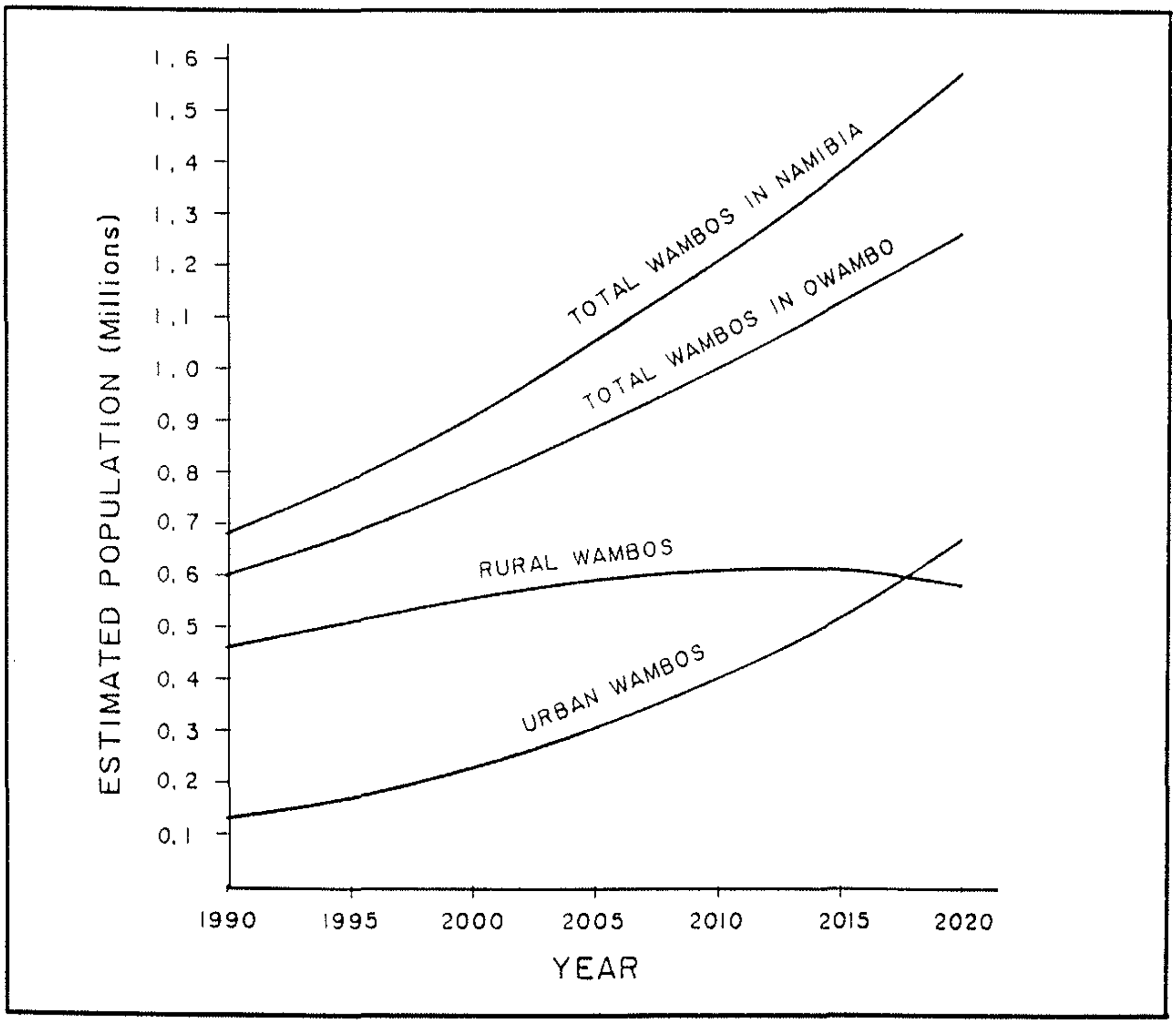


FIGURE 4.1 : POPULATION GROWTH TRENDS

From TABLE 4.10 and 4.11 it can be calculated that the total Wambo population would increase by an average of 2,9 %/a up to 2020 and that due to emigration the total population in Owambo would only increase at an average of 2,6 %/a until the year 2020. The rural population in Owambo would increase at only 0,8 %/a due to urbanization in and emigration from Owambo. The urbanization trend would be 5,7 %/a in Owambo and the increase in the Wambo population in the rest of Namibia would be 4,4 %/a. The increase of 2,9 %/a in the total Wambo population is marginally more conservative than the long term average population increase of 3 %/a proposed by the Division of Statistics of the former Department of Economic Affairs in Namibia.

4.6 ECONOMIC POTENTIAL

4.6.1 General

The Wambo have always been both pastoralists and crop-farmers which gave them a more settled existence than that of the purely pastoral peoples in other parts of Namibia. The Owambo people traditionally practised a subsistence economy based on crop cultivation and communal stock farming. The women are the tillers while the men keep herds of livestock which also serve as a measure of wealth rather than a means for the creation of wealth. At present the economy in Owambo is founded on agriculture, commerce, trade and manpower export.

4.6.2 Crop Cultivation

Due to tribal organization and the land tenure system, 2 to 5 ha of arable land is allocated to families by their chiefs, while land which is not suitable for dryland crop production is used for communal stock farming. The families only have "temporary" usufruct on their land as was explained in **Section 4.3.3**.

The most significant crop is finger millet (mahango), while pumpkins and beans are planted between the mahango rows. Sorghum, maize, groundnuts and watermelons form secondary crops. The generally very low average mahango crop yield of 0,5 ton per family is due to adverse climatic conditions, insufficient fertilisation and traditional soil cultivation techniques. Fields which have been used for a long time are left fallow and new plots are developed as the need arises, but this practice has declined somewhat in densely populated areas because of the scarcity of available land.

Oranges, papaws, guavas and prickly pears are also grown and the fruits of the maroela, wild fig, mangetti, makalani palm and boabab are also harvested.

Some 400 ha of land in the south-east of Owambo has been developed for commercial dryland mahango cultivation.

During good years Owambo produces enough staple food for local consumption, but when crops fail as a result of drought or severe inundation of the land by the Efundja, food must be imported to the region.

4.6.3 Animal Husbandry

The livestock in Owambo consists mainly of Sanga cattle, goats, donkeys and a smaller number of horses, mules, pigs, sheep and poultry. The average herd size is 7,6 head of cattle and 5,5 goats. A family owns on average 9,5 head of livestock. There is no recent information available on the actual livestock numbers in Owambo, but in **TABLE 4.12** a summary is given of the number of stock in Owambo in the past, **(References 17, 20 & 28)** as well as a 1990 estimate for purposes of this report.

TABLE 4.12 : LIVESTOCK IN OWAMBO

TYPE OF ANIMAL	STOCK SIZE					
	1962	1970	1973	1978	MEAN	1990 ESTIMATE
Cattle	379 000	567 000	451 400	523 500	480 000	500 000
Goats	420 000	338 000	325 200	375 200	365 000	400 000
Pigs	4 000	26 000	20 000	±30 000	20 000	30 000
Donkeys, Mules and Horses	24 900	54 000	57 500	81 300	54 500	100 000
Sheep	4 500	9 000	6 500	5 100	6 300	8 000

Cattle production in Owambo fluctuated considerably between 1962 and 1978. The substantial initial increase was due to better stock disease control, but subsequent overstocking and droughts resulted in severe deterioration of the grazing in Owambo. There was a large increase in the number of pigs which can be utilized for pork production, but the alarming increase in donkeys, mules and horses must be regarded as a severe threat to the grazing capacity of the land and the potential for meat production.

There is large scope for meat production and the marketing of livestock on the hoof. A meat canning factory was established at Oshakati, but cattle diseases such as foot-and-mouth, lungsickness and anthrax must still be eradicated to allow the export of cattle to other areas in Namibia and to export markets.

However, the traditional Wambo has a quantitative rather than qualitative outlook on his livestock and this has resulted not only in deterioration of the grazing capacity, but it seems unlikely that the strongly rooted traditional concepts in stock farming could be changed to attain better grazing management in the medium term.

Thirty years ago the average grazing capacity of the veld was 10 ha/LSU, but it has since been reduced to more than 15 ha/LSU in the densely populated areas. Better grazing is still available in the southern and eastern areas of Owambo, but utilization of this resource should be accompanied by good grazing management.

In order to encourage commercial stock farming and the export of cattle on the hoof, a project to settle potential cattle farmers on 96 farms of 4 800 ha each in the Mangetti Block to the east of Oshivelo has been started. This venture could be extended.

Areas which are virtually uninhabited and still available for stock farming should be used for extensive commercial stock farming. The main reason why these areas have not been utilized is the lack of water, but there is some potential for the development of boreholes with suitable quality water. In certain cases water can also be piped into these areas.

It is clear that the future utilization of the stock farming potential of Owambo will depend on better management, efficient stock disease control and marketing outside Owambo.

Attention must therefore also be given to northward adjustment of the so-called **Red Line** veterinary disease control fence.

4.6.4 Fisheries

Fish forms an important component of the traditional Wambo diet and there is a definite market potential for commercial fisheries **(Reference 19).**

Fish farms can be developed in excavated dams and pumped storage dams, but due to high evaporation some replenishment of the water will be necessary. If perennial water from the Cunene River cannot be supplied to augment the water in fish dams, the production will be severely affected in times of drought when water from the ephemeral surface sources is not readily available.

The potential of fish farming for export purposes is reflected by the success of extensive fish farming in Taiwan where the yield is 4 t/ha/a and the export of eel has exceeded US$ 300 million in 1985. There are various methods of fish farming and at a fish farm in Gazankulu in the Republic of South Africa, where the Chinese method of aquaculture is used, a yield of 6,3 t/ha/a has been achieved **(Reference 29).**

Research facilities to study fish breeding for fish farming have been established at Mahanene and the Rural Development Centre at Ongwediva. It seems as if **tilapia** species have good potential for fish farming, but development cost, management and marketing will play a major role in the success of commercial fish farming practice.

4.6.5 Forestry

The afforestation of potential forestry areas in Owambo has been investigated **(Reference 19 & 30)** and a nursery to grow Eucalypt trees has been established at the Rural Development Centre at Ongwediva. It is intended to establish eucalypt plantations in the Mangetti area and the areas to the south of Eenhana and west of Tsandi.

Economically exploitable hardwood trees occur in north-eastern Owambo over an area of approximately 6 000 km². This resource is currently utilized on contract by private firms, but there is a need to replace the trees and to establish plantations which could supply wood for the building industry and as firewood.

4.6.6 Irrigation

The absence of established large scale irrigation farms in Owambo can be attributed to the lack of inexpensive raw water in sufficient quantities, supplied into the interior of Owambo.

The Wambo farmer is familiar with dryland crop cultivation under difficult climatic conditions, but is unfamiliar with irrigation practices. However, some experience has been gained at the Mahanene experimental farm and the Ogongo Agricultural School. These centres can play an important role in the training of suitable potential irrigation farmers.

Irrigation farming can make a substantial contribution towards food production and job creation, but aspects such as the availability of water, suitable soils, the system of land tenure, training of farmers, extension services, market development, the provision of capital and overall economic viability are of cardinal importance to the feasibility of irrigation projects and should be investigated.

4.6.7 Manpower Resources

In the very densely populated areas traditional subsistence farming cannot support all the people and as a result many men enter the labour market by working on farms and in the industrialized centres elsewhere in Namibia.

It is estimated that at any given point in time at least 60 000 workers from Owambo are employed outside the region, but at least 100 000 labourers offer their services on a rotational basis outside Owambo. About 100 000 people are economically active in both the formal and informal sectors in Owambo.

The Administration in Owambo, other Government Departments, the First National

Development Corporation and local small industries are the major employers in Owambo. The average income of unskilled labourers is between R2 500 and R3 600 per annum while semi-skilled and skilled workers earn between R10 000 and R15 000 per annum. The former Administration in Owambo paid out about R25 million per annum in pensions.

4.6.8 Commerce and Industry

Although the region is the most heavily populated in Namibia, it contributes little to the gross domestic product of the country. However, the capacity of the internal economy of Owambo is difficult to monitor and therefore it is not reflected accurately in the economic indicators. Agriculture is the primary economic activity and the backbone of the local economy. Small factories processing meat and wood as well as service industries like workshops and garages have been established, but labour is also exported to the rest of the country and in that way the Wambo has made a major contribution to the establishment of infrastructure and the operation of mines and industries in the whole country.

The stimulation of a deregulated free market economy in Owambo contributed to substantial development in the informal sector. The demand for food and modern commodities has given rise to the establishment of more than 8 000 cuca shops and trading centres throughout Owambo. The Wambo people have an exceptional degree of trading consciousness and there are in fact very few families who do not offer something for sale.

4.7 DEVELOPMENT POTENTIAL

A development strategy in Owambo must not only meet the needs of the people, but should have a holistic approach. In the rural environment the provision of water, education and training, commercial food production and the establishment of fishing, forestry and irrigation projects are required. In the urban environment better housing,facilities for tertiary training and the creation of job opportunities should be attended to.

Trained manpower, both in the technical and the academic field, and funds for development and maintenance of the existing infrastructure are important factors which are required to sustain economic development. The Government should therefore assist to provide the means to create a climate for economic growth.

The development of new stock farms in the less densely populated areas should take place on a commercial basis, accompanied by extension services, stock disease control and sound marketing. The development of irrigation projects, fisheries and forestry would depend on the availability of water from the Cunene, but may make a very important contribution to the economy.

From **Section 2.4.3** it is clear that little potential exists for the establishment of mines and heavy industries in Owambo. The development of the agricultural sector therefore seems to be the key to economic development in Owambo. The unlocking of this potential will stimulate the tertiary economic sectors, but then the local population must co-operate and participate to improve their quality of life. They should accept an adjustment of traditional land use customs, practice commercial farming, be prepared to receive appropriate training and take the responsibility for the operation and maintenance of their infrastructure.

5. THE EXISTING WATER SUPPLY INFRASTRUCTURE

5.1 GENERAL BACKGROUND

As stated previously in **Chapter 1** and **Section 4.4.2** the responsibility for the establishment, operation and maintenance of the existing water supply infrastructure was previously divided between the central government Department of Water Affairs and the Regional Administration in Owambo.

Due to the international nature of the available perennial water sources for Owambo, as well as the national and regional importance of the region, the Department of Water Affairs was made responsible for the establishment, operation and maintenance of the bulk water supply infrastructure in Owambo. This entailed the importation of water from the Cunene River through the construction of a system of canals and pipelines to supply potable water into the more densely populated central and eastern areas of Owambo. Because the regional authorities in the different regions in Namibia had direct access to the local population, they were in a better position to communicate with and obtain the participation of the local people in providing local water facilities. They also had to generate the means to assist with technical and financial aid in this regard. In this way the Regional Administration in Owambo had the responsibility to reticulate the potable bulk water supplied to them by the central government to the local consumers as well as to ensure the establishment of rural water supplies through the utilization of the ephemeral surface water and groundwater sources by constructing, operating and maintaining excavation dams, wells, cisterns and boreholes to provide potable water to the population.

The discussion in this Chapter will therefore focus separately on the bulk water supply network which is the responsibility of the Department of Water Affairs and the rural water supply infrastructure which was the responsibility of the former Regional Authority in Owambo.

5.2 THE BULK WATER SUPPLY NETWORK

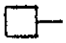
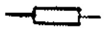
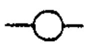
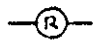
5.2.1 General

The bulk water supply network in Owambo is the single largest water supply system in the country, if not in Africa. It presently consists out of 29 pump stations, 700 km of pipelines, 92 km of canals and 9 purification plants of which the facility at Ogongo is the largest in Namibia. The bulk water supply network can provide more than 40 towns, growth points and villages in the densely populated central area of Owambo with potable water. The basic layout of the existing water supply network is shown in **ANNEXURE 4.**

All the water distributed through the bulk supply system in Owambo is imported from the Cunene River as stated previously. The only places where locally available ephemeral surface water is purified and distributed on a permanent basis by the Department are Nakayale, Elim and Okatana, but local water purification facilities also exist at Oshakati and Ondangwa.

Basic information on the configuration of each component of the network will be discussed according to a schematic diagram and a table with more detailed information which can be related to the total layout provided in **ANNEXURE 4**. Also refer to **TABLE 5.1** for the legend used in all the schematic diagrams.

TABLE 5.1: LEGEND TO FIGURES

SYMBOL	CAPACITY OF COMPONENT AND UNITS	DESCRIPTION
	( ) m^3/s	Canal
	( ) m^3/a	Consumer
	( ) Mm^3	Dam
	( ) m^3	Dam (Excavation)
	( ) m^3	Dam (Pumped storage)
	( ) Mm^3	Dam (Weir)
	( ) m^3/h	Intake Works
	( ) m^3/a	Pipeline
	( ) m^3/h	Pumpstation
	( ) m^3/day	Purification Works
	( ) m^3	Reservoir (Clear water)
	( ) m^3	Reservoir (Elevated)
	( ) m^3	Reservoir (Raw water)

5.2.2 The Cunene River - Olushandja Component

This component comprises three sections. They are the pumpstations and the pipeline between the Cunene River at the Ruacana Falls and Olushandja, the pumpstations and pipeline between the purification works at the Ruacana Falls and Ruacana Town, the Ruacana airport and Olifa, as well as the pumpstation, pipeline and canal from the Calueque Dam to Olushandja. See **FIGURE 5.1** on page 79 for a schematic layout and refer to **TABLE 5.2** on page 79 for more technical data.

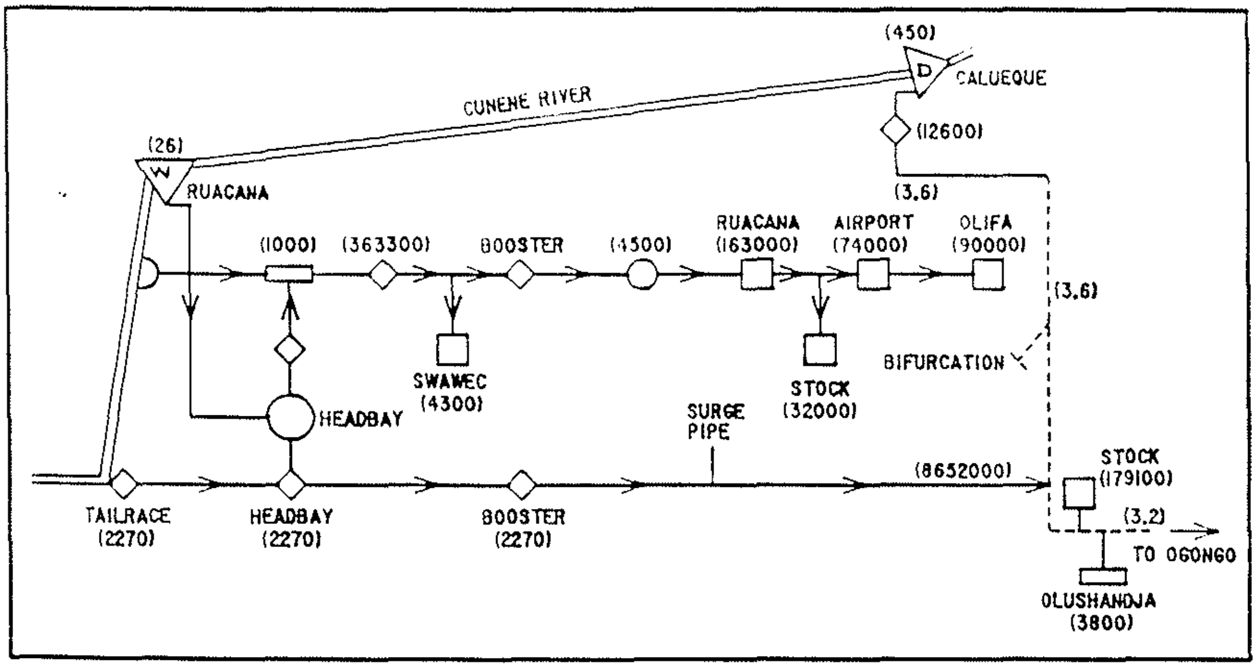


FIGURE 5.1 : CUNENE RIVER - OLUSHANDJA COMPONENT LAYOUT

TABLE 5.2 : CUNENE RIVER - OLUSHANDJA COMPONENT TECHNICAL DETAIL

SECTION	WATER CARRIER					
	TYPE	MATERIAL	LENGTH (m)	DIAMETER (mm)	CLASS	CAPACITY (m^3/h)
Headby to Purification Works, Ruacana and Olifa	Pipe	Steel AS*	1 000 10 000 14 000 25 000	152 152 152	-	50
Headbay to Canal	Pipe	Steel FRC*	8 550 2 136 12 750 16 444 39 880	711 700 700 700	- 6 12 18	2 270 2 270
Calueque Dam to Olushandja Dam	Pipe Canal	Steel Concrete Blocks	2 437 12 000 9 605 21 605	1 658 Trapezoidal	- -	21 600 21 600 11 500

*AS = Asbestos-cement

*FRC = Fibre Re-enforced Cement

The purification works at the Ruacana Falls normally obtains raw water from the headbay to the power station, but it is also possible to draw water from an intake at the water fall. The plant which can supply 1 000 m^3 of purified water per day, utilizes a standard, continuous purification process including flocculation, filtration and disinfection. Some of the purified water is used for domestic purposes at the hydro-electric power station and the rest is pumped through a 152 mm diameter steel pipeline to a 4 500 m^3 terminal reservoir near Ruacana Town from where the water gravitates to Ruacana Town, the airport and Olifa. Stock drinking facilities are also provided along the pipeline between the reservoir and Olifa.

As explained previously in **Section 3.2.3**, raw water can be pumped from the Ruacana Falls or the Calueque Dam into Owambo. Raw water can be drawn directly from the Cunene River at the tailrace of the power station or from the Ruacana Weir via the headbay to the power station. This water can then be pumped at a rate of 0,6 m^3/s through a 711 mm diameter steel pipeline, via a booster pumpstation, onto the escarpment at Ruacana Town from where the water can gravitate through a 700 mm diameter fibre re-enforced cement pipeline into the canal between the Calueque Dam and Olushandja. This trapezoidal concrete lined canal can also be used to convey water at a design rate of 6 m^3/s from a pumpstation at the Calueque Dam through a 2 400 m long, 1 658 mm diameter steel pipeline to the canal. With the existing pump configuration, when installed at Calueque, it is possible to supply water at a rate of 3,5 m^3/s.

During 1989 a total of 9,0153 Mm^3 of water was supplied from the headbay at Ruacana into Owambo while 363 300 m^3 of that water was diverted through the Ruacana purification works to the consumers at Ruacana and environs. The remaining 8,652 Mm^3 was supplied into the Calueque-Olushandja canal.

5.2.3 The Olushandja - Okahau Component

This component comprises a batch process purification works which drawns water from the Calueque-Oslushandja canal, a pumpstation and a pipeline to Okahau. Refer to **FIGURE 5.2** and **TABLE 5.3** on page 82 for a schematic layout and more technical detail respectively.

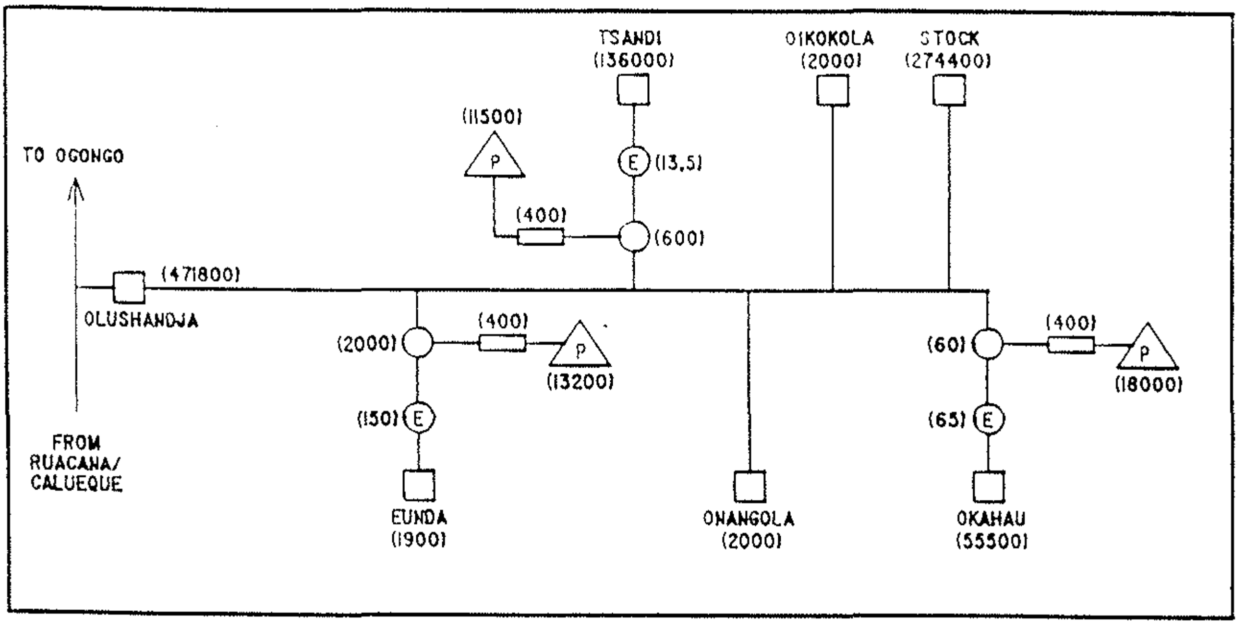


FIGURE 5.2 OLUSHANDJA-OKAHAU COMPONENT LAYOUT

TABLE 5.3: OLUSHANDJA-OKAHAU COMPONENT TECHNICAL DETAIL

SECTION	WATER CARRIER					
	TYPE	MATERIAL	LENGTH (m)	DIAMETER (mm)	CLASS	CAPACITY (m^3/h)
Olushandja to Eunda	Pipe	uPVC*	10 685	250	4	180
Eunda to Tsandi	Pipe	FRC*	9 891 9 588 4 558 14 492 49 169	250 250 250 300	12 12 18 18	135
Tsandi to Okahau	Pipe	FRC	16 108 5 580 1 100 1 100 943 24 831	250 250 250 250 250	12 18 4 30 36	150
To Onangola	Pipe	FRC	1 828	100	13	42
To Oikokola	Pipe	FRC	4 144	100	13	25

*uPVC = Unplasticised Polyvinyl Chloride

*FRC = Fibre Re-enforced Cement

Along the pipeline to Okahau water is also supplied to the settlements at Eunda, Tsandi, Onangola, Oikokola and to stock watering points. There are local water purification plants rated at 400 m^3/day at Tsandi and Okahau but they are not in operation at present. It must also be mentioned that there is an unlined earth canal from the southern embankment of the Olushandja Dam to Okahau.

From **TABLE 5.3** on page 81 it is clear that the type of pipes, pipe diameters and pipe classes are not successive and consistent between Olushandja and Okahau. The reason for this is that the scheme was not built according to the original design specifications, because pipe material which were available at the time of construction, were used. Construction of the first section between Olushandja and Eunda was carried out on an emergency basis when the Olushandja Dam was empty and consist of Class 4 uPVC pipes. Currently the water in the Olushandja-Okahau pipeline is pumped from Olushandja to Okahau, but the section with the lowest pipe class is situated at Olushandja, while the section with the highest pipe class is at Okahau. Water should therefore be pumped in the apposite direction form Okahau to Olushandja and the reason why the original design was done in this way, is because it was envisaged that water would eventually be supplied from the central purification works at Ogongo, via Okahau to Tsandi and Eunda.

5.2.4 The Olushandja-Ogongo Component

This component mainly comprises the canal from the Olushandja purification works, past the Olushandja Dam, Mahanene, Ombalantu and Onakayale to the purification works at Ogongo. The capacity of the canal is 3,2 m^3/s between Olushandja and Onamine 1,9 m^3/s between Onamine and Ombalantu, but at Ombalantu it decreases to 1,5 m^3/s up to Ogongo. Along the canal water is drawn off for stock watering purposes, but there is also an unlined earth canal which collects rainfall runoff, between Ombalantu and Ogongo. Refer to **FIGURE 5.3** and **TABLE 5.4** on page 83 for a schematic layout and more technical detail of the Olushandja-Okahau component respectively.

At Ombalantu there is a pumped storage dam, a batch process purification plant with a capacity of 700 m^3/day and a clear water reservoir.

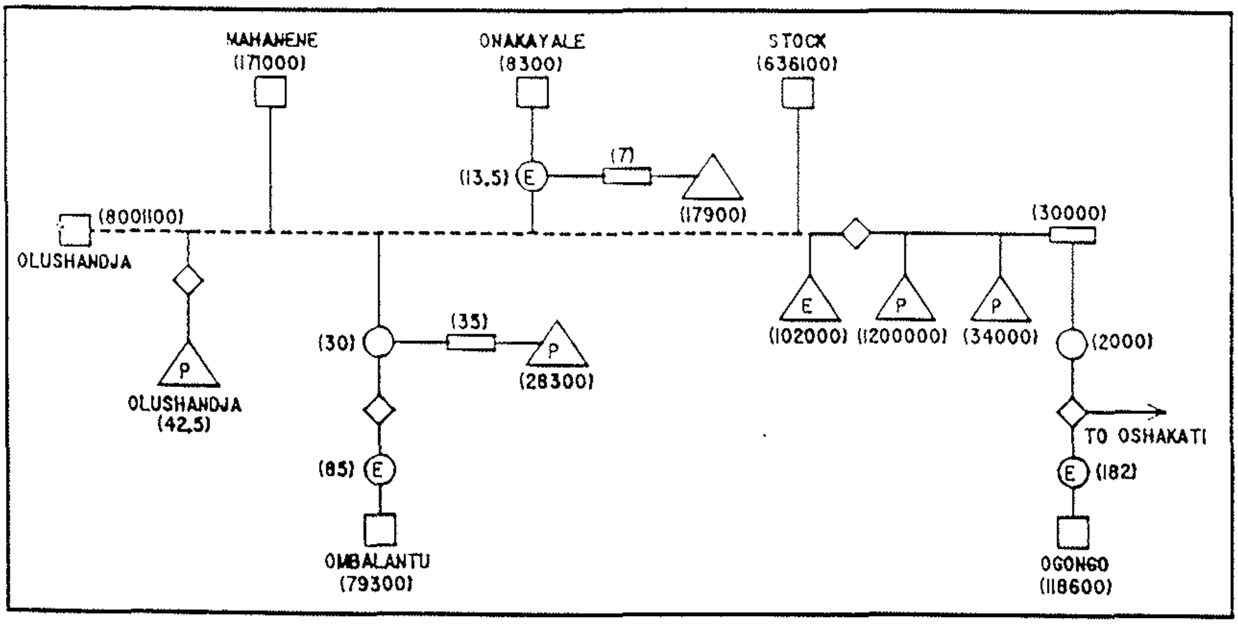


FIGURE 5.3 : OLUSHANDJA-OGONGO COMPONENT LAYOUT

TABLE 5.4: OLUSHANDJA-OGONGO COMPONENT TECHNICAL DETAIL

SECTION	WATER CARRIER				
	TYPE	MATERIAL	LENGTH (m)	SHAPE	CAPACITY (m^3/h)
Olushandja to Ombalantu	Canal	Concrete Blocks	35 606	Tapezoidal	11 500
Ombalantu to Ogongo	Canal	Concrete	34 280	Parabolic	5 400
Ombalantu to Ogongo	Canal	Unlined	34 000	-	5 000

At Ogongo there is an excavation dam which collects the runoff in the canal. From this dam raw water is supplied into two raw water storage dams and the purification works which has a capacity of 30 000 m^3/day. The purification works operates on a continuous basis, including flocculation filtration and disinfection. The purified water is stored in a 2 000 m^3 clear water reservoir from where it can be pumped to Oshakati or Okahau.

The original, local water purification works at Ogongo is not in operation any more, but the 182 m^3 concrete water tower is still used for the distribution of water to Ogongo town and hospital.

Onakayale is a settlement to the west of Ogongo and to the south of the canal. The settlement has its own 17 800 m_3 raw water pumped storage dam, a 60 m^3/day batch water purification plant, a 30 m^3 ground storage reservoir and a 13,5 m^3 water tower.

5.2.5 The Ogongo-Okahau Component

This component is presently under construction and will provide water to the settlements at Onamundindi, Ohashiti and Epato, as well as to a number of stock watering points spaced at intervals of approximately two kilometres along the pipeline. A new 3 000 m^3 terminal reservoir will be provided at Okahau and 12,9 m^3 elevated water towers at the settlements mentioned. It would also be possible to pump water from Okahau to Tsandi. Refer to **FIGURE 5.4** and **TABLE 5.5** on page 85 for a schematic layout and more technical detail respectively.

5.2.6 The Ogongo-Oshakati Component

This component comprises a pumpstation at Ogongo and a pipeline from Ogongo to Oshakati. Along the pipeline water is supplied to the Ogongo Agucultural College, Oshikuku and Ukwambi as well as to private consumers with connections to the pipeline and to stock watering points. Refer to **FIGURE 5.5** and **TABLE 5.6** on page 86 for a schematic layout and more technical detail respectively.

The settlements of Elim and Okantana is situated near the pipeline, but are not connected to the pipeline because local runoff collected in pumped storage dams are purified for domestic consumption at each place. The capacity of the purification works at each settlement is rated at 400 m^3/day.

At Oshakati, which is a major distribution point for water to the town and further to the Ondangwa, there are an excavation dam, three pumped storage dams, a continuous process purification plant, a pumpstation to supply water into six elevated water towers for local reticulation and into the pipeline to Ondangwa. The purification works at Oshakati is normally not operated if purified water is available from Ogongo. There is also an old unlined canal between Ogongo and Oshakati. This canal collects surface runoff and can be utilized to supply excess raw water from the Caluegue-Ogongo canal system to the rural population along the canal between Ogongo and Oshakati.

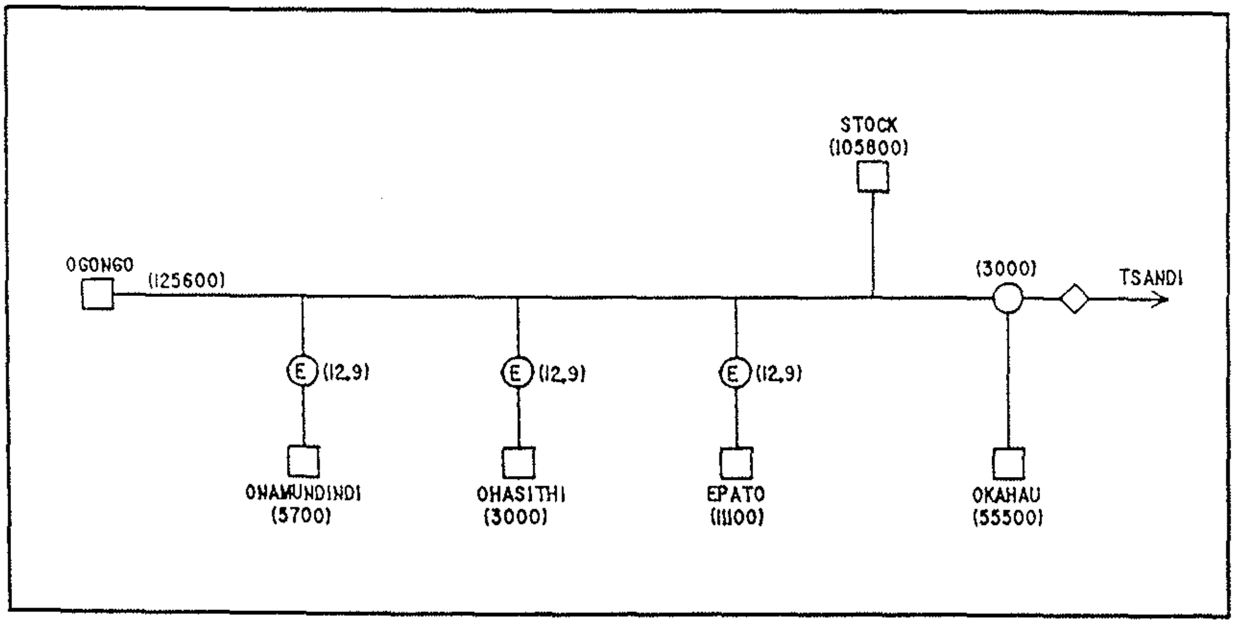


FIGURE 5.4 : OGONGO-OKAHAU COMPONENT LAYOUT

TABLE 5.5 : OGONGO-OKAHAU COMPONENT TECHNICAL DETAIL

SECTION	WATER CARRIER					
	TYPE	MATERIAL	LENGTH (m)	DIAMTER (mm)	CLASS	CAPACITY (m^3/h)
Ogongo to Okahau	Pipe	FRC*	39 510 3 695 43 205	350 350	12 18	400
To Onamundindi	Pipe	uPVC	900	150	18	5
To Ohashiti	Pipe	uPVC	50	150	12	5
To Epato	Pipe	uPVC	100	150	12	5

*FRC = Fibre re-inforced cement

*uPVC = Unplasticised Polyvinyl Chloride

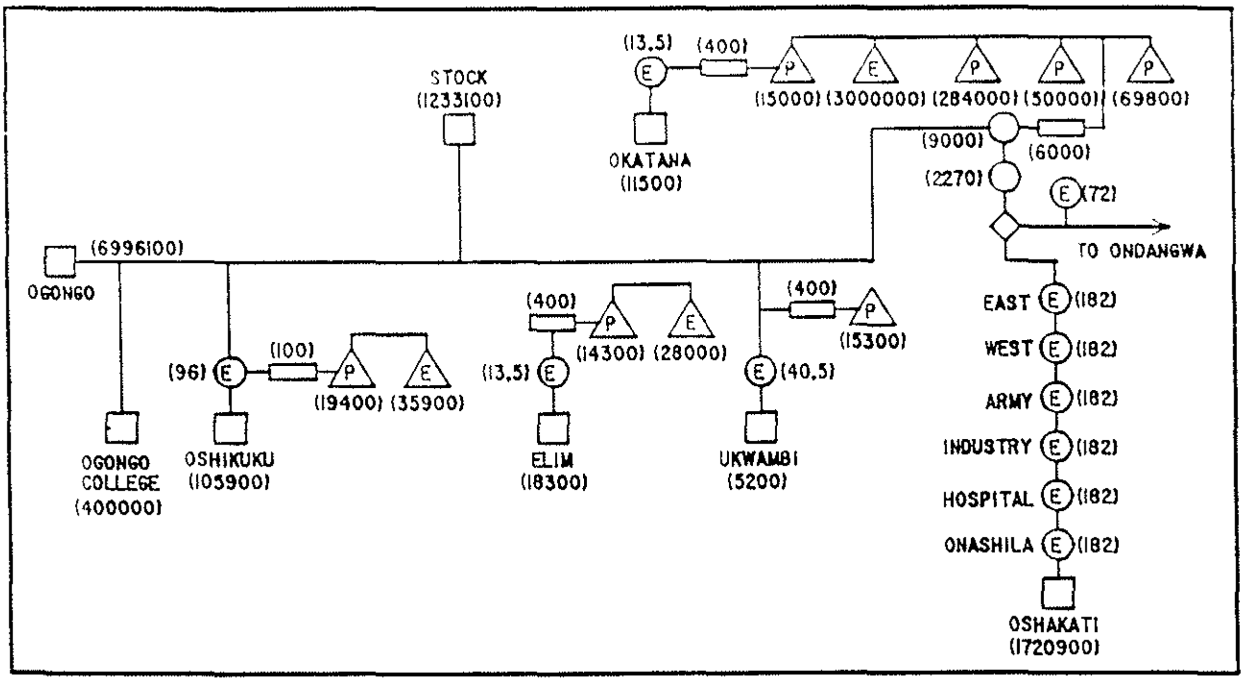


FIGURE 5.5: OGONGO-OSHAKATI COMPONENT LAYOUT

TABLE 5.6 : OGONGO-OSHAKATI COMPONENT TECHNICAL DETAIL

SECTION	WATER CARRIER					
	TYPE	MATERIAL	LENGHT (m)	DIAMETER (mm)	CLASS	CAPACITY (m^3/h)
Ogongo	Pipeline	FRC*	15 700	600	18	1 440
		FRC	14 300	600	12	
to		FRC	8 200	600	6	
		FRC	14 935	800	6	
			53 135			
Oshakati	Canal	Unlined	54 000	-	-	5 000
To Oshikuku	Pipeline	FRC	1 690	150	6	36
To Ukuambi	Pipeline	uPVC*	4 345	75	6	3
To Oshakati						
- Hospital	Pipeline	FRC	550	150	C	
- East		FRC	1 000	150	C	
- West		FRC	2 200	150	C	
- Army		FRC	1 255	160	6	
- Industry		FRC	2 200	150	F	
- Onashila		FRC	3 300	200	12	

*FRC = Fibre re-enforced Cement

*uPVC = Unplasticised Polyvinyl Chloride

5.2.7 The Oshakati-Ondangwa Component

This component comprises a pumpstation at Oshakati and a new bulk water supply pipeline between Oshakati and Ondangwa. The old bulk water supply pipeline between Oshakati and Ondangwa is at present utilized as a reticulation pipeline to consumers between Ondangwa and Oshakati. The water is pumped from Oshakati, but the pipeline is blanked off near Ondangwa.

Along the above-mentioned two pipelines water is supplied to Ongwediva Town and the Ondangwa airport from the new pipeline, as well as to Ongwediva Town, Ongwediva College, Ongwediva Mission, stock watering points and to private consumers from the old pipeline.

At Ondangwa, which is a major distribution point for local water supply to Oshivello and to Oshilongo, there are two excavation dams, a pumped storage dam, a purification works a clear water storage reservoir and a pumpstation to supply water to the town, Olunu, Onandjokwe, Oshivello and to Oshilongo.
Refer to **FIGURE 5.6** for a schematic layout and **TABLE 5.7** on page 88 for more technical detail of this component.

5.2.8 The Ondangwa-Oshivelo Component

This component which is also known is the Southeast Pipeline, comprises a pumpstation at Ondangwa and a pipeline along the tarred road to Oshivelo. The pipeline terminates approximately 60 km from Oshivelo. Refer to **FIGURE 5.7** and **TABLE 5.8** on page 89 for a schematic layout and more technical detail of this component.

Along the pipeline water is supplied to Onandjokwe, Onayena, Onyaanya, Ondjamba, Omuntele and Ambende as well as a number of private consumers, stock watering points, and the agricultural projects of Rössing and Ferco at the southern end of the pipeline.

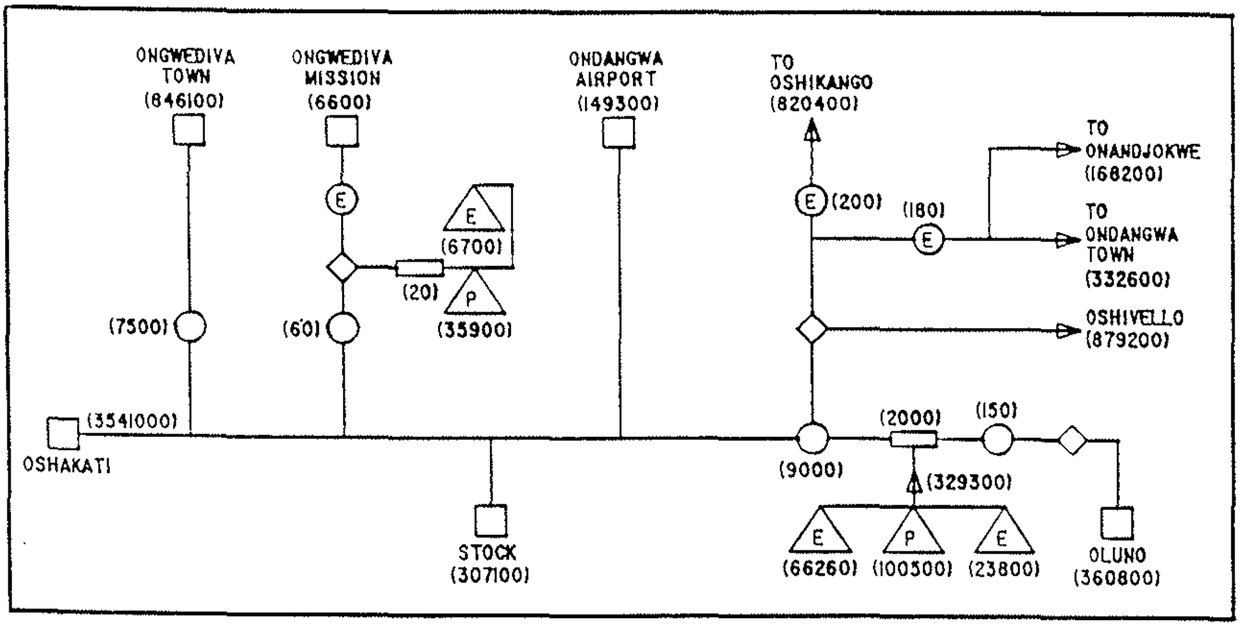


FIGURE 5.6 : OSHAKATI-ONDANGWA COMPONENT LAYOUT

TABLE 5.7 : OSHAKATI-ONDANGWA COMPONENT TECHNICAL DETAIL

SECTION	WATER CARRIER					
	TYPE	MATERIAL	LENGHT (m)	DIAMETER (mm)	CLASS	CAPACITY (m^3/h)
Oshakati to Ondangwa	Pipe	FRC* FRC	6 500 28 500 35 000	500 500	12 6	738
To Ongwediva Town	Pipe	FRC	410	300	12	330
To Ongwediva Mission	Pipe	FRC	2 840	75	6	55
To Ondangwa Airport	Pipe	uPVC	500	75	6	5

*FRC = Fibre Re-enforced Cement

*uPVC = Unplasticised Polyvinyl Chloride

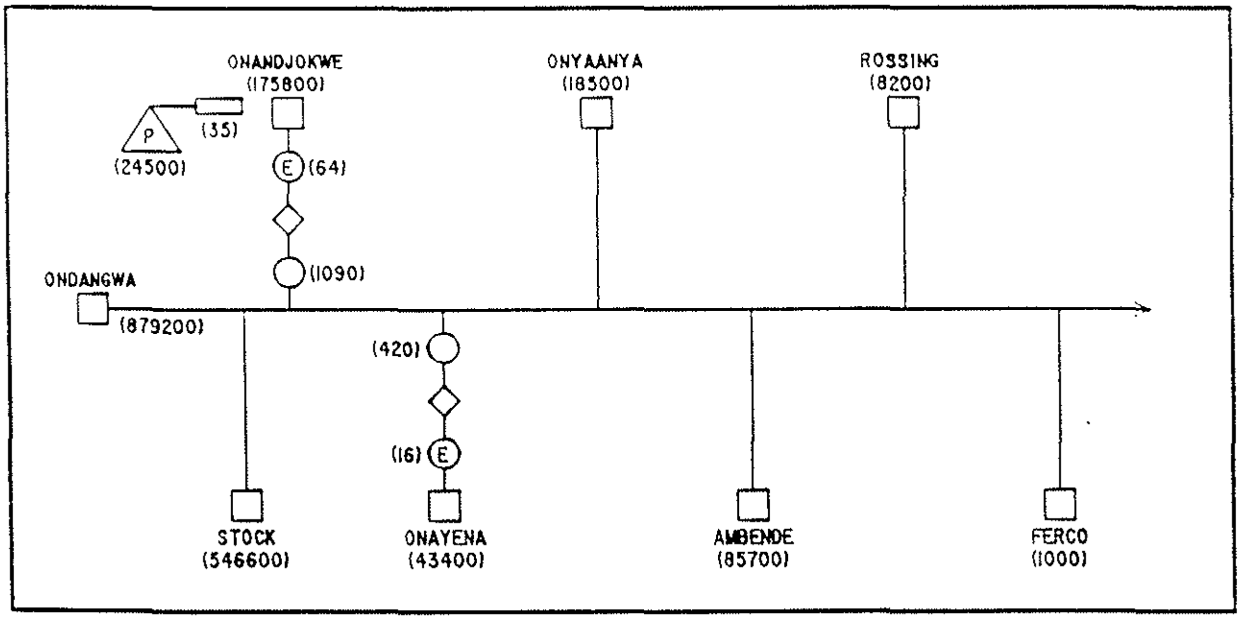


FIGURE 5.7 : ONDANGWA-OSHIVELO COMPONENT LAYOUT

TABLE 5.8 : ONDANGWA-OSHIVELO COMPONENT TECHNICAL DETAIL

SECTION	WATER CARRIER					
	TYPE	MATERIAL	LENGHT (m)	DIAMETER (mm)	CLASS	CAPACITY (m^3/h)
Ondangwa to Oshivelo	Pipe	FRC*	35 450 53 350 20 200 109 000	450 350 300	12 12 12	270
To Onandjokwe	Pipe	FRC	410	250	12	200
To Onayena	Pipe	FRC	2 840	250 150	12 12	550 75
Okatope to Ambende	Pipe	AC* AC* uPVC*	7 820 7 890 12 550 28 260	250 250 250	12 12 6	56

*FRC = Fibre Re-enforced Cement

*AC = Asbestos Cement

*uPVC = Unplasticised Polyvinyl Chloride

5.2.9 The Ondangwa-Oshikango Component

This component comprises a major bulk water supply artery running from Ondangwa in the south to Oshikango in the north. A number of pipelines branch off from this pipeline in a westerly and easterly direction. When looking at the layout of this water scheme in **FIGURE 5.8** it is clear that it resembles a herringbone and therefore it is popularly known as the Herringbone Scheme (Afrikaans: Visgraatskema). Also refer to **TABLE 5.9** on page 91 for more technical detail.

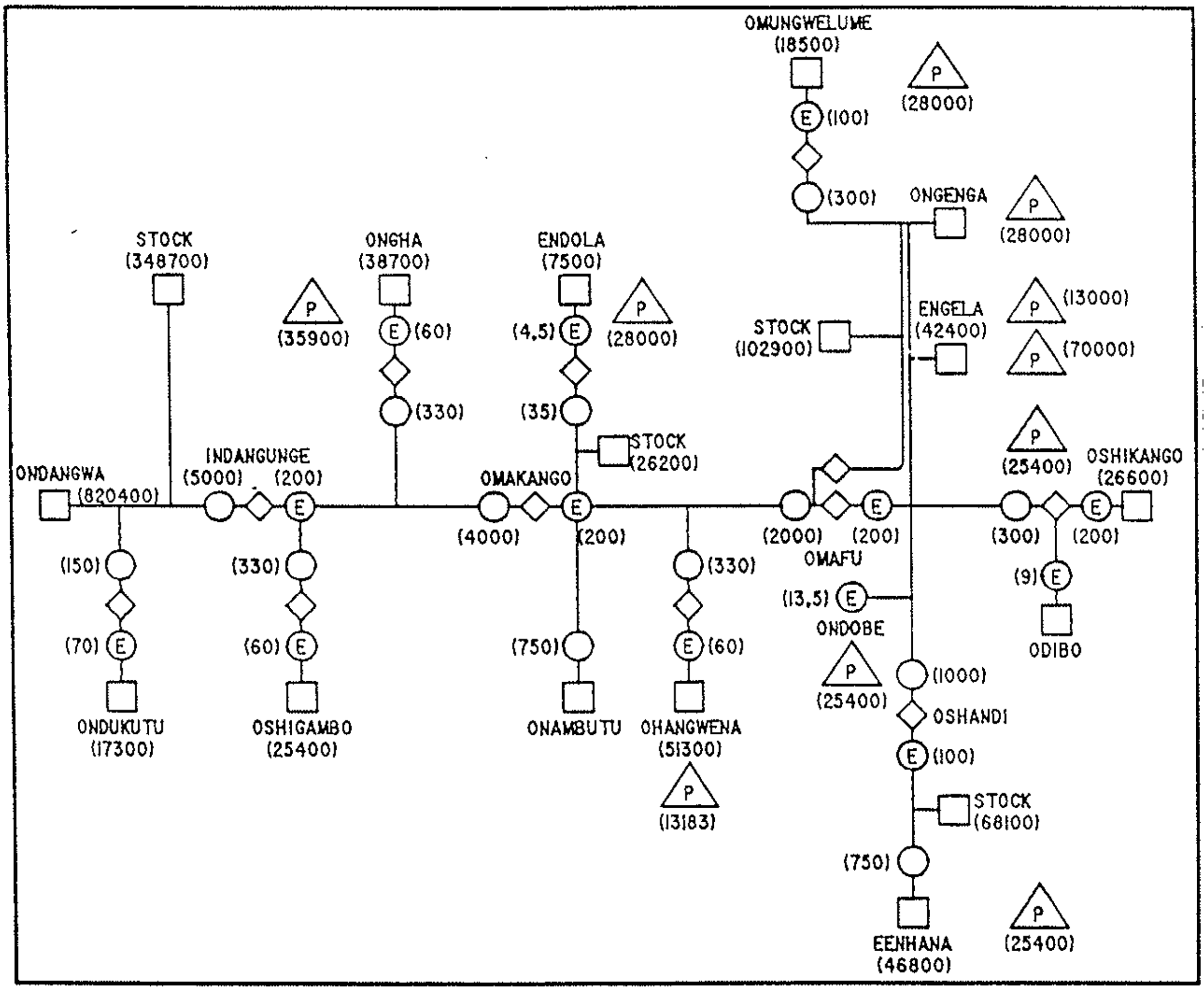


FIGURE 5.8 : ONDANGWA-OSHIKANGO COMPONENT LAYOUT

At Ondangwa water is pumped from a 11 000 m^3 clear water reservoir into a water tower from where it gravitates over a distance of 14 km into a 5 000 m^3 ground level reservoir at Iindangunge. At Iindangunge water is pumped into an 180 m^3 elevated reservoir from where water gravitates over a distance of 25 km into a 4 000 m^3 ground level reservoir at

Omakango. At Omakango water is pumped into a 180 m³ elevated reservoir from where it gravitates over a distance of 19 km into a 3 000 m³ ground level reservoir at Omato. At Omato water is pumped into a 180 m³ elevated reservoir from where it gravitates into a 300 m³ a ground level reservoir at Oshikango. Water is pumped from this reservoir into a 180 m³ elevated reservoir for local distribution.

TABLE 5.9 : ONDANGWA-OSHIKANGO COMPONENT TECHNICAL DETAIL

SECTION	WATER CARRIER					
	TYPE	MATERIAL	LENGHT (m)	DIAMETER (mm)	CLASS	CAPACITY (m^3/h)
Ondangwa to Iindangunge	Pipe	HDPE*	14 215	295,4		190
To Ondukutu	Pipe	uPVC*	1 828	90	6	98
Iindangungé to Omakango	Pipe	HDPE	21 769	295,4		151
To Ongha	Pipe	uPVC	800	160	6	18
To Endola	Pipe	HDPE	18 000	80		18
To Onambutu	Pipe	HDPE	41 000	200		-
Omakango to Omafu	Pipe	HDPE	19 586	208,6		82
To Ohangwena	Pipe	FRC	1 500	100	6	16
Omafu to Oshikango	Pipe	HDPE	5 770	145,2	6	72
To Odibo	Pipe	HDPE	5 329	50		3
Omafo to Omungwelume	Pipe	HDPE uPVC HDPE	23 340 23 340 8 200	100 160 75	6	19 55 8
To Engela	Pipe	HDPE	1 650	100	4	40
Omafu to Oshandi	Pipe	HDPE	32 400	200	4	57
To Ondobe	Pipe	HDPE	7 600	50		
Oshandi to Eenhana	Pipe	HDPE	15 488	166		57

*HDPE = High Density Polyethylene

*uPVC = Unplasticised Polyvinyl Chloride

From Ondangwa water is reticulated through an old bulk water pipeline to Onandjokwe and Oshigambo. Between Ondangwa and Iindangunge water is drawn off to supply Ondukutu. From Iindangunge water is supplied to Oshigambo and between Iindangunge and Omakango water is drawn off to supply Ongha.

From Omakango water is supplied to Endola and can be supplied to Onambutu, but the pipeline to Onambutu has not been in operation for some time due to technical problems.

Between Omakango and Omafo water is supplied to Etale and Ohangwena.

From Omafo water can be supplied to Omungwelume via Engela and Ongenga to the west and to Ondobe, Oshandi and Eenhana to the east.

At Oshikango water can be supplied from the local 180 m^3 elevated water tower to Odibo.

Water is also supplied for stock drinking along all the pipelines of the Herringbone Scheme.

The local pumped storage dams and small purification plants at Oshigambo, Ongha Endola, Ohangwena, Oshikango, Ongenga, Omungwelume, Oshandi and Eenhana have not been used for potable water provision since the Herringbone Scheme came into operation.

5.3 CAPACITY OF THE BULK WATER SUPPLY NETWORK

Due to the fact that there may be a difference between the installed capacity of a particular pumpstation, the capacity of the pipeline through which the water is pumped and the actual water demand on the system, it is appropriate to consider the capacity of the water carrier for planning purposes. **TABLE 5.10** on page 93 therefore lists the different components of the bulk water supply network in Owambo as well as their corresponding capacities and the actual water supplied through the different water carriers during 1989/90. This information will be used further for planning purposes in this report.

TABLE 5.10 : CAPACITY OF THE BULK WATER SUPPLY NETWORK

BULK WATER SUPPLY COMPONENT	CAPACITY OF COMPONENT (m^3/a)	1989/90 CONSUMPTION (m^3/a)
Ruacana to Olifa	365 000	363 000
Ruacana-Olushandja	15 000 000	8 652 000
Calueque-Olushandja	90 000 000	-
Olushandja-Ogongo	40 000 000	8 001 100
Olushandja-Okahau	1 300 000	471 800
Ogongo-Okahau	3 000 000	125 600
Ogongo-Oshakati	10 500 000	6 996 100
Oshakati-Ondangwa	5 500 000	3 541 000
Ondangwa-Oshivelo	2 000 000	879 200
Ondangwa-Oshikango	1 500 00	820 400
TOTAL PRODUCTION		9 015 000

5.4 RURAL WATER SUPPLY SITUATION

5.4.1 General

As previously stated, the responsibility for the reticulation of bulk water at major settlements and the provision of rural water supply points had been responsibility of the local administration.

In January 1990 a survey was done to determine the extent of the rural water supply infrastructure in Owambo. It was established that the local administration had been responsible for the supply of water to 230 settlements, the reticulation of water to 25 villages and towns as well as the provision of water to 100 farms. The manpower involved to attend to this infrastructure was 23 supervisors and 130 labourers. The annual recurrent expenditure to operate and maintain the water schemes was R700 000 in the 1989/90 financial year. The replacement value of the existing rural water supply infrastructure is valued at R5,7 million.

The local authority in the region was also responsible for the operation and maintenance of sewerage pipelines, oxidation dams and 54 sewerage pumping stations at the various towns and settlements in Owambo. Three sewage tankers were also used to empty septic tanks in certain areas.

5.4.2 Potable Rural Water

Although some provision was made, no priority was given to the supply of potable rural water to the scattered, small communities in the density populated central Cuvelai and Etaka oshana drainage area by the local administration because the local population had access to water from numerous flooded dry river beds and pans during the rainy season. During the dry winter months use was made of wells in the oshana beds. These wells had to be deepened as the water table receded and when the local saline water horizon had been reached the people either had to move away to the more permanent bulk water supply network or had to transport water from those sources over as much as 40 km to their settlements.

It can therefore be argued that a combination of self-help measures by the local population and neglect from the regional authorities contributed to the present situation where inadequate potable water supplies are available for utilization by the local population residing at places which are long distances away from the potable water supply network.

However, the local administration did make as a substantial contribution towards the development of boreholes in the outlaying areas where borehole water could be utilized, but where the local population was unable to drill the deep wells required to obtain water.

The provision of sufficient and hygienic standpipe facilities and stock watering areas along the bulk water supply infrastructure were also neglected and many people and cattle have to queue up to tap water from rudimentary public water supply points.

Due to the fact that livestock has access to the open water in the oshanas and wells, the water is polluted. The unhygienic conditions prevailing at standpipe facilities and the unprotected open water sources, cause health risks and contributes to the occurrence of diarrhoeal disease in the area. These adverse conditions needs urgent rectification.

5.4.3 Excavation and Pumped Storage Dams

In order to supplement the available surface water supplies in the rural areas a large number of excavation dams, pumped storage dams, purification works and safe potable water supply pumps were constructed by the local Administration and the Department of Water Affairs. Refer to **Section 3.2.**

With the exception of those facilities which were controlled by the Department of Water Affairs, very little maintenance work had been done by the local administration during the past 10 to 15 years. Many dam basins have silted up and very few pumps systems are still in operation. This situation definitely needs attention.

5.4.4 Wells

According to a survey conducted by the United Nations Children's Fund (UNICEF) in February 1990 **(Reference 31)** an estimated 150 lined hand-dug wells had been constructed in Owambo to date. The depth of the wells range between 3 m and 10 m, the average being between 6 m and 7 m. The wells are fitted with either a handpump or windlass and bucket. The local administration built 44 of these wells before 1978 and they were all fitted with handpumps, but neither the wells nor the handpumps, were maintained since that time. Most of them are not in use any more.

5.4.5 Rural Borehole Water Supply

According to the survey by the Department of Water Affairs, there are at present about 400 boreholes in operation in Owambo. Of these, 358 have been installed with diesel pumpsets while 20 have been provided with wind mills. Reservoirs, ranging in size from 1,5 m^3 to 15 m^3 have been built next to most boreholes. About 25 boreholes are operated by other organizations.

The local administration assisted the population to establish boreholes and to do maintenance work on pipelines, drinking troughs for cattle and pump installations, and this assistance will have to be continued by future authorities.

According to the UNICEF survey the Catholic Mission in Oshikuku, the Anglican Church at Odibo, the Council of Churches and the Rural Development Centre at Ongwediva had all attempted the drilling of new boreholes, but had relatively little success because of the saline groundwater in central Owambo. All of this work had been done without consulting the Geohydrology Division of the Department of Water Affairs and in the opinion of the Department these virtually futile and un-coordinated drilling efforts led to unnecessary expenditure which could have been saved and appropriated elsewhere.

6. WATER DEMAND

6.1 GENERAL

The magnitude of the future water demand in Owambo will depend on the rate of development in the social, agricultural and industrial sectors of the economy. The number of people, the population growth, the improvement in the standard of living and the corresponding increase in unit water consumption, the effect of urbanization as well as the provision of facilities for health, education, housing and recreation will impact significantly on the water demand.

The possible development of the rural areas into more commercial agricultural units can be a major stepping stone in the generation of wealth in Owambo, but the expansion of activities like stock farming, irrigation, forestry and fisheries would require adequate water supplies to support them. It is also expected that the traditional subsistence farming practice would continue for a long time in both the densely populated central area and the less developed surrounding hinterland.

Although no large scale water consuming mines or industries are expected to develop in Owambo, there will be some scope for the establishment of small service industries which would also generate an increased water demand.

The water demand due to irrigation, fish farming and forestry will be too high to be satisfied from local water sources. Water will have to be imported from the Cunene River to support such development, but the rate at which the development will take place is difficult to estimate.

In **Chapter 5** it was shown that Owambo has a well developed bulk water supply system in the central area. The main purpose of this water network was to supply water to the growth points and urban communities in Owambo. However, very little provision was made for rural water supply in the areas immediately adjacent to the bulk water supply network while the areas further away to the east, south and west of the central area were neglected even more.

Although the volume of water pumped into the bulk water supply network is measured at various points along the pipelines, it is mainly done to prepare bulk water accounts according to the approved water tariffs. The water meters were therefore not installed to measure the specific water consumptions at certain places. The water consumption of the rural communities were never metered by the Department or the previous Administration who was actually responsible for rural water supply.

The result is that fairly acceptable information is available on the water demand trends in the more urbanized central area, but that very little is known about the water requirements of the people in the outlying rural areas.

Other important factors which have an influence on the water supply and demand situation are the availability of surface water during the rainy season, the utilization of wells and boreholes, as well as the fact that without access to the Calueque Dam, only a relatively small, but sufficient quantity of very expensive water could be pumped from Ruacana into Owambo.

The effect of rural water consumers, who stay some distance away from the formal water supply network, is also difficult to determine. Those people obtain water from the bulk water network, especially during the dry season, and transport it over long distances to their houses. Due to this situation, they only use a very small volume of water per day per person, but the total demand of all the small users on the total bulk water supply system may be much more significant than anticipated. The per capita consumption of the rural communities may also increase if the access to water from the existing water network is improved by distribution pipelines.

In view of all the uncertainties concerning actual water consumption trends, the future water demand in Owambo will be determined by using the following approaches, namely:

1. Calculation of the theoretical water demand
2. Projection of the actual water demand
3. Proposing a weighted future water demand estimate

6.2 UNIT WATER DEMAND

In order to determine the theoretical water demand in Owambo, unit water consumption criteria which have been based on local experience and standards of the World Health Organization, the Institute for Water Pollution Control, the Department of Development Aid in the Republic of South Africa, and the Development Bank of Southern Africa, will be used. Refer to **TABLE 6.1**.

TABLE 6.1: ASSUMED UNIT WATER CONSUMPTION IN OWAMBO

CONSUMER	CONSUMPTION ℓ/unit/day
Person in the remote rural areas	10
Person residing less than 4 km from a pipeline	25
Squatters at towns and settlements	60
Person with a piped water connection	200
Day scholars at schools	10
Children at school hostels	150
Persons in police and army bases	300
Equivalent large stock unit	45
Clinic (per outpatient)	450
Hospital (per bed)	50
Irrigation (per hectare)	50 000

6.3 THEORETICAL WATER DEMAND

The main purpose of this section is to determine what the total, theoretical future water demand in Owambo would be by making acceptable assumptions on the most probable future water consumption patterns and comparing the results with the ability of the available water sources to supply in the demand.

In view of the fact that the potential of the local groundwater and surface water sources have not been quantified the first approach would be to determine what the situation would be if the total estimated water demand must be supplied from Ruacana or the Calueque Dam.

With the available equipment at this point in time it is possible to abstract 3,5 m^3/s or 90 Mm^3 of water from Calueque with the available pumpsets if access could be gained to the Cunene River at Calueque. If the total agreed volume of water could be abstracted, then at least 6 m^3/s or 160 Mm^3/a could be made available from Calueque. The existing capacity of the Ruacana abstraction point on the Cunene River is only 10 Mm^3/a, but this could possibly be upgraded to at least 15 Mm^3/a. The energy cost component of the water supplied from Ruacana is, of course, very high and this option should be avoided.

In order to calculate the estimated theoretical future water demand by the year 2020 in Owambo, the population statistics in **TABLE 4.11** and the per capita consumption figures in **TABLE 6.1** were used. The effect of urbanization and the increase in per capita water consumption due to an increase in the standard of living were also taken into consideration.

The stock numbers in **TABLE 4.12** were converted to equivalent large stock units in order to determine the effect of stock water consumption, but is was assumed that there would be a reduction in stock numbers due to better grazing management by the year 2020 and that the present 670 000 equivalent stock units will be reduced to at least 500 000 units by that time.

Due to the fact that primary water demand, that is water for humans and stock, is considered to be the first priority for supply, the water that can possibly be made available from the Cunene River for irrigation purposes will be determined after the primary water demand has been deducted. Although industrial water demand is considered to be a secondary priority to the irrigation demand, which is seen as a tertiary priority, the effect of industrial water demand has been accommodated within the population per capita demand because there is very little scope for large scale industrial development in Owambo. The results of the calculations are shown in **TABLE 6.2** and it is interesting to note that the average theoretical increase in the primary water demand, excluding irrigation is 4%/a.

TABLE 6.2 : THEORETICAL WATER DEMAND

CONSUMER	**WATER DEMAND Mm³/a**		
	1990	**2005**	**2020**
Urban population	9,6	35,0	61,3
Rural population	4,2	7,5	10,7
Stock	11,1	9,5	8,0
Irrigation, Fisheries and Forestry	negligible	52,0	80,0
TOTAL	24,9	86,0	160,0
PLANNING FIGURE	25	85	160

From **TABLE 6.2**, and considering the capacity of the pumpstations capable of abstracting water from Cunene, it is clear that the Ruacana pumpstation, even if it is upgraded to supply 15 Mm^3/a, will not be able to supply in the total 1990 theoretical water demand in Owambo. However, the Calueque pumpstation will, when installed, be able to supply in the water demand up to the year 2005 with the existing capacity of 3,5 m^3/s and at least up to year 2020 if the capacity could be upgraded to 6,0 m^3/s.

The irrigation potential which can be developed by the year 2005 if Calueque is in operation, is 2 000 ha, resulting in a tertiary water demand of 52 Mm^3/a after the primary and secondary demands have been supplied. The irrigation potential could likewise be increased to at least 4 500 ha by the year 2020.

A further conclusion to be drawn from these arguments are that renewed access to Calueque is of the utmost importance for Owambo and that either the existing 3,5 m^3/s pumping capacity, or the agreed 6,0 m^3/s will be sufficient to satisfy the primary water demand in Owambo, even if no internal surface water or groundwater is utilized. However, practical and capital cost considerations make such a proposition impossible. The conjunctive and

and capital cost considerations make such a proposition impossible. The conjunctive and integrated use of all the available surface and underground water sources in Owambo are therefore a prerequisite to supply water at affordable costs to the local consumers.

6.4 PRESENT AND PROPOSED FUTURE WATER DEMAND ALONG THE EXISTING BULK WATER SUPPLY NETWORK

In order to estimate the future water demand along the existing bulk water supply network, it will be assumed that the increase in consumption could be 3%/a or 5%/a or 7%/a. These figures do not include the water demand due to irrigation, forestry and fish farming because it is considered a third priority demand to be satisfied if surplus water is available.

The proposed growth rate of 3%/a corresponds to the expected increase in the population. As previously pointed out, the water demand by stock will probably decrease due to better range management and very little large scale industrial development is expected. The estimated water demand due to these assumptions is shown in **TABLE 6.3**.

TABLE 6.3 : ESTIMATED FUTURE WATER DEMAND AT 3%/a GROWTH

BULK WATER SUPPLY COMPONENT	1989/90 CONSUMPTION (Mm^3/a)	ESTIMATED FUTURE WATER DEMAND (Mm^3/a)		
		1990	2005	2020
Total Network	9,015	9,285	14,065	16,279
Ruacana-Olifa	0,363	0,375	0,565	0,656
Ruacana-Olushandja	8,625	8,910	-	-
Calueque-Olushandja	-	-	13,5	15,623
Olushandja-Ogongo	8,001	8,240	12,5	14,45
Olushandja-Okahau	0,472	0,492	0,74	0,852
Ogongo-Okahau	0,126	0,129	0,2	0,227
Ogongo-Oshakati	6,996	7,206	10,9	12,582
Oshakati-Ondangwa	3,541	3,647	5,5	6,395
Ondangwa-Oshivelo	0,879	0,906	1,37	1,588
Ondangwa-Oshikango	0,820	0,845	1,3	1,482

The proposed growth rate of 5%/a corresponds to the expected water demand due to a normal population increase, an increase in urbanization and the improvement of living standards when more facilities or infrastructure are created in the urban centres and the rural population obtains better access to piped water supplies. The estimated water demand due to these assumptions is shown in **TABLE 6.4**.

TABLE 6.4 : ESTIMATED FUTURE WATER DEMAND AT 5%/a GROWTH

BULK WATER SUPPLY COMPONENT	1989/90 CONSUMPTION (Mm^3/a)	ESTIMATED FUTURE WATER DEMAND (Mm^3/a)		
		1990	2005	2020
Total Network	9,015	9,466	18,775	38,962
Ruacana-Olifa	0,363	0,381	0,755	1,569
Ruacana-Olushandja	8,652	9,085	-	-
Calueque-Olushandja	-	-	18,0	37,393
Olushandja-Ogongo	8,001	8,400	16,5	34,58
Olushandja-Okahau	0,472	0,496	0,98	2,039
Ogongo-Okahau	0,126	0,132	0,26	0,543
Ogongo-Oshakati	6,996	7,346	14,5	30,237
Oshakati-Ondangwa	3,541	3,718	7,35	15,304
Ondangwa-Oshivelo	0,879	0,923	1,83	3,799
Ondangwa-Oshikango	0,820	0,861	1,7	3,546

The proposed growth rate of 7%/a, which is considered very high, includes the possible expected water demand due to a normal population increase, an increase in urbanization and the improvement of living standards as indicated above, but also provides for possible industrial development and the establishment of new water distribution pipelines to larger centres which are economically accessible, but further away from the existing water supply infrastructure. The estimated water demand due to these assumption is shown in **TABLE 6.5** on page 103

TABLE 6.5 : ESTIMATED FUTURE WATER DEMAND AT 7%/a GROWTH

BULK WATER SUPPLY COMPONENT	1989/90 CONSUMPTION (Mm³/a)	ESTIMATED FUTURE WATER DEMAND (Mm³/a)		
		1990	2005	2020
Total Network	9,015	9,646	24,9	68,624
Ruacana-Olifa	0,363	0,388	1,0	2,763
Ruacana-Olushandja	8,652	9,258	-	-
Calueque-Olushandja	-	-	23,9	65,861
Olushandja-Ogongo	8,001	8,561	22,1	60,906
Olushandja-Okahau	0,472	0,505	1,3	3,591
Ogongo-Okahau	0,126	0,134	0,35	0,956
Ogongo-Oshakati	6,996	7,486	19,3	53,256
Oshakati-Ondangwa	3,541	3,789	9,8	26,955
Ondangwa-Oshivelo	0,879	0,941	2,4	6,693
Ondangwa-Oshikango	0,820	0,878	2,3	6,245

6.5 WATER DEMAND AREAS

6.5.1 General

In order to address the supply of water in an orderly manner, Owambo was divided into eight different water demand zones. In the determination of these zones the physiographic conditions, the existing bulk water distribution network, other infrastructure, as well as known groundwater sources and the socio-economic development potential were considered.

The different zones are illustrated in **MAP 6.1** on page 104. Each zone was chosen in such a way that at least one primary water carrier is available from where secondary distribution lines can be constructed to attain a more even distribution of the water in the particular zone. The proposed zones are listed and briefly described below, but more detail is given in **Sections 6.1.2** to **6.1.9**:

ZONE 1 : Area in north-western Owambo, outside the brine lake area.

ZONE 2 : Area within the brine lake area south of the Angolan border and to the north of the Olushandja-Okahau-Ogongo pipelines, including the Calueque-Olushandja-Omabalantu-Ogongo Canal and the major centre at Okalongo.

ZONE 3 : Area adjoining the Ogongo-Oshakati-Ondangwa pipeline, including centres like Oshikuku, Elim, Okatana and Ongwediva.

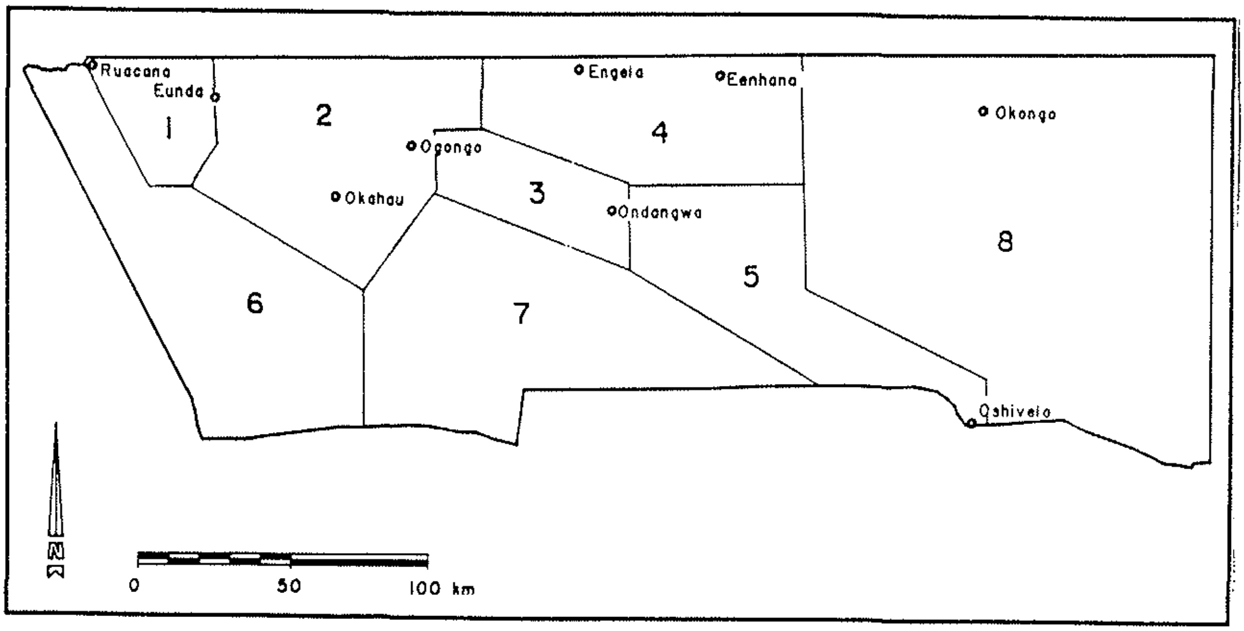
ZONE 4 : Area presently supplied with water by the Ondangwa-Oshikango pipeline or the Herringbone System, but extended to west of Omungwelume and east of Eenhana.

ZONE 5 : Area adjoining the Ondangwa-Oshivelo pipeline, including Omuntele and Ambende.

ZONE 6 : Area south of Ruacana and the Olushandja-Okahau-Ogongo pipeline in western and south-western Owambo, partially located within the brine lake area.

ZONE 7 : Area in the central southern Owambo, immediately to the north of the Etosha Game Park, within the brine lake area.

ZONE 8 : Area in eastern Owambo, outside the brine lake area.



MAP 6.1 : WATER DEMAND ZONES

6.5.2 Zone 1

The population density in **Zone 1** varies between 6 to 24 persons per km² along the Ruacana-

Olushandja pipeline and less than 5 persons per km^2 further to the south.

Although the available groundwater is fit for both human and animal consumption, the borehole yield are less than 5 m^3/h. Surface water is available from the Cunene River or in a few pans which may have some water after a good rainy season. The only reliable water resource is therefore for Cunene River.

The Ruacana-Olifa pipeline provides water to the major centres in the area while the Ruacana-Olushandja pipeline is utilized for the supply of water into the rest of Owambo.

The future development in the area will rely on urbanization at Ruacana and Olifa, increased production from stock and dryland farming, as well as the large scale utilization of areas with soils which are suitable for irrigation. However, the development of the irrigation potential will depend on access to the Calueque Dam.

6.5.3 Zone 2

The population density in **Zone** 2 varies between 6 to 24 persons per km^2 in the rural areas, and 25 to 50 persons per km^2 near the urban centres.

The zone lies within the brine like and the groundwater is unfit for either human or animal consumption. The entire zone falls within the western edge of the oshana drainage region and although surface water runoff is available during the rainy season, it is not a reliable source and difficult to store due to the absence of suitable dam sites. However, the Olushandja Dam has been built in the western part of the zone, but the dam not only relies on pumped water from the Calueque Dam, but has very adverse dam basin characteristics.

The existing bulk water supply infrastructure in the zone comprises the Calueque-Olushandja-Ogongo canal, the Olushandja-Okahau pipeline and the new Ogongo-Okahau pipeline. Water purification plants are located at Olushandja, Ombalantu, Nakayale and Ogongo. The larger centres and rural communities can therefore be served by the available pipelines or additional pipelines could be constructed.

The future development of the zone will depend on stock and dry land farming, irrigation projects and possible fish farming at Mahanene or in the Olushandja Dam. Rapid urbanization is taking place at Ombalantu and Anamulenge while the construction of a new water supply line to Okalongo seems necessary in the near future.

6.5.4 Zone 3

The population density in **Zone 3** varies between 6 to 24 persons per km^2 in the rural areas adjacent to the existing formal infrastructure (tarred road and water supply pipeline) to more than 50 persons per km^2 at the urban centres.

The zone lies within the brine lake area and the groundwater is unfit for human and animal consumption. Although the zone falls within the central oshana drainage basin, surface runoff only occurs during the rainy season, is unreliable and difficult to impound due to the flat topography.

The Ogongo-Oshakati-Ondangwa pipeline system runs through the zone and not only has to supply in the water demand of the whole zone, but also has to carry all the water required in **Zones** 4 and 5. The load on the existing pipeline to provide the water demand at the major urban centres and to the rural communities is exceeding its capacity because the system is virtually operated day and night.

As far as development in this zone is concerned, it has become clear that it would be the most important area for urban development. Oshakati and Ongwediva are the fastest growing centres in Owambo while Ondangwa, Oshikuku, Elim and the rural area inbetween is not left behind. Stock and dry land farming are the most important agricultural activities while possibilities for service industries exist in the urban centres. Fish farming in the oshanas and forestry nurseries may also be possibilities for future development. Space for urban development at Oshakati may pose a problem due to the low lying oshanas in the area surrounding the town, but better possibilities exist around Ongwediva. In recent years a large squatter community developed in the area and the impact of those people on the water demand could increase very fast as better living conditions have been created for them.

6.5.5 Zone 4

The overall population density in **Zone 4** is extremely high and is in fact the highest in the whole Owambo region. The number of people varies between 25 and 50 or more than 50 per km^2.

The groundwater sources in the zone are unfit for human or stock consumption, but due to the fact that the population makes use of shallow wells to obtain drinking water, it seems as if there is a perched water table and a groundwater source which may be able to support the water demand of small communities in the area. However, these sources are not reliable, especially during periods of drought, but it is clear that there is much speculation on the occurrence and magnitude of this resource. It should therefore be investigated thoroughly.

The extreme western portion of **Zone 4** lies within the central oshana drainage basin. Runoff usually occurs during the rainy season, but the floods are unreliable and difficult to harness. In very good rainy seasons the whole area becomes inundated. However, this surface water source is important to relieve the water demand load on the formal bulk water supply system and to recharge groundwater sources. The extreme eastern portion of **Zone 4** lies outside the major oshona drainage system, but surface water also makes an important contribution to relieve the water demand on the piped water supplies, albeit not a very reliable source.

The Ondangwa-Oshikango pipeline which runs northwards to Oshikango, has numerous branchlines in an easterly and westerly direction, hence the water scheme is known as the Herringbone System. This very important water scheme serves one of the most densely populated areas of the country and is running at full capacity to supply in the water demand according to the water production statistics. It is therefore of major importance to upgrade and extend the Herringbone System to place reliable piped water resources within reach of the rural communities which are the most affected when their wells run dry.

6.5.6 Zone 5

The population density of **Zone 5** is between 6 and 24 persons per km^2 and most of the people is concentrated in the immediate vicinity of the Ondangwa-Oshivelo infrastructure axis (tarred road, powerline and water supply pipeline). The groundwater sources occur along the eastern edge of the brine lake area and is unfit for human of stock drinking purposes. There may be an artesian aquifer with potable water at Oshivelo, but it needs further investigation. Very little surface runoff occurs during the rainy season, except for the accumulation of water in a number of small pans which cannot be considered reliable, but makes a contribution to alleviate the demand on piped water.

Due to this situation, potable water is supplied into the zone by means of the existing Ondangwa-Oshivelo pipeline and smaller branchlines to places like Onandjokwe, Onyaanya, Onayena and Ambende.

The development in **Zone 5** will mostly depend on stock and dryland farming, forestry, urbanization at the bigger centres and the establishment of service industries. As the existing bulk water supply pipeline is the furthest away from the Cunene River water source, the extension of branch pipelines into the zones adjacent to **Zone 5** should be considered very carefully before implementation because of the capital cost and the possibility to supply potable groundwater from the artesian aquifer at Oshivelo. The extent of the artesian aquifer should therefore be investigated.

6.5.7 Zone 6

The population density in **Zone 6** is very sparse with only up to 5 persons per km^2.

The groundwater sources in the area are not very strong and in many cases unsuitable for human consumption. However, the groundwater environment needs to be investigated further, especially to the south of Okahau where a perched, potable water source is indicated. Very little surface water runoff occurs in this zone, but is it sufficient to fill the numerous small pans, although not very reliable.

There is no piped bulk water supply scheme into the area and depending on the results of further hydrogeological investigations, piped water might be considered if boreholes or wells cannot be developed to supply in the water demand.

The opportunities for development in **Zone 6** is limited to stock and dryland farming, but irrigation projects further to the south of **Zones** 1 and 2 may be a long term future possibility if water can be made available from the Calueque Dam.

6.5.8 Zone 7

The population density in **Zone** 7 is less than 5 people per km^2 because the area is located within the brine lake area and the groundwater is too saline for human or stock consumption. However, during the rainy season surface water is available in the large number of pans and in the oshanas which converge from the north into Lake Oponono and continues from there into the Etosha Pan. This water resource is not perennial, but when water is available, stock is moved into the area to graze.

The opportunities for development in this zone are very limited. Stock farming is possible, but only on a seasonal basis. No urban centre occurs in **Zone** 7 and virtually no possibilities exist for socio-economic development. The capital cost to supply piped water into the area will also be prohibitively expensive.

6.5.9 Zone 8

The population density in **Zone 8** is less than 5 persons per km^2 except for certain areas near Okongo in the north, along the Angola border, and in the immediate vicinity of Oshivelo and at rural settlements.

The groundwater in the zone is fit for both human and stock consumption except at certain locations. Borehole yields are less than 5 m^3/h, but is sufficient to support stock farming. However, further geohydrological investigations are called for to determine the characteristics of the hydrogeological environment and the potential of the groundwater sources.

At present there is no formal bulk water supply infrastructure in the zone, but due to the availability of groundwater and the long distances from the perennial surface water sources it will not be economical to pipe water into the region.

The possibilities for development in the zone is limited to stock or dryland farming, but due to the present lack of boreholes for stock drinking proposes, there are large areas which could be made available for stock farming. The total potential of this zone has not been developed, but proper grazing management should accompany the establishment of water supplies. In the Mangetti farming area to the east of Oshivelo stock farms have already been developed and this trend is likely to continue. There is also a possibility to shift the veterinary stock disease control fence to the north of those farms. There is some potential for forestry development and projects have already been attempted in the Mangetti and near Onankali.

6.6 ESTIMATED FUTURE WATER DEMAND IN EACH WATER DEMAND ZONE

Based on the assumption in **Section 6.3**, a theoretical calculation of the water demand in each of the proposed water demand zones has been made and is shown in **TABLE 6.6**. The results in **TABLE 6.6** will be used to direct proposals on the future extension of the bulk water supply network in Owambo, as well as the improvement of all the other rural water supplies.

TABLE 6.6 : ESTIMATED FUTURE ZONE WATER DEMANDS

ZONE	WATER DEMAND (m^3/a)		
	1990	2005	2020
1	370 000	36 400 000	80 450 000
2	3 950 000	8 620 000	13 290 000
3	4 630 000	14 900 000	25 180 000
4	5 410 000	14 000 000	22 640 000
5	3 200 000	7 770 000	12 340 000
6	1 670 000	1 710 000	1 750 000
7	1 570 000	1 430 000	1 290 000
8	4 100 000	3 700 000	3 290 000
TOTAL	24 900 000	88 530 000	160 230 000

6.7 ESTIMATED FUTURE WATER DEMAND IN OWAMBO

From the information in **Sections** 6.3 and 6.4 it is clear that an estimate of the future water demand is very difficult due to a inadequate data on actual water consumption and a lack of direction on development possibilities. However, for planning purposes it will be accepted that the rate of future growth in the primary water demand will be between 3%/a and 7%/a. An average rate of 5%/a between 1990 and the year 2020 as well as a growth rate of 3%/a between the years 2006 and 2020 are therefore accepted. In order to estimate the 1989 water demand as basis for this calculation, the actual 1989 water demand for water demand zones 1 to 5 (as in **TABLE 6.3**) plus the theoretical water demand for zones 6 to 8 (as in **TABLE 6.6**), will be taken as the total water demand for 1989. The irrigation water demand, at a growth rate equivalent to an increase of 150 ha/annum up to the year 2020, was added to the figures.

TABLE 6.7 : ESTIMATED FUTURE WATER DEMAND

YEAR	WATER DEMAND (m^3/a)		
	PRIMARY	IRRIGATION	TOTAL
1989	16 300 000	negligible	16 300 000
1990	17 100 000	negligible	17 100 000
1995	21 800 000	13 500 000	35 300 000
2000	27 900 000	26 100 000	54 000 000
2005	35 600 000	40 500 000	76 100 000
2010	41 300 000	54 000 000	95 300 000
2015	47 800 000	67 500 000	115 300 000
2020	55 400 000	81 000 000	136 400 000

TABLE 6.7 shows that the total estimated primary water demand, which include industrial demand, will increase from 16,3 Mm^3 in 1989 to 55,4 Mm^3 by the year 2020 while the irrigation demand may reach 81,0 Mm^3 by the year 2005, depending on the actual rate of development.

7. FUTURE BULK WATER SUPPLY DEVELOPMENT

7.1 EXTENSION OF THE EXISTING MAJOR BULK WATER SUPPLY NETWORK

7.1.1 General

From the discussion in **Section 6.5** it is clear that the magnitude and reliability of the local surface water sources in central Owambo is questionable and that local groundwater from wells is not sufficient to support urban development. The result is that the bulk water supply network will have to be upgraded and extended to ensure the security of water for a developing Owambo.

This can be achieved by upgrading the capacity of the major or most critical components of the bulk water supply network as the first priority. The second priority would be the construction of minor bulk supply pipelines to important urban centres which have not yet been linked to the existing network. The third priority would be to link smaller rural communities with distribution pipelines from the bulk water supply network.

The estimated future water demand as presented in **TABLES 6.4, 6.6** and **6.7** will be used in conjunction with the available information on planning proposals to extend the bulk water supply network as described in **References 32** to **36**.

7.1.2 Major Water Carrier Sufficiency

The purpose of this Section is to determine the ability of the major bulk water carriers to supply in the water demand by comparing their capacity with the expected future water demand in 15 years time. Refer to **TABLE 7.1** on page 113.

From the information in **TABLE 7.1** it is clear that the Ruacana-Olushandja pipeline cannot supply in the estimated, theoretical 1990 bulk water demand, but that if the pumpstation at Calueque can be re-installed with the available pumpsets rated at 3,5 m^3/s, the Calueque-Olushandja canal will be able to supply the expected demand, including water for some 2 000 ha of irrigation, until at least the year 2005.

TABLE 7.1 : BULK WATER SUPPLY SUFFICIENCY

BULK WATER SUPPLY COMPONENT	EXISTING CAPACITY (Mm^3/a)	WATER DEMAND AREAS	ESTIMATED WATER DEMAND (Mm^3/a)	
			1990	2005
Ruacana-Olifa	0,365	1+2+		
Ruacana-Olushandja	15,0	3+4+	20,7	84,0
Calueque-Olushandja	90,0	5+6+7		
Olushandja-Okahau	1,3	2+3+		
Olushandja-Ogongo	40,0	4+5+	20,4	48,4
Ogongo-Okahau	3,0	6+7+		
Ogongo-Oshakati	10,5	3+4+5	13,2	36,7
Oshakati-Ondangwa	5,5	4+5	8,6	21,8
Ondangwa-Oshikango	1,5	4	5,4	14,0
Ondangwa-Oshivelo	2,0	5	0,9*	1,8*

* Refer to **TABLE 6.4**.

The Olushandja-Ogongo canal will only be able to supply in the water demand required at Ogongo until the year 2000 if no local surface or groundwater sources are available to the east of Ogongo to augment the water demand, such as during drought periods. The further development of the potential of the local water sources is therefore necessary.

The Ogongo-Oshakati pipeline is already insufficient to meet the theoretical water demand of zones 3, 4 and 5 and is in urgent need of upgrading. Refer to **MAP 6.1**.

The Oshakati-Ondangwa pipeline is already insufficient to supply in the theoretical water demand of zones 4 and 5, but the upgrading of this pipeline can be delayed if water is supplied directly from Oshakati to Omakango into the zone 4, via the remainder of the Herringbone system further to the north from Omakango. In that case the theoretical capacity

7.2.5 Ombalantu

The construction of a new purification plant and additional storage facilities has recently been completed. However, consideration should also be given to the construction of a short pipeline from the new Ombalantu purification works to Anamulenge, as well as the construction of a storage facility at Anamulenge.

7.2.6 Ombalantu-Ogongo Canal

This canal, which has a capacity of 40 Mm^3/a is relatively new and functions very well, but for water balancing purposes and future planning is it necessary to know what volume of water arrives at Ogongo. It is thus necessary that a water measuring structure be installed in the canal at Ogongo.

7.2.7 Nakayale

The storage facilities at this scheme are insufficient and should be upgraded as required.

7.2.8 Ogongo

Operational problems are experienced with the dosing system and sludge dams at Ogongo. A new design has already been proposed and as soon as it is implemented, the purification plant should be able to produce at least 30 000 m^3/day.

The pump capacity, as presently installed at Ogongo, is not sufficient to supply in the water demand along the Ogongo-Oshakati pipeline. Certain proposed changes in the pipework at the pumpstation will improve the situation, but the peak water demand would still exceed the pump capacity. It is therefore urgently required that the whole pumpstation should be redesigned to meet the maximum flow capacity of the pipeline.

The water which is distributed to an army base, public watering point and the Agricultural College at Ogongo should be metered separately as there is suspicion of a large wastage of is considered a long term project.

7.2 PROBLEMS WITH THE EXISTING BULK WATER NETWORK

7.2.1 Ruacana-Olushandja Pipeline

Although the pipeline capacity is 2270 m^3/h, the present pumping capacity is only 1400 m^3/h due to operational problems with the existing old pumps. The installation of new pumps is therefore necessary to utilize the full capacity of the pipeline. The possible construction of an additional booster pump station will facilitate a further increase the capacity of the pipeline, but this extension would most probably only become necessary if access to the Calueque Dam cannot be restored.

Water is presently metered with single in-line water meters at the Headbay pumpstation and at the Booster pumpstation. The readings of the two meters differ considerably despite the fact that there is no draw-off along that section of the pipeline. It is therefore necessary to have at least two in-line water meters at each metering point. The use of ultrasonic water meters should also be considered.

The Ruacana-Olifa pipeline and the purification works at Ruacana should be upgraded from a present capacity of 365 000 m^3/a to provide in the anticipated water demand of 400 000 m^3/a by the year 2005.

7.2.2 Calueque Dam - Olushandja Canal

As discussed in **Section 3.2.3** of this report it was proposed that consideration should be given to the completion of the Calueque Dam and the upgrading of the pumping capacity to 6 m^3/s. This proposal should therefore be investigated as soon as the political situation allows it. However, for planning purposes, and in view of other uncertainties, it will be assumed that the completion of the Calueque Dam will be a long term objective to be achieved by the year 2000.

7.2.3 Olushandja-Eunda-Tsandi-Okahau Pipeline

This scheme was built in phases with pipes which were surplus from other pipeline projects and not necessarily the same diameter. Due to this the central section of the pipeline consists of 300 mm diameter pipes while the rest of the pipeline is 250 mm in diameter. The original intention was also to pump water from Ogongo, via Okahau to Tsandi and Eunda and therefore the pipe class at Okahau is higher than at Olushandja. The pipeline should therefore preferably be operated in the opposite direction than at present.

The Olushandja purification works and pumpstation presently deliver 1,3 Mm^3/a of water at a head of only 13 metres, but with the existing Class 4 UPVC pipeline to Tsandi it is possible to utilize the full capacity of the pipeline by increasing the pumping head to 40 metres. However, the capacity of the purification works is too low to warrant the increase in pumping capacity and consideration was therefore given to the construction a new pipeline from the existing purification works at Ogongo to Okahau.

7.2.4 Olushandja-Ombalantu Canal

In some places this canal is lower than the surrounding natural ground level. During the rainy season water flows from the higher ground into the canal and wash sand and mud into the canal. The canal embankment has also been badly eroded in places. Certain sections of the canal have been filled up to 80 percent with sand. Maintenance should also be done on the relatively steep embankments and consideration should be given to build structures to avoid the deposition of sand in the canal.

The canal should be cleaned regularly as part of a continuous maintenance operation.

Water is drawn from the canal for the experimental farm at Mahanene, but at present no functioning metering facility exists. This matter should receive urgent attention to facilitate meter readings on a monthly basis to be included in the water account for Owambo.

7.2.5 Ombalantu

The construction of a new purification plant and additional storage facilities has recently been completed. However, consideration should also be given to the construction of a short pipeline from the new Ombalantu purification works to Anamulenge, as well as the construction of a storage facility at Anamulenge.

7.2.6 Ombalantu-Ogongo Canal

This canal, which has a capacity of 40 Mm^3/a is relatively new and functions very well, but for water balancing purposes and future planning is it necessary to know what volume of water arrives at Ogongo. It is thus necessary that a water measuring structure be installed in the canal at Ogongo.

7.2.7 Nakayale

The storage facilities at this scheme are insufficient and should be upgraded as required.

7.2.8 Ogongo

Operational problems are experienced with the dosing system and sludge dams at Ogongo. A new design has already been proposed and as soon as it is implemented, the purification plant should be able to produce at least 30 000 m^3/day.

The pump capacity, as presently installed at Ogongo, is not sufficient to supply in the water demand along the Ogongo-Oshakati pipeline. Certain proposed changes in the pipework at the pumpstation will improve the situation, but the peak water demand would still exceed the pump capacity. It is therefore urgently required that the whole pumpstation should be redesigned to meet the maximum flow capacity of the pipeline.

The water which is distributed to an army base, public watering point and the Agricultural College at Ogongo should be metered separately as there is suspicion of a large wastage of urgent installation of water meters are therefore necessary.

7.2.9 Ogongo-Okahau Pipeline

This water scheme is presently under construction at an estimated capital cost of R7,3 million and would not only supply more water to Okahau, but would also facilitate the supply of water to the rural communities adjacent to the pipeline and at more remote centres to the south and southeast of Okahau. At the same time attention is also given to the upgrading of the clear and raw water storage facilities at Okahau. It was proposed to construct a 5 000 m^3 concrete reservoir.

7.2.10 Ogongo-Oshakati Pipeline

In order to utilise the maximum flow capacity of this pipeline it is necessary to remove the shut-off ball valve in the reservoir at Oshakati and to replace it with an automatic telemetry system.

The large number of individual small rural consumer connections to the pipeline, especially between Ogongo and Oshikuku should be limited by giving one tapping point to several consumers. The principle should also be accepted that not only large consumers such as schools may be allowed water connections, but also the rural communities. Due to the high operating pressure of the pipeline, all connections must make provision to accommodate the situation.

Even if the Ogongo-Oshakati pipeline is optimally operated, it will not be able to supply in the water demand by 1995 if the present water demand grows at more than 5%/a. As the whole water supply network east of Oshakati is dependant on this water carrier it is necessary, as a matter of priority, to upgrade it in time. A canal and a new purification works at Oshakati should be investigated as soon as possible.

7.2.11 Oshikuku

The components of the water supply network are in a good condition and have sufficient capacity to supply in the water demand for the next few years. However, the construction of an additional reservoir at Oshikuku should be investigated.

7.2.12 Oshakati

Water supplied from Ogongo normally flows directly into the 9000 m^3 concrete reservoir at Oshakati. As soon as the reservoir is full, a ball valve closes and prevents further inflow. The surplus water then runs into the round open storage dam.

The existing water meter on the Ogongo-Oshakati pipeline is between branchline to the round dam and the concrete reservoir. Water running into the open dam is thus not metered. An additional water meter must therefore be installed on the branch pipe to the open storage dam.

Two in-line water meters or an ultrasonic water meter must also be installed on the manifold with which water is distributed to the water towers in the different parts of Oshakati. This measure will reduce the existing five metering points to only one. It is also recommended that each of the pipelines between the pumpstation and the water towers in Oshakati be handed over to the local authorities as they form an integral part of the reticulation system in the town.

As mentioned before, some of the purified water from Ogongo is diverted into the open round dam at Oshakati. This water is exposed to contamination, but may have to be pumped into the water supply network when the need arises. This procedure is not acceptable and more bulk water storage facilities must urgently be built at Oshakati. The present situation can have serious consequences, especially if it is considered that some of the water is distributed to hospitals.

If the proposed Ogongo-Oshakati water carrier is a canal and the proposed Oshakati-Omakango pipeline is build, then a purification works with a capacity of at least 2 000 m^3/a and an additional clear water storage facility of at least 10 000 m^3 will be required.

7.2.13 Oshakati-Ondangwa Pipeline

This component of the water supply network has no serious problems as both the pumpsets and pipeline are in good condition and have sufficient capacity to supply in the water demand for at least the next five years if the burden of supplying water into the Herringbone System can be relieved by providing the proposed new pipeline between Oshakati and Omakango.

7.2.14 Ondangwa

The only major problem at Ondangwa is the limited clean water storage facilities. Purified water from Oshakati flows into the existing 9 000 m^3 concrete reservoir, but when the reservoir is full, water is diverted into an open storage dam. This is a similar situation as at Oshakati and an additional clean water storage facility of at least 5 000 m^3 is required, but this requirement needs further investigation.

7.2.15 Ondangwa-Oshivelo

This component of the water supply network has no serious problems and the pipeline will have sufficient capacity for many years to come. However, in future it would be necessary to upgrade the pumps according to the water demand.

In order to determine the actual water consumption pattern along the pipeline it, it is recommended that additional water meters be installed at Onathinge on both the Ondangwa-Oshivelo pipeline and Onathinge-Onayena branch pipeline. One water meter should also be provided on the Ondangwa-Oshivelo pipeline at Okatope. All these water meter readings should be taken regularly on a monthly basis. The information obtained will play an important role in the planning and design of the future water supply infrastructure in south-eastern Owambo.

7.2.16 Ondangwa-Oshikango Pipeline (Herringbone System)

The Ondangwa-Iindangunge component is no longer able to supply in the peak water demand of the Herringbone System because it has reached its design capacity of 1,5 Mm^3/a.

However, it is still able to meet the average water demand, but would not be able to do so once the constricting components further along the Omakango-Oshikango pipeline component has been upgraded. It is therefore necessary to investigate the possibility of a pipeline between Oshakati and Omakango.

Water is already boosted from Ondangwa towards Iindangunge, but the capacity could only be increased by upgrading the pumpstation to deliver water at a slightly higher pressure. In this way the capacity of the system can be increased to 2,6 Mm^3/a. It is also recommended that a water meter be installed at Iindangunge to measure the volume of water consumed or wasted between Ondangwa and Iindangunge.

The Iindangunge-Omakango component can supply in the average water demand, but not in the peak demand. The future water requirement along this pipeline is estimated at 2,3 Mm^3/a. The water in the pipeline gravitates from the tower at Iindangunge towards Omakango. If the tower at Iindangunge is bypassed, water can be boosted to Omakango at a higher pressure, but this possibility requires further investigation before implementation. Water should also be metered at both Iindangunge and Omakango to determine the exact rural water consumption along this pipeline component of the Herringbone System.

The Iindangunge-Oshigambo pipeline has sufficient capacity to supply in the water demand at Oshigambo, but the pumpstation should be upgraded. A 300 m^3 ground reservoir is also required at Oshigambo. Water should also be measured at Iindangunge and Oshigambo to determine the rural water consumption along the pipeline.

The Omakango-Endola pipeline is in good condition, but needs upgrading. An additional pipeline is required to supply at least 130 000 m^3/a.

The Omakango-Omafo pipeline component of the Herringbone system can no longer supply in the average water demand and water shortages are experienced at all the centres north of Omakango. The pumpstation and the pipeline must therefore be upgraded to supply at least 1,700 000 m^3/a to Omafo. An additional 5 000 m^3 reservoir is also necessary at Omakango. The direct boosting of water from Omakango to Omafo could relieve the problem to some extent, but needs further investigation. The metering of water at Omakango and Omafo is extent, but needs further investigation. The metering of water at Omakango and Omafo is necessary to determine the extent of rural water consumption along this component of the Herringbone System.

The existing Omakango-Onambutu pipeline has been damaged during the war and should be repaired to supply at least 300 000 m^3/a. A 350 m^3 ground level reservoir should also be provided.

The Omafo-Oshikango component of the Herringbone System has only recently being recommissioned and except for the shortage of water available at Omafo, there are no other problems.

The Omafo-Engela pipeline needs upgrading to supply 20 000 m^3/a.

On the Omafo-Eenhana pipeline there is a booster pump station at Oshandi, but it has not been in operation for a number of years. This reduces the capacity of the pipeline and Eenhana experiences water shortages at times. Water could be boosted from Omafo in future, but the whole matter needs further investigation to improve the supply of water to Eenhana and it seems that an additional pipeline to supply at least 700 000 m^3/a should be provided, as well as an additional 4 000 m^3 reservoir at Omafo and a 750 m^3 reservoir at Eenhana. This project would also require a 1 000 m^3 ground level reservoir and a 100 m^3 water tower at Oshandi. The construction of an elevated reservoir at Eenhana should also be investigated.

On the Omafo-Omungwelume pipeline there is a booster pumpstation at Ongenga, but it has not been operational for some time. Water is currently being pumped from Omafo to Omungwelume, but there are problems with this component of the Herringbone System. There is a lack of water at Omafo for further distribution, and the Ogongo-Omungwelume pipeline is also insufficient. The pipeline should be upgraded to supply 500 000 m^3/a and a 700 m^3 reservoir should be provided at Ongenga.

At Ondukutu and Ongha there are no problems with the water supply facilities, but Ohangwena needs a 450 m^3 ground level reservoir, Oshitaye needs a 200 m^3 ground level reservoir and Odibo needs a 150 m^3 water tower.

From the above it is clear that the Herringbone System needs extensive upgrading.

7.3 UPGRADING OF LOCAL SURFACE WATER WORKS

The surface water storage excavation and pumped storage dams which are in need of maintenance should receive the necessary attention because, although these water sources are not considered reliable enough to support urban water demand, they are at least suitable to support rural domestic and stock water demand. In this way the burden on expensive piped water systems can also be relieved.

The possibility of additional dams should also be investigated and the whole effort to upgrade, maintain and extend these facilities should also be organized by the rural development authorities in participation with the rural communities. Refer to **ANNEXURE 4** for the location of these dams. According to existing records there more than 200 dams which may need maintenance and a maintenance programme should commence as soon as possible.

It has also been estimated that at least 2 000 wells will have to be upgraded or developed to ensure safe water supplies for the population.

7.4 EXTENSION OF GROUNDWATER SOURCES

Due to a lack of comprehensive knowledge on the hydrogeological environments in Owambo, there may exist possibilities to locate and utilize perched fresh water aquifers in the brine lake area by constructing proper wells or handpump systems. The same principle applies for deeper borehole water supplies in the western and eastern areas, as well as the southeastern artesian area. These aspects should also be investigated because at least 450 boreholes would be required to satisfy the water demand in zones 6 and 8 to support stock farming activities. The extension of groundwater schemes in the rural environment is also seen as development which should be done with the participation of the local communities and assisted by rural water development authorities.

It has been estimated that at least 600 boreholes will be required to provide water for domestic and stock consumption.

7.5 SUMMARY

Although the water supply network in Owambo is very large and comprises many components, the day to day operation and maintenance is at a very high standard, especially when the local conditions in Owambo are taken into consideration.

A number of the components of the water supply network have reached their design capacity and should be upgraded to supply in the existing water demand. In some cases there are possibilities for short terms solutions by altering pipework and pump configurations at relatively small capital cost.

At some places the water storage capacity is insufficient and it will be necessary to build small elevated storage facilities while at other places it is necessary to build very large ground level reservoirs.

The installation of a number of additional water meters at various points along the supply network must also receive priority. Also refer to **Section 9.3.5**.

In spite of the proposed upgrading and extending of the bulk water supply network, attention should also be given to the improvement of local surface water and groundwater schemes to provide the water to the rural communities and to augment expensive piped water supplies.

For this purpose it is proposed that geohydrological consultants be appointed to investigate the hydrogeological environments in Owambo in order to determent the groundwater potential in the region and to appoint hydrological consultants to determine the surface water runoff potential by utilizing the latest technology to measure or estimate runoff.

A brief summary of the proposed upgrading and extension of the bulk water supply network is given in **TABLE 7.2** on page 125. A planning period of 15 years was taken for pipelines and 30 years for canals. The proposed capacities of the different components will have to be verified by more detailed studies.

It is therefore recommended that the Planning Division conducts further investigations into the upgrading and extension of all the water supply facilities in Owambo as indicated above.

TABLE 7.2 : PROPOSED EXTENSION OF THE WATER SUPPLY NETWORK

COMPONENT	DATE REQUIRED	SUPPLY REQUIRED (m^3/a)
Major Water Carriers		
Ogongo-Oshakati	1990	30 000
Oshakati-Omakango	1990	12 000 000
Herringbone System	1990	10 000 000
Oshakati-Ondangwa	1995	4 000 000
Calueque Dam - Olushandja	2000	135 000 000
Minor New Pipelines		
Anamulenge	1995	20 000
Elim	1995	50 000
Okalongo	1995	450 000
Okangkolo	1995	200 000
New Distribution Pipelines		
Amwaanda	1995	50 000
Olukonda	1995	50 000
Onaanda	1995	50 000
Ondobe	1995	30 000
Long Term Development		
Ombalantu-Tsandi	2010	70 000
Ombalantu-Omungwelume	2010	5 000 000
or		
Ogongo-Omungwelume	2010	5 000 000
Local Water Sources		
Dams (± 200)	Continuous	5 000 000
Wells (± 2 000)	Continuous	2 000 000
Boreholes (± 600)	Continuous	5 500 000
Water Source Investigations		
Hydrological Investigations	1995	Not applicable
Geohydrological Investigations	1995	Not applicable

8. PROPOSED DEVELOPMENT PROGRAMME AND ESTIMATED CAPITAL COST

The Master Water Plan for Owambo only provides broad guidelines for the future development of the water supply infrastructure in the region. Due to a lack of detail on the actual water and supply situation at a number of places, it has been proposed that further investigations should be done. The timing of projects and the actual estimated costs which are given in this report should therefore be seen as provisional. Please refer to **TABLE 8.1** on page 127 for more detail.

It is shown that to upgrade the formal water supply network at least R127,8 million would be required within the next 15 years, while for the upgrading of local water sources an estimated R20 million would be required. It is also estimated that R12 million would be required for water resource investigations in Owambo to support rural water supply development. The capital cost for the proposed long term development schemes is R45,2 million and the total estimated capital cost for water supply infrastructure development in Owambo during the next 15 to 25 years is R225 000 000 or at least R10 million per annum.

9. WATER SUPPLY AND TARIFF POLICY

9.1 GENERAL

In determining resource allocation and pricing policies for the supply of water in Owambo, the principles of equity, efficiency and affordability should be considered as well as community participation at all levels.

Equity demands that the population should have access to safe water. **Efficiency** requires that scarce water sources should not be wasted, water schemes should be cost effective and water supply infrastructure should be maintained. **Affordability** recognizes that water resources are limited and has implications for capital investment, recurrent costs and cost recovery. The definition of water scheme development priorities should be to strike a balance between what is efficient and what is equitable.

TABLE 8.1 : PROPOSED PROGRAMME AND CAPITAL COST

COMPONENT	SUPPLY REQUIRED (m^3/a)	DATE REQUIRED	CAPITAL COST (Rand)
Major Water Carriers			
Ogongo-Oshakati	30 000 000	1990	55 000 000
Oshakati-Omakango	12 000 000	1990	10 000 000
Herringbone System	10 000 000	1990	25 000 000
Oshakati-Ondangwa	4 000 000	1995	5 000 000
Calueque Dam - Olushandja	135 000 000	2000	40 000 000
Subtotal			135 000 000
Minor New Pipelines			
Anamulenge	20 000	1995	500 000
Elim	50 000	1995	800 000
Okalongo	450 000	1995	8 000 000
Okangkolo	200 000	1995	1 500 000
Subtotal			10 800 000
New Distribution Pipelines			
Amwaanda	50 000	1995	500 000
Olukonda	50 000	1995	500 000
Onaanda	50 000	1995	500 000
Ondobe	30 000	1995	500 000
Subtotal			2 000 000
Long Term Development			
Ombalantu-Tsandi	70 000	2010	5 000 000
Ombalantu-Omungwelume	5 000 000	2010	44 000 000
or			
Ogongo-Omungwelume	5 000 000	2010	40 200 000
Subtotal			45 200 000
Local Water Sources			
Dams (± 200)	5 000 000	Continuous	5 000 000
Wells (± 2 000)	2 000 000	Continuous	5 000 000
Boreholes (± 600)	5 500 000	Continuous	10 000 000
Subtotal			20 000 000
Water Source Investigations			
Hydrological Investigations	N/A	1995	2 000 000
Geohydrological Investigations	N/A	1995	10 000 000
Subtotal			12 000 000
GRAND TOTAL			225 000 000

The responsibilities of Government and the participation of the community, especially in the rural environment of Owambo, should be a united effort to ensure adequate and safe water for all.

9.2 WATER SUPPLY POLICY

9.2.1 Water Supply Objectives

The major objectives with water supply in Owambo is to support and facilitate social upliftment, rural development and employment creation. The population must be provided with, or assisted to help themselves to provide reasonable access to safe water for drinking, personnal hygiene and other domestic purposes.

However, to support socio-economic development and growth in Owambo, it is a prerequisite to create on adequate and reliable bulk water supply infrastructure as and when required. The capital cost for the establishment of bulk water schemes, as well as the operation and maintenance cost for those schemes, are very high. This financial burden cannot be carried by the consumer alone, but some contribution in which affordability will play a major role, must be made.

The participation of all beneficiaries at all levels to plan, implement, operate and maintain their water supplies in an economical way is necessary to achieve the water supply objectives.

9.2.2 Water Supply Responsibilities

The conservation and judicious utilization of water in the arid environment of Namibia should be encouraged to ensure that such a scarce commodity is used optimally for balanced development in all sectors of the economy. The limited water resources and high capital cost to establish the necessary water supply infrastructure require the implementation of a national water strategy aimed at the location of resources, the prevention of resource pollution, the supply of water and water management. These responsibilities have been entrusted to the Department of Water Affairs and also include the bulk supply of water at a local, regional and national level.

However, not only the Government Regional or Local Authorities, but individuals and communities are also responsible for the establishment, operation and maintenance of their water supplies, as well as the judicious utilization of the water provided. The consumers in Owambo should therefore make a contribution towards the development and operation of their water supplies.

9.2.3 Water Resource Development and Allocation

The available water resources in Owambo are limited, but the integrated and combined use of water may bring relief. The only way to achieve this goal is to utilize the ephemeral surface water and potable groundwater sources optimally on an integral basis and to augment those resources with water from a more reliable source such as the Cunene River.

Therefore, the principle applied for the development of water resources for specific consumers in Owambo is that local water sources must be utilized first, then a regional water source (like piped water) further away and finally a national water source which can supply much more water than required by a region. The Cunene River is considered such a resource for water supply to Owambo, the generation of hydropower and the possible importation of water to other regions in the north of Namibia.

Where scarce water resource have to be shared by a number of consumers, the priorities dictate that domestic consumers and stock watering requirements are the first priority to be satisfied. The second priority is seen as the water demand for industries and mining because those activities create employment and generate export income for the country. Irrigation is considered to be a third priority while other use, such as for navigation or recreation purposes are the least important.

9.3 WATER TARIFF POLICY

9.3.1 Water Tariff Objectives

The long term objective of the bulk water tariff policy in Namibia is that all consumers should pay for water at the actual cost to supply water. However, due to the fact that the capital cost component of the water schemes in Owambo is prohibitively high, the present aim is that domestic consumers with a piped water supply should at least pay for their water at a tariff which equals the recurrent cost to supply the water. For those people who cannot afford water, it is supplied free of charge and is therefore fully subsidized by the state.

In the case of commercial undertakings such as mines, a tariff which covers the full capital and running cost is levied, but there are no such examples in Owambo at present.

Although it is possible to calculate the water cost for each water supply component or at every scheme in Owambo, no differentiated water tariffs are levied, but a uniform water tariff for the whole region.

The water tariff policy is generally directed towards bringing home to the consumer the value of water as a scarce commodity in an arid region and the tariffs are subject to annual revision and periodic adjustment according to the economic situation in Namibia.

9.3.2 Water Cost Structure

A distinction is made between the capital cost component and running cost component of the total cost to supply water. The capital cost component is a fixed redemption cost after the money has been invested in the water scheme, while the running cost component is variable according to economic conditions.

The capital cost component of the total water cost is the capital cost of the water scheme amortized as a function of the actual water supplied over the lifetime of the scheme.

The running cost comprise several cost components which include operating, maintenance and overhead costs. The operating costs are salaries, supplies, stores and services. The maintenance cost for water schemes in Owambo is taken as the average for the whole country. The overhead cost is a percentage of the cost incurred by the Department for administrative duties, the location of water sources, the planning, design and construction of water schemes, as well as the control function to ensure the optimal conservation and utilization of the water resources in the country.

9.3.3 Water Supply Cost in Owambo

A breakdown of the cost to supply water in Owambo is shown in TABLE 9.1.

TABLE 9.1 : WATER SUPPLY COSTS

COST COMPONENTS	COST (c/m^3)	
Fixed Cost		155
Capital	155	
Subtotal	155	
Running Costs		94
	84	
Operation	4	
Maintenance	6	
National Overheads	94	
Subtotal		
TOTAL WATER COST		249

2.3.4 Water Tariffs in Owambo

Although the running cost component of the total water cost is 94 c/m^3 in Owambo, the present water tariff is only 66 c/m^3. The cost of water supply in Owambo is therefore heavily subsidized by the State.

According to the 1988/89 water demand estimate in Owambo, the running cost to supply the water will be R7,3 million of which R4,9 million will be recovered from the sale of water.

The financial implications are that no capital cost recovery is achieved and that there will a loss of R2,4 million for the Government to supply in the expected water demand in Owambo during the 1988/89 financial year. This situation needs rectification in future.

Extremely high operating costs are incurred in Owambo due to the fact that water must be supplied from Ruacana, the effects of war damage and water losses in general. The Owambo region is at present responsible for more than 44% of the total deficit between bulk water supply expenditure and income in Namibia.

9.3.5 Water Metering

Accurate water metering in Owambo is necessary to prepare water accounts, to determine water consumption trends, to establish where water is misused or wasted, to draw up a water balance for future planning purposes and to estimate future water supply costs to levy appropriate water tariffs. With this purpose in mind, a report (**Reference 35**) have been prepared to recommend the installation of the required water metres. Also refer to **ANNEXURE 5** for more detail on the proposed water metering network in Owambo.

9.4 COMMUNITY INVOLVEMENT

In future the emphasis on the improvement and extension of bulk water supply schemes in Owambo will shift to rural water supply development because the bulk water supply network is reasonably well established to sustain the development of the urban centres and irrigation projects while rural water supply has been neglected.

This also implies greater community involvement if the population would like to have reasonable access to water sources which would be hygienic, protected from pollution and sufficient to improve the standard of living and productive commercial activities.

The communities can be assisted by the Government to help themselves in the establishment of rural water supplies, but the cost of rural water supplies will most probably have to be subsidized on equity grounds. However, the population can make an initial contribution in kind by providing labour to construct wells and subsequently to maintain water systems.

The low density of the rural population in Owambo and their low income will make it difficult to levy water tariffs although there must be some degree of cost recovery to limit the burden on recurrent costs.

It is therefore proposed that the Department of Water Affairs assist with water resource development and that the rural development authorities responsible for Owambo assist with the training and education the population to establish reliable water supply facilities (wells, hand pumps, windmills, diesel driven pumps, etc.) and to ensure health for all through hygienic water use and sanitation.

The recovery of cost and water tariffs remain a sensitive issue in which the communities should be mobilized to collect fees for domestic and stock drinking water.

10. SUMMARY AND CONCLUSIONS

10.1 SUMMARY

10.1.1 General

In **Chapter 1** to this report a brief description was given on the development of the water supply infrastructure in Owambo as proposed in and directed by various reports on master and regional water planning in the past.

The purpose of this Regional Master Water Plan for the Owambo Region has been to document the latest information which dictates the requirements for water supply infrastructure development and to recommend broad planning proposals for the future improvement and extension of regional and rural water supply schemes.

10.1.2 Geographical Characteristics

During the discussion on the geographical characteristics of Owambo in **Chapter 2** it was shown that the region receives a relatively high rainfall, but that the rainfall is erratic and unreliable to a large extent. The very flat topography does not allow the construction of major surface water storage works and the area is indeed prone to seasonal flooding in the central areas when good precipitation occurs. It was also shown that due to the geology of the region, the potential for mining and industrial development is limited and that the hydrogeological conditions are problematic for the development of groundwater sources. This is mainly due to high salinity, depth to water table and pollution in open wells. Although the region is covered by the generally, marginally irrigable sands of the Kalahari Group, there are some soils with potential for irrigation development in the western areas. The vegetation cover can also support stock farming as an important agricultural activity. Subsistence dry land farming with pearl millet as the most important crop, makes an important contribution towards self-sufficiency in food production, but due to the poor soils and erratic rainfall this activity is very susceptible to failure.

10.1.3 Water Resources

In **Chapter 3** it was described how the prevailing hydrological and hydrogeological conditions in Owambo, as well as water quality problems, limit the available water resources to ephemeral surface runoff in the central area and marginally potable groundwater in the western and eastern areas. However, the whole region lies adjacent to the perennial Cunene River and access to this very important water source has already been established through major water supply infrastructure. Due to the regrettable war situation along the Angola-Namibia border in the past, the previous water abstraction agreements could not be implemented effectively and will have to be renewed as soon as possible to augment the local water resources in order to support development in Owambo.

10.1.4 Development Potential

Chapter 4 provided an overview of the socio-economic conditions in Owambo and although the formal infrastructure development for the major centres in Owambo can be compared with the best in Africa, the outlying rural areas were neglected in the past. The provision of water, roads, electricity and communications, as well as the improvement of health, education, social and community services, will impact upon settlement trends, the urbanization of the rural population and their water requirements. Possibilities exist for the development irrigation projects, fish farming and forestry while dry land crop production and stock farming are major areas for future improvement. However, the potential for mining and large scale industrial development seems limited. It has also been estimated that by the year 2020 the total Owambo population in Namibia would be 1,57 million of which 1,24 million will reside in Owambo. About half of the population in Owambo is also expected to reside in the rural areas and it is therefore of great importance to ensure that the rural environment be included in future development projects. These aspects will most certainly impact upon the future water demand pattern, its magnitude and the possibilities for water supply schemes in terms of natural, human and financial resources.

10.1.5 Water Supply Infrastructure

As described in **Chapter 5**, the formal bulk water supply network to the urban centres has been very well developed in the past, but the expected increase in water demand due to urbanization and the distribution of water to the neglected rural communities would require the upgrading and improvement of the existing facilities. The development of new infrastructure and the maintenance of the existing infrastructure would also require substantial capital input. However, it is clear that capacity and cost constraints for piped water will be severe and that the judicious development of small scale surface water storage works and the effective utilization of the available groundwater potential should be a major priority until more reliable piped water supplies can be provided where possible, practical and affordable.

10.1.6 Water Demand

From the discussion in **Chapter 6** it is clear that it is not only very difficult to determine or estimate the total potential of the internal ephemeral surface water and groundwater sources in Owambo, but that to estimate the future water demand is just as problematic and complex. However, the whole region was divided into eight different water demand and supply zones on the basis of the existing water supply infrastructure, possible development potential, the associated water demand and the availability of water resources to support development. A theoretical calculation of the most probable water consumption by the year 2020 has been made and a description given on possible ways to supply in the estimated water demand in order to provide a comprehensive background to these problems. The estimated future water demand was also determined by examining the past water consumption patterns along the existing bulk water supply network.

10.1.7 Water Supply Development

The water supply infrastructure development proposed in **Chapter** 7 of this report is based on the estimated water requirements in the different water demand and supply zones. It was shown to what extent the perennial Cunene River and other local water sources will be able to supply in the estimated future water demand, but due to practical and economic considerations, it will not be possible to pipe Cunene River water into every remote corner of Owambo. The incorporation and utilization of all the available local water resources are therefore of utmost importance to support rural development at affordable costs. It is therefore proposed that Cunene water should be reserved for urban, rural and irrigation development where feasible. Due to practical considerations and cost implications the ephemeral surface water and groundwater should be utilized to meet the water demand in the rural areas. A broad master water planning strategy has been proposed to include consideration of the security of access to Cunene water, the improvement and maintenance of the existing bulk water supply infrastructure to urban centres, the extension of the bulk water supply network, the distribution of piped water to the rural communities, the upgrading of facilities to utilize the surface water potential and the formulation of investigations into the groundwater resources of the region with the aim of establishing more shallow wells and boreholes for rural water supply purposes.

10.1.8 Programming and Cost

A programme for the execution of the proposals and the capital cost involved is briefly reflected upon to serve as guidelines within the total framework of a complex water infrastructure development strategy for the Owambo region.

10.1.9 Community Participation

Due to the nature of the water supply situation in Owambo, the cost to supply potable and raw water for each type of water demand is exceedingly expensive. The burden on the Government to supply in the bulk water demand of all formal urban and peri-urban centres and to provide for the assurance of supply under the prevailing adverse hydrological conditions, is immense. It is therefore essential that the rural communities should be involved to advise Government on their needs and they should be assisted to make a contribution towards the development their water supplies. The communities must therefore be provided with an extension service to develop water sources and safe water supplies which are affordable. It should be the aim to bring safe water as near as possible to every community in Owambo. However, all these objectives can only be realised if some practical means to facilitate funding, participation and the levy of water tariffs could be devised and implemented. Proposals are made in that regard and could be considered for adjustment and implementation by the Ministries and local authorities involved.

10.2 CONCLUSIONS

The major conclusions for the report is summarized briefly as follows:

10.2.1 The discussions in this Regional Master Water Plan for Owambo are considered to be a fair representation of the current (March 1990) situation in Owambo as far as water consumption, estimated future demand and the required future water supply infrastructure is concerned.

10.2.2 The proposals in the Master Water Plan serves as broad guidelines for the future development of the water supply infrastructure and all proposals should be investigated in much greater detail before implementation.

10.2.3 The major increase in the estimated future water demand in Owambo will be mainly be generated by the agricultural sector through irrigation, fish, farming, forestry and stock watering. The increase in population and improvement of the standard of living will also result in urbanization and an increase in water consumption in the urban centres where community services and infrastructure will be extended. Improvement to housing, schools, clinics, churches, shops, public service offices and service industries, as well as water, electricity, sewage and telecommunication will take place.

10.2.4 The Cunene River should be seen as the major water resource to support agricultural, and urban development in Owambo. Due to this fact, access to the

Caluegue Dam should be assured through a new international agreement with the Peoples Republic of Angola.

10.2.5 Surface water resources are not completely reliable for urban and rural water supply development. The utilization of these resources are, however, important from an economical point of view, but safeguarding these sources with water from the Cunene should always be kept in mind. The utilization of excavation and pumped storage dams should also receive attention and viable systems should be renewed or repaired.

10.2.6 Groundwater source are important in those areas where it is potable or suitable for stock watering purpose. It is therefore necessary to embark upon thorough geohydrological investigations to establish the true nature of the hydrogeological environments in Owambo, especially with reference to the occurrence of a possible perched fresh water table which could be utilized by rural communities through digging of wells or hand pump systems.

10.2.7 The provision of assistance to the rural communities to participate in the establishment of safe drinking water supplies from wells and boreholes should be a major priority to improve health and welfare. The supply of safer water through improved well construction should be attended to at the same time.

10.2.8 This existing bulk water supply network should be maintained and extended where appropriate, feasible and affordable. Expensive piped water networks should therefore be avoided into stock farming areas where groundwater sources could be located and utilized.

10.2.9 The major priority for bulk water infrastructure development to secure the assurance of supply in the central and north-eastern areas of Owambo will be to upgrade the bulk water supply link between Ogongo and Oshakati, as well as a link between Oshakati and Omakango to relieve the load on the Oshakati-Ondangwa-Omakango pipeline system. The provision of additional pipelines to improve the distribution of water through the existing Herringbone Network to serve adjacent areas in central and northern Owambo is also a major priority. The possibility to provide piped water into the central northwestern area to Okalongo and the central southern area to Elim, Onaanda and the area south of Okahau should also be investigated. An eastern extension from the Ondangwa-Oshivelo pipeline to Okankolo and a pipeline from the artesian groundwater sources at Oshivelo to stock farming development north of Oshivelo should also be considered if no suitable local groundwater sources can be located.

10.2.10 The location of future irrigation, fisheries or forestry projects should be chosen in areas adjacent to the canal systems in Owambo and more specifically in western Owambo where irrigable soils are available and relatively easily accessible with water from the Calueque Dam.

10.2.11 In view of the high capital costs involved in the proposed hydrogeological investigations, the upgrading of existing excavation and pumped storage dams, the development of rural water supplies and the upgrading, extension and maintaining of the vital bulk water supply network, efforts should be made to obtain foreign or external financial assistance through the donor community or international financing organizations.

10.2.12 The principle of community participation in water development programmes and the levy of water tariffs where appropriate, should be investigated and implemented.

10.2.13 The importance of environmental assessments to propose adequate management strategies when new water projects are proposed and implemented is recognised and should receive proper attention during all phases of water project development in Owambo.

11. RECOMMENDATIONS

It is recommended that:

11.1 The contents of this report be accepted as a true reflection of the existing conditions in Owambo relating to water consumption, future water demand and the proposed requirements for adequate water supplies.

11.2 The conclusions in **Section** 11.2 be accepted as the basic guidelines for future water supply infrastructure development in Owambo.

11.3 The proposed future water supply infrastructure development as described in **Chapter** 7, as well as the proposed development programme and the capital cost estimates in **Chapter 8** be accepted in principle for further elaboration as required within the framework of the actual future rate of development and the availability of capital to finance water infrastructure development.

11.4 The proposed water supply and tariff policy in **Chapter 9** be accepted as a basis for further discussion, adjustment and effective implementation by Government.

11.5 A copy of the Regional Mater Water Plan for Owambo be submitted to the Director General of the National Planning Commission.

PLANNING DIVISION

This report has been compiled by

Mr P Heyns Pr Eng, Director: Investigations and Research

Mr S Aldrich Pr Eng, Chief: Planning

Mr J H G Davel, Assistant Engineer, Planning Division

12. APPROVAL OF RECOMMENDATIONS

12.1 This report is approved for submission to the Director: Investigations and Research.

CHIEF: PLANNING
DATE:

12.2 The recommendations in **Chapter 11** are supported and the report submitted to the Permanent Secretary for Water Affairs for approval.

DIRECTOR: INVESTIGATIONS AND RESEARCH
DATE:

12.3 The recommendations in this report are approved.

PERMANENT SECRETARY FOR WATER AFFAIRS
DATE:

13. REFERENCES

1. **Owamboland Master Water Plan.** Department of Water Affairs, Namibia. September 1968. (Internal report).

2. **Waterbronontwikkeling in Suidwes-Afrika met Spesiale Verwysing na die Benutting van Binnelandse Surplus Watervoorrade as Alternatief tot die Benutting van Water van die Noordelike Grensriviere.** Department of Water Affairs, Namibia. August 1974. (Internal report).

3. **Herwaardering van die Meesterwaterplan (1968) vir Owambo.** Department of Water Affairs, Namibia. July 1974 (Internal report).

4. VAN DER MERWE J.H. **National Atlas for South West Africa/Namibia.** Windhoek: Nasionale Boekdrukkery, 1983.

5. BEYERS J.J. KATSIAMBIRTAS E.E. **Climate of South West Africa Series no 1.** Department of Transport, Meteorological Service, Namibia. September 1987 (Preliminary internal report).

6. SöNGE G, **Mineraalbronne en mynbou-ontwikkeling. Beplanningsnavorsing vir Owambo. Ad hoc verslag no 2.** Instituut vir Beplanningsnavorsing, Universiteit van Stellenbosch, 1974.

7. **Report on some economic aspects of the geology of Owambo.** Geological Survey. Namibia 1980.

8. A.O.C. TECHNICAL SERVICES (Pty) Ltd. **Reconnaissance Survey of Owamboland Soil for Irrigation from Lower Cunene River.** South West Africa Water and Electricity Corporation (Pty) Ltd. November 1966.

9. A.O.C. TECHNICAL SERVICES (Pty) Ltd. **An Economic Assessment of the Proposed 4 000 Hectares Irrigation Project. Supplement to the Report on a**

Reconnaissance Soil Survey of Owamboland. South West Africa Administration, Water Affairs Branch. March 1967.

10. A.O.C. TECHNICAL SERVICES (Pty) Ltd. **Report on an Agrinomic and Management Study of the proposed first phase irrigation areas in Owamboland.** South West Africa Administration, Water Affairs Branch. July 1967.

11. LOXTON R.F, HUNTING AND ASSOCIATES. **Consolidated Report on reconnaissance surveys of soils of northern and central South West Africa in terms of their potential for irrigation.** Windhoek. Department of Water Affairs, Namibia. December 1971.

12. SWANEVELDER C.J, DE KOCK G.L, NIEMANN W.A. **Fisies-geografiese aspekte. Beplanningsnavorsing vir Owambo. Ad hoc verslag no 4.** Instituut vir Beplanningsnavorsing, Universiteit van Stellenbosch, 1974.

13. OLIVIER H, **Great Dams in Southern Africa**

14. **Cunene Hydro-Power Potential.** Department of Water Affairs.

15. **Memorandum on the water supply to Owambo from the Cunene River.** Department of Water Affairs, File 11/3/1, Namibia. December 1987. (Internal Memorandum).

16. **Report of the Commission of Enquiry into South West Africa Affairs,** 1962-63 Government Printer, Pretoria, RSA.

17. CLAASEN P.E, PAGE D. **Ontwikkelingsplan vir Owambo. 1978.**

18. LOXTON, VENN AND ASSOCIATES, PLAN. **Ontwikkelingstrategie vir Owambo. Werksdokument.** Augustus 1985.

19. LOXTON, VENN AND ASSOCIATES, PLAN. **Ontwikkelingstrategie vir Owambo. Samevatting, November 1985.**

20. **Owambo.** Department of Foreign Affairs, RSA 1971

21. MALAN J.S **Peoples of South West Africa/Namibia**, HAUM Pretoria, May 1980.

22. **Namibia Today.** Department of Governmental Affairs, March 1988.

23. TOTEMEYER G.K.H. **Staatkundige en enkele aspekte van sosiale ontwikkeling in Owambo. Bespreking, evaluasie en aanbevelings. Beplanningsnavorsing vir Owambo. Ad hoc verslag no 1.** Instituut vir Beplanningsnavorsing, Universiteit van Stellenbosch, 1974.

24. **Population census 1970, South West Africa. Report no 02-05-26,** Secretary for Statistics, Department of Economic Affairs, Pretoria, South Africa. September 1978.

25. **Population census 1981 - Geographical distribution. Report no 01-01** Director of Development and Co-ordination, Department of Economic Affairs, South West Africa/Namibia, 1981.

26. STALZ E.L.P, **Verstedeliking in Suidwes-Afrika/Namibia - Verkenningstudie.** Buro vir Navorsing, Akademie. Navorsingsverslag 1/1987.

27. **Oshakati - Ongwediva - Ondangwa - Olunu omgewing Sosio-ekonomiese opname.** PLAN Medewerkers vir die Direktoraat: Ontwikkelingskoördinering, 1985.

28. KASSIER W.E, VAN DER MERWE F.J. **Die Landbousektor in Owambo. Ontleding van die huidige situasie en aanbevelings ten spyte van toekomstige ontwikkeling. Beplanningsnavorsing vir Owambo. Ad hoc**

verslag no 3. Insitituut vir Beplanningsnavorsing, Universiteit van Stellenbosch, 1974.

29. **Aquaculture S A Waterbulletin** Vol 14 No 3 and Vol 15 No 6, 1988

30. LOXTON VENN AND ASSOCIATES. **Proposals and Feasibility Study for a Forestry Project in Owambo.** March 1987.

31. SPRUITJ H, **UNICEF Assessment Mission for Water Supply Projects in the Owambo Region in Northern Namibia.** Windhoek, February 1990.

32. **Ogongo-Okahau Regional State Water Scheme.** Planning Report, Department of Water Affairs, Namibia. Report no 2700/4/1/1/B1, March 1988.

33. **Ogongo-Okalongo Regional State Water Scheme.** Planning Report. Department of Water Affairs, Namibia. Report no. 2700/1/9/B1, September 1988.

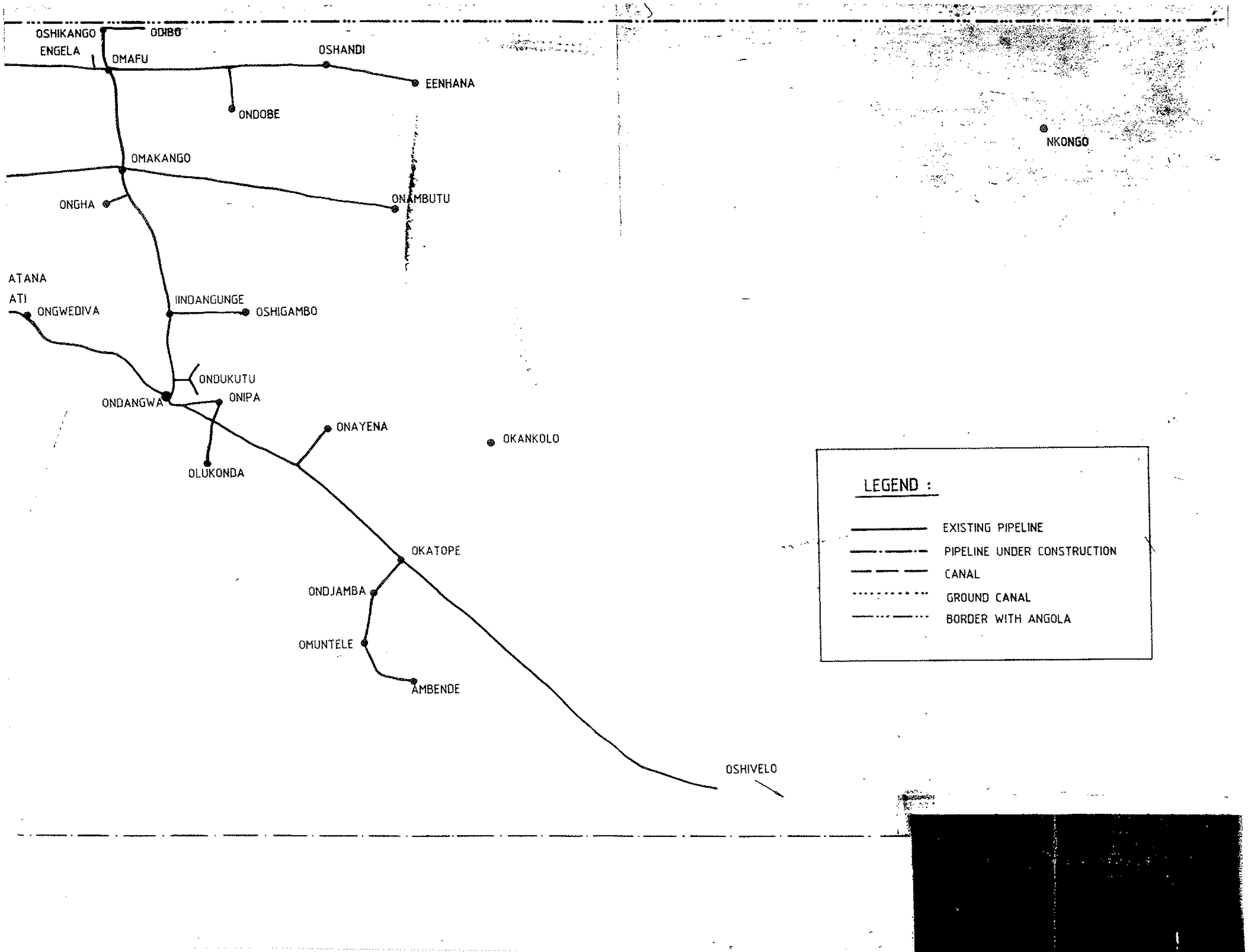
34. **Ogongo-Oshakati Regional State Water Scheme.** Draft Preliminary Planning Report. Department of Water Affairs, Namibia. Report no 2700/4/1/7/5/P1, November 1989.

35. **Oshakati-Omakango Regional Water Scheme.** Draft Planning Report. Department of Water Affairs, Namibia. Report no. 2700/4/1/10/P1, February 1990.

36. **Memorandum oor die Voorgestelde Wysiging van die Watervoorsienings-ooreenkomste en Metering van Water in Owambo.** Department of Water Affairs, File 13/1/B, Namibia, Junie 1989 (Internal Memorandum).

37. **Perspectives on Water Supply in Namibia.** Department of Water Affairs, Namibia. June 1989 and update February 1990.

38. **Namibia. Perspectives for National Reconstruction and Development.** United Nations Institute for Namibia. April 1986.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