DEMARCATION OF WATER BASINS
ON NATIONAL LEVEL

- Improve Knowledge Base
- Collect Data on Demarcated Etosha Sub-Basins
- Establish GIS
- Compile Maps

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1. ANALYSIS AND RANKING OF CRITERIA FOR THE DELIMITATION OF NAMIBIA BASINS

1.1 INTRODUCTION

The concept of integrated water resources management on basin level was identified by the Namibian Water Resources Management Review (NWRMR) as a keystone of the Namibia reform process in the water sector. The current regional focus is the Etosha (Cuvelai) basin in the north-central part of Namibia. The project will concentrate on the establishment of a Basin Management Committee in the Cuvelai-Iishana Sub-Basin. The substantial basin management experiences which have been generated in the Kuiseb Basin will also been utilized for implementation in the Cuvelai-Iishana Sub-Basin.

On the basis of the joint analysis of the key issues on integrated land and water management in basins, a planning workshop in April 2004 identified key activities to be addressed under the German supported NWRMR project within the remaining period up to December 2005. The identified main activities for institutional support and capacity building serve as reference for the consultancy. Through a tender procedure consultants were asked to submit proposals for four components. BIWAC cc was appointed to carry out the investigations regarding component 1, i.e. the finalization of the basin demarcation on national level, to improve the knowledge base of the Namibian basins and to collect more detailed data on the demarcated Etosha –Cuvelai sub-basins. The specific tasks of the assignment are:

1. Analyse criteria considered for delimitation of basins and sub-basins applicable to Namibia;
2. Provide an overview of hard copy maps and digital (GIS) mapping relevant to the criteria above;
3. Collect and critically analyse the delimitations already carried out at national and basin level;
4. Make proposals regarding the demarcation of basins within Namibia;
5. Finalize digital mapping using ArcView GIS format for the approved demarcation at national level and at Etosha Basin level;
6. Make proposals for the selection of 5 basins for completion of basin profiles;
7. Prepare a final report with all above information.

1.2 ANALYSIS OF CRITERIA USED FOR THE DELIMITATION OF THE NAMIBIAN BASINS

To support the process of the demarcation of Namibia’s water basins digital data was collected from various sources, namely the Directorate of Survey and Mapping (DSM), NamPower, Roads Authority (RA), National Planning Commission (NPC), Lund Consulting Engineers (LCE), Rural Water Supply (RWS), NARIS, NamWater, Department of Water Affairs (DWA), Ministry of Agriculture, Water and Rural Development (MAWRD) and the Ministry of Environment and Tourism (MET).

Data evaluation showed that of all available information supplied the data of the Atlas of Namibia (John Mendelsohn et al, MET 2002) and the Profile of North Central Namibia (John Mendelsohn et al,
MET 2000) proved to be most comprehensive, showing the highest reliability and consistency. Therefore this data was mostly used for the delimitation of the water basins as well as for the map production even though the data reflect the situation up to the year 2000/2001 only. Updating this data would be a major task and is beyond the scope of this project. However, some updating or correction was performed on data were possible or assumed to be necessary. It must be pointed out however, that some data lack accuracy and have to be treated with caution. The groundwater and river catchments delineation, groundwater quality and pipeline routing are examples for data sets, which do not show a high accuracy or are outdated.

By using ArcView GIS, different criteria were overlain to evaluate, categorize and analyse their relevance for the delimitation of the water basins. Maps were produced showing combinations of relevant criteria in relation to the basin demarcation. The maps can be viewed as Appendixes 1 and 2.

A map in the scale of 1 : 1 300 000 was compiled showing the proposed delimitation of 11 water basins and relevant delimitation criteria. Four maps in the scale of 1 : 300 000 were produced for each Etosha Sub-Basin, providing an overview of the basin delimitation and delimitation criteria. The maps are presented as hard copies as well as ArcView projects.

The source data and all compiled GIS data and projects are available on two CDs. Where existing, data files are accompanied by metadata files, which state the data source and its accuracy.

1.3 RANKING OF CRITERIA USED FOR THE DELIMITATION OF THE NAMIBIAN BASINS

The first condition for the basin criteria was the availability of digital data for the incorporation in the project GIS. As shown in the above paragraph the obtained data is not always reliable and sometimes lacks the necessary accuracy, depending on the source.

A guideline for criteria to be considered for the basin demarcation was given in the Terms of Reference. The next task the grouping of individual criteria in five categories, i.e. Physiographic Parameters, Water Supply and Consumption, Population Density and Political/Administrative Regions, Infrastructure, Socio-Economic and Cultural Units and Other. The available criteria for the delimitation of each proposed basin were then considered and evaluated with regard to importance, accuracy and relevance. The result is a ranking of criteria within five categories according to the hierarchy in Table 1.

The criteria for the basins on national level are mainly based on the surface and groundwater catchments of the larger river systems. In most cases (an exception is the Kuiseb Basin) two or more rivers and their minor tributaries were combined in one larger basin. Here, the other criteria such as water supply, administrative regions, infrastructure or cultural and environmental units were considered. The main objective was to establish equally sized basins throughout the country where relevant water matters of national and regional importance can be adequately addressed.

For the delimitation of sub-basins it is considered important to establish more manageable units with emphasis on local water aspects. Important criteria are water supply networks and sources, water consumption and land use, to a minor extent also constituency boundaries, conservancies and cultural units. Each of these sub-basins should have an administrative centre where the offices or representatives of relevant Government institutions and the other main stakeholders are present or easy to reach. Meetings of the sub-basin management committee should be held at a venue of the administrative centre.
In the case of the Etosha Basin four sub-basins are suggested, which are based on recommendations by the Etosha (Cuvelai) Management Committee. The still to be established management committees of the other national water basins will have as well to give their input with regard to the sub-division of the management units or sub-basins.

The ranking of the criteria as presented in Table 1 is rather a guideline than a strict rule and the ranking especially in the categories 3-5 can be changed and adapted depending on the individual basin situation.

### Table 1: Criteria Ranking

<table>
<thead>
<tr>
<th>Category 1: PHYSIOGRAPHIC PARAMETERS</th>
<th>Category 2: WATER SUPPLY AND CONSUMPTION</th>
<th>Category 3: POPULATION DENSITY AND POLITICAL/ADMINISTRATIVE REGIONS</th>
<th>Category 4: INFRASTRUCTURE, SOCIO-ECONOMIC AND CULTURAL UNITS</th>
<th>Category 5: OTHER</th>
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<tbody>
<tr>
<td><strong>Groundwater catchments</strong></td>
<td><strong>Water supply infrastructure</strong></td>
<td><strong>Political administrative regions</strong></td>
<td><strong>Infrastructure</strong></td>
<td><strong>Environmental units</strong></td>
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<tr>
<td>Hydrogeological units and</td>
<td>Water Points</td>
<td>Regions</td>
<td>Roads</td>
<td><strong>Financial aspects</strong></td>
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<td>Hydrogeological units and</td>
<td>Pipelines, Canals</td>
<td>Constituencies</td>
<td>Railway</td>
<td><strong>International aspects</strong></td>
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<td>Groundwater flow boundaries</td>
<td>Water Supply Dams</td>
<td>Boundaries, borders</td>
<td>Power lines</td>
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<td>Sub-terrain control areas</td>
<td>Groundwater Schemes</td>
<td>Conservancies</td>
<td>Airports, harbours</td>
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<td>Water Control Areas</td>
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<td>Surface water catchments</td>
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<td>Rivers (perennial, ephemeral), pans,</td>
<td>Bulk water schemes</td>
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<td>oshanas etc.</td>
<td>Municipalities, towns</td>
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<td>Small water schemes</td>
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<td>National Parks, farms etc.</td>
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<td>Enumeration areas</td>
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<td><strong>Socio-Economic</strong></td>
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<td><strong>Cultural units</strong></td>
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<td><strong>International aspects</strong></td>
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2. CRITERIA FOR THE DEMARCATION OF THE 11 WATER BASINS

2.1 ETOSHA BASIN

2.1.1. Physiographic Parameters

The main criteria for the Etosha Basin are the drainage catchment area of the Etosha Pan as lowest area of the North-Central Region as well as the groundwater catchment, which coincides roughly with the surface water catchment. The name ‘Etosha’ Basin is considered more adequate compared to the term ‘Cuvelai’ Basin, which only describes the catchment of the iishana system with a river drainage originating in the north. It is, however, the correct term for the smaller Cuvelai-iishana Sub-Basin as described in the next paragraph below.

The Etosha Basin is also an established geological/hydrogeological term defining a sub-basin of the larger intra-continental Kalahari basin, which comprises large areas of north-central and north-east Namibia as well as areas in neighbouring countries, i.e. Angola, Zambia, Botswana and Zimbabwe.

Ground- and surface water flow is directed from all sides to the centre of the basin, the Etosha Pan. In the western and southern part the proposed basin boundaries follow mainly the surface water divides between the Etosha catchment and the Kunene and Ugab-Huab catchments, which coincide often with the geological contact of the Damara Sequence and the Basement. The borderline between the Omusati and Kunene regions follows the Kamanjab-Ruacana road between Etosha in the south and Ruacana in the north and is defined as the western boundary of the Etosha Basin.

The eastern boundary of the Etosha Basin follows roughly the surface and groundwater divide between the Etosha catchment and the Omatako-Okavango catchment. The political borderlines between the Ohangwena and Oshikoto regions and the Kavango and Otjozondjupa regions, however, coincide almost with the water divides and are therefore considered as the more practical boundaries of the Etosha Basin.

The southern boundary is defined by the surface water divide but often also by the Damara Sequence / Basement rock contact. The basal quartzitic and dolomitic rocks of the Damara Sequence represent the main groundwater recharge area of the intra-continental Etosha Basin and are, in hydrogeological terms, considered as the outer rim of the basin. The eastern part of the so-called Kamanjab Inlier with predominantly Basement rocks is geographically part of the Huab Basin although surface water is partly draining to the north towards the Basement / Dolomite contact.

2.1.2. Population Density and Political/Administrative Areas

The Kaross/Otjovazandu area within the Etosha National Park belongs geographically and historically to the Kunene catchment (west flowing rivers) and was excluded from the Etosha Basin.

The eastern and western boundary of the Etosha Basin is defined by the political borderlines between the Oshikoto and Ohangwena regions (Etosha Basin) and the Kavango and Otjozondjupa regions (Okavango-Omatako Basin) and the Omusati Region (Etosha basin) and the Kunene Region (Kunene Basin), respectively.
2.1.3. Infrastructure, Socio-Economic and Cultural Units

The Etosha Basin comprises the Oshana, Omusati, Ohangwena and Oshikoto regions where the inhabitants belong to the ethnic group of the Oshiwambo speaking people and is therefore ethnically homogenous.

For the demarcation of the Etosha Basin and the four sub-basins in relation to the various criteria see the thematic maps in Appendix 2.

2.2 CUVELAI (IISHANA) SUB-BASIN

2.2.1. Physiographic Parameters

The Cuvelai-Iishana Sub-Basin comprises a system of flat river channels (iishana), which form a massive inland delta. The iishana are seasonally flooded by so-called efundjas and drain into the Omadhiya lakes and from there via the Ekuma River into Etosha Pan. The oshana channel system originates in Angola and is fed by a number of rivers, which have their headwaters as far north as the Encoco highlands.

The groundwater of the Cuvelai-Iishana Sub-Basin is relatively shallow but mostly brackish or saline. The eastern and western boundary follows mainly the transition zone between fresh and saline groundwater. The boundary to the north is defined by the Angola border.

2.2.2. Water Supply and Consumption

A network of canals and pipelines supply water originating from the Calueque Dam in Angola. The water is pumped into a canal to the Olushandja Dam in Namibia and gravitates from there south-eastwards to purification plants at Outapi, Ogongo and Oshakati from where it is pumped into the pipeline network. Some of the Olushandja Dam water flows in a southeastern direction towards the Omadhiya lakes via the Etaka canal. The Etaka canal is, however, excluded from the Cuvelai-Iishana Sub-Basin and part of the Olushandja Sub-Basin, mainly due to administrative reasons.

2.3 NIipele-Odila SUB-BASIN

2.3.1. Physiographic Parameters

The Niipele-Odila Sub-Basin comprises the eastern part of the Ohangwena Region and the northeastern part of the Oshikoto Region. The omiramba Niipele and Odila flow in a southwestern direction towards the Etosha Pan. The omiramba are dormant and water filled only locally after heavy rainfall events.

The sub-basin is underlain by the Ohangwena Kalahari Aquifer, which is the main source for sustainable water supply in the region. The western and southern boundary of the sub-basin is defined by the extent of the freshwater containing portion of the aquifer. The eastern boundary is defined the border to the Kavango Region, which follows largely the surface water divide between the drainage to the Etosha Pan and the Okavango River. The northern delimitation is the border to neighbouring Angola.
2.3.2. Water Supply and Consumption

There are no bulk water schemes in the sub-basin and all villages and settlements are supplied by groundwater sources as well as from seasonally water filled pans that spread over the area. Since independence a large number of water wells were drilled to supply the partly isolated villages and to date most of the population has access to safe drinking water. The main settlements, i.e. Okongo, Omundaungilo and Ohumbulwa are supplied with groundwater from their own boreholes, operated by the Directorate Rural Water Supply, Ministry of Health and other Government institutions.

The water is used for livestock farming and no irrigation is taking place. There are, however, gardening projects planned in the sub-basin.

2.3.3. Population Density and Political/Administrative Areas

The sub-basin includes the Okongo Constituency and larger parts of the Epembe, Okankolo and Omundaungilo constituencies of the Ohangwena Region. The Okongo Quarantine Camp, situated near the border to the Kavango Region is included into the sub-basin although being within the Okavango River catchment.

2.3.4. Infrastructure, Socio-Economic and Cultural Units

There is no major infrastructure in the sub-basin and the population mainly makes a living from small-scale subsistence farming.

2.3.5. Other

The Ohangwena Kalahari Aquifer extends into Angola in the north, where the main groundwater recharge area is believed to exist in the upper catchments of the Omuramba Odila and the Cubango (Okavango) River. The proposed Niipele-Odila Sub-Basin committee should make an effort to co-opt authorities of the neighbouring Cuando-Cubango Province in Angola when discussing aquifer management and conservancy measures.

2.4 TSUMEB SUB-BASIN

2.4.1. Physiographic Parameters

The Tsumeb Sub-Basin is defined by the drainage of surface and groundwater from the Otavi Mountain Land in the south towards the Etosha Pan in the north. The boundary in the south is defined by the geological contact between the Basement rocks and the dolomitic arc of the Damara Sequence, which represents the recharge area of the Kalahari Aquifer underlying the Etosha Basin. The eastern boundary follows roughly the surface and groundwater divide between the Etosha and Okavango basins. The northern sub-basin margin is also defined by the surface and groundwater divide between the omiramba Niipele-Odila in the north and the omiramba Omuthiya-Owambo in the south. The Etosha Pan and its southern foreland are enclosed into the sub-basin.

2.4.2. Water Supply and Consumption

Groundwater is the main source of water supply in the sub-basin, as no major dams or pipeline routes exist. Bulk groundwater schemes are operated by the water utility NamWater at Oshivelo, within the Etosha National Park and at Tsintsabis. The water supply of Tsumeb Town is managed by the Municipality. The Tsumeb Mine is dormant but groundwater is abstracted from the mineshaft and pumped into the municipal reticulation system.
The groundwater in the sub-basin is used for large-scale stock farming but also for crop irrigation, mainly in the area of the dolomite synclines to the north and east of Tsumeb. Most of the water holes of the Etosha National Park are supplied from boreholes, which tap the upper Kalahari Aquifer. The groundwater resources of the Tsumeb Sub-Basin are used locally and no export to other regions is planned in the near future. The proposed emergency water supply scheme from the dolomite aquifer near the Abenab Mine is part of the Okavango-Omatako Basin. The planned construction of the pipeline link between Oshivelo and Omutsegwonime is at this stage not considered.

2.4.3. Population Density and Political/Administrative Areas

The eastern sub-basin boundary follows the borderline between the Oshikoto Region and the Otjozondjupa and Kavango regions. In the west the boundary is defined by the borderline between the Oshana and Oshikoto regions.

2.4.4. Infrastructure, Socio-Economic and Cultural Units

The sub-basin comprises mainly commercial farmland and communal farmland that is commercially managed.

2.5 OLUSHANDJA SUB-BASIN

2.5.1. Physiographic Parameters

The Olushandja Sub-Basin is delimited mainly by the western surface and groundwater flow regime of the Etosha Pan. Dolomite rocks of the Damara Sequence form a mountain arc stretching from the contact to the Kamanjab Inlier in the south towards Ruacana in the north. This mountain range with outcropping bedrock is the main recharge area from where groundwater flow is directed towards the Etosha Pan in the east. Although the Olushandja Dam and the Etaka Canal are geographically part of the Cuvelai-Iishana Sub-Basin, they are included in the Olushandja Sub-Basin due to administrative and socio-economic reasons.

2.5.2. Water Supply and Consumption

The western part of the sub-basin is supplied mainly from groundwater resources. The dolomitic arc and the calcrete platform of the foreland show good groundwater quality and quantity. Further down gradient towards the basin centre the water quality declines and near the Etaka Canal all groundwater is saline. The main settlements Outapi, Ruacana, Onesi, Tsandi and Okahao are supplied with Kunene water via pipeline.

Additional pipelines are planned to supply the saltwater areas west of the Etaka Canal. NamWater pumps approximately 70 Mm³ per annum from the Calueque Dam in Angola of which about 50% evaporate in the Olushandja Dam. From there the water is further distributed to the densely populated Cuvelai area through a lined canal to Oshakati and the Etaka Canal towards the Omadhiya lakes.

The pipeline network within the Olushandja Sub-Basin distributes water purified in the Olushandja and Outapi purification plants. The purification plants at Ogongo and Oshakati supply the pipeline network of the Cuvelai-Iishana Sub-Basin. From a management point of view it is therefore possible to separate the pipeline network of the Olushandja Sub-Basin from the rest.
The Etunda irrigation project between Ruacana and Olushandja is one of the largest single water consumers in Namibia. At this stage about 11 Mm³ per annum are supplied by NamWater to the project. The water is supplied via a canal from the Calueque Dam in Angola. It is planned to double the water consumption in the near future.

2.5.3. Population Density and Political/Administrative Areas

The western sub-basin boundary between Ruacana in the north and the Etosha National Park in the south is defined by the borderline between the Kunene and the Omusati regions.

The Onesi, Outapi, Tsandi and Okahao constituencies are included. Most of the population lives in the densely populated area along the Etaka Canal and in the towns and larger settlements nearby. Most of the western sub-basin is, however, sparsely populated and could most probably not be managed on its own. The grassland of western Omusati is used for livestock farming by local communities but also by large-scale semi-commercial farmers, who reside in the densely populated area east of the Etaka Canal.

2.5.4. Infrastructure, Socio-Economic and Cultural Units

The sub-basin is populated by Oshiwambo speaking people and is separated from the Otjihimba speaking ethnical group of the Kunene Region.

Future development might include the planned tar-road from Onesi to Opuwo and then further to Cape Fria, where a new harbour town is proposed. The irrigation potential of the sub-basin south of Ruacana is good and it is likely that new agriculture projects similar to the Etunda irrigation project might emerge.

2.5.5. Other

The solely water supply source of the eastern part of the sub-basin and its pipeline network is the Calueque Dam in Angola. It is therefore of great importance to co-opt officials from neighbouring Angola to the proposed management committee. The dependency from sources outside Namibia is a crucial aspect of the water supply to the sub-basin and must be considered also when deciding about the development of alternative water supply options such as desalination.

2.6 KUNENE BASIN

2.6.1. Physiographic Parameters

The delineation of the Kunene Basin is based on the groundwater basin criteria as obtained from the DWA. The basin includes the surface water catchment of the Kunene River from its entry point to Namibia at Ruacana Falls and the surface catchments of other west flowing rivers from the Munutum in the north to the Hunkab in the south. The southern borderline follows mainly the water divide to the Uniaib and Huab catchments. The eastern borderline follows generally the geological Basement / Damara Sequence contact and separates the Kunene Basin from the catchment of the Etosha Pan.

2.6.2. Population Density and Political/Administrative Areas

The eastern borderline of the Kunene Basin follows the regional boundary between Kunene and Omusati. The Otjovazandu and Kaross part of the Etosha National Park belongs geographically to the Kunene Basin and was therefore included.
2.6.3. Infrastructure, Socio-Economic and Cultural Units

The proposed Kunene Basin is inhabited mainly by the ethnical group of the Otjihimba People, who are governed to a large extent by traditional authorities. The entire land is communal farmland with small-scale livestock farming activities. Tourism plays a major role for the economic development within the basin compared to the situation in the Etosha and Huab-Ugab basins. Future development includes the new harbour town at Cape Fria and the proposed hydropower plant at Epupa Falls. Both projects are partly disputed by the local authorities for environmental and cultural reasons and the proposed basin committee will have to deal with these planned development projects, which would drastically affect the development in the Kunene Basin.

For comparison of the proposed water basins demarcation on national level with selected criteria see Appendix 1.

2.7 UGAB-HUAB BASIN

2.7.1. Physiographic Parameters

The Ugab-Huab Basin is mainly defined by the catchments of the west flowing Ugab and Huab rivers. The much smaller catchments of the Uniab and Koigab rivers in the north and the Messum and Orawab rivers in the south are also included.

The eastern part of the Kamanjab Inlier also belongs geologically and hydrogeologically to this basin although the surface water drainage is directed to the north towards the Etosha Basin. Otavi and Otjiwarongo are the centres in the northeastern part of the basin and are located adjacent to the so-called Platfeld area, which is currently under investigation with regard to future groundwater development. The southwest draining parts of the Otavi Mountainland and the main marble ridges supplying bulk water to Otjiwarongo are also included.

In the south the borderline follows mainly the surface catchment of the Ugab River, but near the coast an area was cut-off, which is called Omaruru Alluvial Plains, and which is considered as being part of the Omaruru-Swakop Basin.

2.7.2. Water Supply and Consumption

The Uis Town was excluded from the basin because it is supplied with Omaruru River water from the Nei-Neis borehole water scheme via pipeline.

Terrace Bay, although being physiographically part of the Kunene Region was allocated to the Ugab-Huab Basin because of the NamWater supply scheme, which transports groundwater from the Uniab River in the south to Terrace Bay via a 30 km long pipeline.

The Damara Marble aquifer, which supplies water to Otjiwarongo via pipeline, extends in the northeast into the catchment of the Omatako River. This portion, located east of Otavi, was included into the basin. The sub-terrain water control area of Otjiwarongo also extends into this area and the boundary to the Kavango-Omatako Basin is here defined by the farms still belonging to the control area.

2.7.3. Infrastructure, Socio-Economic and Cultural Units
The proposed basin is relatively large and includes important commercial farming areas but also tourism and environmental sensitive areas. For practical and management purposes the basin shall be divided into at least two sub-basins, i.e. the Upper Ugab Sub-Basin (Otavi, Otjiwarongo, Outjo) and the Lower Ugab-Huab Sub-Basin (Khorixas, Kamanjab, Cape Cross).

2.8 TSONDAB-KOICHAB BASIN

2.8.1. Physiographic Parameters

The Tsondab-Koichab Basin is framed by the Kuiseb Basin in the north, the Orange-Fish Basin in the east and south and by the Atlantic Ocean in the west. The surface and groundwater drainage is directed towards the Atlantic in the west. The eastern boundary of the basin follows mainly the surface water divide, in the north roughly the water divide between the Kuiseb and Tsondab rivers.

All rivers south of the Kuiseb River do not reach the Atlantic Ocean in a well-defined riverbed. However, there are indications that they continue under the Namib Dune Sea and eventually discharge into the ocean. The catchments of these rivers are not well defined and it is necessary to combine them into one basin.

The desert landscape and environment of the basin is similar throughout the proposed basin between the Tsondab River in the north and the former Sperrgebiet area in the south and can be described as one environmental unit.

2.8.2. Population Density and Political/Administrative Areas

The basin is sparsely populated with the vast majority of people living at Lüderitz, and the separation of the basin into smaller units would not be advisable for management and financial reasons.

Most of the proposed basin area is demarcated as national park and private conservancy, mainly to protect the unique Namib Desert environment. In the north the borderline follows the regional boundary between Hardap and Erongo. The mining town Oranjemund in the south is excluded as being part of the proposed Orange-Fish Basin.

2.9 ORANGE-FISH BASIN

2.9.1. Physiographic Parameters

The Orange-Fish Basin is located in the south-central part of Namibia and is defined mainly by the surface catchments of the Orange and Fish rivers. The Fish River originates in the Nama Plains northwest of Maltahöhe, and flows in a southern direction towards the perennial Orange River. The confluence of both rivers is some 35 km southwest of Ai Ais within the Fish River Canyon Park.

The Orange River originates in South Africa and defines the border between Namibia and South Africa between Ariamsvlei in the east and Oranjemund at the Atlantic Ocean. The basin comprises all tributaries towards the Fish and Orange rivers within the confines of Namibia.

In some areas, mostly along the western basin margin, the boundary deviates slightly from the surface water catchment, where groundwater basins and geological formations are considered as more critical criteria for the definition of the basin.
2.9.2. Water Supply and Consumption

The Scorpion Mine is included into the basin although physiographically belonging to the Tsondab-Koichab Basin. The reason is that the mine is supplied with water from the Orange River via a bulk water pipeline.

The Khoexas Area northeast of Keetmanshoop was excluded because the underground water flow is directed towards the Stampriet basin in the east. The farms in that area are part of the sub-terrain water control area of the Stampriet basin because they are situated in the marginal recharge area of the important Karoo aquifer.

2.9.3. Infrastructure, Socio-Economic and Cultural Units

The Orange-Fish Basin is dominated by commercial farming and important mining activities. The diamond mining activities at Oranjemund and along the Orange River are sometimes in conflict with large scale farming activities (grape farming) and both interest groups have to co-operate in order to use the natural resources of the basin in a socio-economic and environmental considerate manner.

The Karasburg District forms a separate environmental and socio-economic unit within the basin but future development in this area depends on the access to and possible water supply from the Orange River. One example is the development of the proposed copper mine at Haib, southwest of Karasburg. This is only possible if bulk water can be supplied from the Orange River, because the aquifer potential of the regional groundwater basin is poor.

2.9.4. Other

The Orange River is shared with South Africa and activities in the upper catchment of the river will affect the entire Orange-Fish Basin. A close co-operation with South African Orange River Basin authorities is advisable. For management purposes the basin should be divided into smaller units at a later stage.

2.10 SWAKOP-OMARURU BASIN

2.10.1. Physiographic Parameters

The basin is mainly defined by the surface water catchments of the Swakop and Omaruru rivers. Both ephemeral rivers originate in the central highlands and flow in a western direction towards the coast where they discharge into the Atlantic Ocean.

In the northwest, parts of the Orawab catchment are included because the Omaruru Alluvial Plains extent into this area. The paleo-channels of the Omaruru Alluvial Plains are defined as being hydraulically connected to the Omaruru Delta, which constitutes one of the important aquifers within the Swakop-Omaruru Basin.

2.10.2. Water Supply and Consumption

The Swakop and Omaruru river catchments comprise the economically most important water supply schemes in Namibia. The capital Windhoek and the coastal area including mines are supplied from water sources developed within the two catchments. The water supply of the two catchments is interlinked and especially the lower Swakop catchment depends on imported water from the Omaruru
Delta. It is therefore recommended to combine the two catchments into one basin because developments in either catchment will have a direct impact on the development of the other. However, for management purposes it is proposed to subdivide the basin into two sub-basins, i.e. the Omaruru-Lower Swakop Basin and the Upper Swakop-Upper Omatako Basin. The Omatako Dam is an important source of the Windhoek water supply scheme and the upper catchment of the Omuramba Omatako was integrated into the basin. The Dolomite Karst Aquifer of the Grootfontein Area is part of the Kavango-Omatako Basin but is an emergency water supply source for the central region, i.e. the Swakop-Omaruru Basin. The Karst Area is connected to the central area by the Eastern Water Carrier network. Existing and planned groundwater abstraction schemes are situated at Kombat Mine, Berg Aukas Mine and in the Abenab Mine area. A close co-operation between the management committees of both important basins is required for the optimal utilisation of the groundwater resources and the sustainable water supply to the central regions.

2.10.3. Infrastructure, Socio-Economic and Cultural Units

The Rössing Uranium Mine is one of the main single consumers in the basin and is responsible for the development of the Omaruru Delta. The opening of a new uranium mine at Langer Heinrich is in an advanced stage and NamWater shall supply water via pipeline also from the Omaruru Delta scheme. The demand is in the range of 1 – 1.5 Mm³/annum. The new mine development is situated at the southern margin of the basin, on the water divide between the Swakop and Kuiseb rivers.

Future development might include seawater desalination to supplement the water supply to the coastal area. Another possible scenario is the construction of a bulk water pipeline to the Okavango River to supply water to the central regions. The pipeline, which transports water from the Swakoppoort Dam to Karibib and the Navajab Gold Mine could then be extended to the Rössing Mine and the water could be gravitated through the existing pipeline to Swakopmund. In all cases the entire basin is affected and the co-operation between authorities and stakeholders is required.

2.11 KUISEB BASIN

2.11.1. Physiographic Parameters

The Kuiseb Basin was the first basin in Namibia to be investigated in terms of the newly developed basin management principles and a basin profile involving all relevant stakeholders was carried out in the previous years. The basin delimitation was based mainly on the surface catchment of the ephemeral Kuiseb River. The Kuiseb River originates in the Khomas Highland west of the capital Windhoek and flows in a western direction through the escarpment and the desert plain foreland towards the Atlantic Ocean. The Kuiseb delta south of Walvisbay and paleo-channels underlying the Kuiseb Dune area are included. For this study only minor changes were effected, for example along the southern boundary, where the basin boundary was slightly shifted to coincide with the regional border between Erongo and Hardap.

2.12 NOSSOB-AUOB BASIN

2.12.1. Physiographic Parameters

The Nossob-Auob Basin comprises the surface catchments of the southeast flowing Black and White Nossob rivers, the Olifants, Seeis, Skaap, Oanob and Auob rivers. The discharge area is the so-called Stampriet Artesian Basin, where significant groundwater resources are confined to Karoo Sequence
sediments covered by Kalahari Sequence layers. The outcropping Karoo sediments occur around the basin and form a rim of south and southeast dipping layers of mainly sandstone and shale.

These recharge areas are included into the basin even if they are located slightly outside the surface water divide. The Aminuis Area for example is part of the Nossob-Auob Basin although there is no significant drainage. But the underlying Karoo sediments are considered as being part of the groundwater basin. The northeastern boundary follows the geological contact between the underlying Nosib Group sandstones and the upper Karoo sediments.

2.12.2. Water Supply and Consumption

The main towns, Gobabis and Rehoboth are supplied with water from the Otjivero and Oanob dams respectively. The dams are situated in the upper catchments of the White Nossob and Oanob rivers. The water supply to Gobabis is supplemented by Black Nossob River run-off and groundwater from a borehole scheme northeast of Gobabis.

The remainder of the basin is supplied with groundwater from boreholes with the Stampriet Artesian Aquifer as the main source. The farmers in the Nossob-Auob Basin will have to co-operate more closely in future to avoid over-abstraction from the aquifer, which is extensively exploited for large-scale irrigation projects. The water quality is declining in flow direction towards the border to Botswana and South Africa in the southeast and large farming communities have to survive with sub-standard groundwater containing elevated volumes of salt.

Most of the basin, except the Rehoboth Area, the area north of the Windhoek International Airport, north of Aminuis and east of Keetmanshoop, is declared a sub-terrain water control area and any activities regarding water abstraction or drilling are subject to permission by the Department of Water Affairs. As a result of the new Water Bill these control areas will be obsolete and replaced by a more comprehensive legislation where basically the whole country is protected and subjected to abstraction and drilling permits.

2.12.3. Population Density and Political/Administrative Areas

The population density of the Nossob or Auob river catchments is too low to allow the existence of separate basins. For financial and administrative reasons these two catchments were combined. The basin stretches in north-south direction over a number of regions such as the Khomas, Omaheke, Hardap and Karas regions. The political boundaries were here not considered as delimitation factors.

2.12.4. Infrastructure, Socio-Economic and Cultural Units

Except the Aminuis enclave the area is dominated by large-scale farming activities. Farmer’s unions will have to play an important role in the basin management committee.

2.12.5. Other

Botswana and South Africa border to the basin in the east. They are located in the discharge area of the basin’s surface and groundwater drainage and the need for sharing of water resources or the demand for joint planning of the development of water resources is at this stage no priority.

2.13 EISEB-EPUKIRO BASIN

2.13.1. Physiographic Parameters
The basin comprises the surface catchments of the omiramba Otjozondju, Eiseb and Epukiro. They all originate in Steinhausen-Hochfeld area and flow in an eastern direction through the Omaheke semi-desert into Botswana. The flow of the groundwater is also directed from all sides towards the Eiseb ‘Graben’ area and from there further towards Botswana. The discharge area is downstream the Okavango Delta where the groundwater most probably evaporates in saltpans of the central Kalahari.

The Rietfontein and Chapmans rivers, draining the Rietfontein Block area and the quartzitic outcrop area east of Gobabis are also included into the basin.

2.13.2. Water Supply and Consumption

Gobabis, the capital of the Omaheke Region is partly supplied from a well field located northeast of Gobabis, within Nosib Group quartzite. Groundwater flow is directed towards the east into the basin centre. Gobabis, although being located in the Black Nossob catchment area is proposed to be also included into the Eiseb-Epukiro Basin, and the basin boundary runs through Gobabis Town.

2.13.3. Population Density and Political/Administrative Areas

The population density is intermediate at the basin margins, where the groundwater sources are sufficient in terms quantity and quality. Towards the basin centre the groundwater potential is very low and there are large areas with no people or very low numbers of people. The main towns or settlements such as Gobabis, Epukiro, Summerdown, Otjinene and Gam are all located in the basin margin areas. For political and administrative aspects it is considered necessary to combine the Eiseb and Epukiro basins as well as the minor above mentioned catchments into one basin and to have Gobabis included as the place where most of the decision makers and administrators are located.

2.13.4. Infrastructure, Socio-Economic and Cultural Units

The Trans Kalahari Highway leads through the basin, linking the business centres in South Africa with Walvis Bay Harbour. A link to the Caprivi Highway in the north is planned, which would link the Trans Kalahari Highway with the Grootfontein-Tsumkwe road and open up large areas of the basin centre for future development.

The basin is mainly populated by Otjiherero speaking people, and only in the north, parts of the former Bushmanland with predominantly San speaking people are included.

2.13.5. Other

Since the middle 1990s Otjiherero speaking people from Botswana return to Namibian soil for resettlement on invitation by the Namibian Government. The water supply situation is, however, problematic and a number of attempts to develop sufficient groundwater resources were unsuccessful. Only recently some success was reported by a team of hydrogeologist working under the technical cooperation project between Namibia and Germany. New groundwater sources were found in the Eiseb Graben area, which could be utilised to supply the local population and the settlers. The exploration work has to continue for a better assessment of the aquifer potential. The aquifer seems to extend into neighbouring Botswana and a co-operation with the foreign authorities is recommended.

2.14 KAVANGO-OMATAKO BASIN

2.14.1. Physiographic Parameters
The Kavango-Omatako Basin comprises the surface catchments of the perennial Okavango River and its main tributary on Namibian ground, the Omuramba Omatako. The omiramba Nhoma and Kaudom drain through the Kaudum Game Park into Botswana and eventually into the Okavango Delta and are therefore part of the Kavango River catchment. The Okavango River originates in the Angola highlands and forms an about 300 km long borderline between Namibia and its northern neighbour Angola until the river turns south through the eastern Kavango Region into Botswana and then into the intra-continental Okavango Delta.

The ephemeral Omuramba Omatako originates at the main watershed between west and east flowing rivers north of Okahandja. The upper part of the catchment up to the Omatako Dam is proposed as part of the Swakop-Omaruru Basin due to water supply infrastructure, mentioned in the chapter below. The course of the omuramba protrudes all the way through the Otjozondjupa region in northeastern direction and enters the Kavango Region approximately at the 19º latitude. The confluence with the Okavango River is at Ndonga, some 60 km east of Rundu.

2.14.2. Water Supply and Consumption

Most people of the Kavango Region settle in a relatively narrow zone along the banks of the Okavango River and use the river water for human and livestock consumption. Large-scale commercial irrigation projects emerge along the river, which are in demand of large volumes of fresh water. It is planned to increase production from these farms in line with the Green Scheme project launched by the Ministry of Agriculture, Water and Rural Development.

The catchment of the Omuramba Omatako includes the Grootfontein Karst Aquifer, one of the most productive aquifers in Namibia. The groundwater is used locally for irrigation crop farming but it is also exported to consumers in the central area via the Eastern Water Carrier canal and pipeline system. Karst synclines I, III and IV (in parts), which contain most of the strategic groundwater resources of the dolomitic Karst land are part of the Okavango-Omatako Basin.

The Omuramba Omatako and Okavango River catchments are combined into the larger Okavango-Omatako Basin because there are plans to construct a pipeline from Rundu to Grootfontein in order to supply fresh water to the central area with its ever-growing water demand. An ambitious water supply project like this needs the co-operation of all stakeholders in both catchment areas. Bulk water abstraction from the Okavango River has an affect on the environments of neighbouring countries as well and the planning and implementation of the scheme is only possible by participating in international river basin management efforts.

If looking at national and local water supply schemes it would be advisable to sub-divide the basin into more practical and manageable units, for instance into a Okavango-Lower Omatako and a Central Omatako Sub-basin. The latter comprises the existing and planned bulk water supply schemes of the Grootfontein Karst Area, including Kombat Mine, Berg Aukas Mine and the proposed well field at Abenab Mine. The Berg Aukas-Otjituo–Okamatapati-Okakarara-Goblenz pipeline network, which transports fresh water from the Karst area east of Grootfontein to the rural farming area of the former Western Hereroland, is also part of this proposed sub-basin.

2.14.3. Population Density and Political/Administrative Areas

The basin comprises the entire Kavango Region and large areas of the Otjozondjupa Region. The northwestern basin boundary is defined by the borderline between the Kavango and the Ohangwena and Oshikoto regions. In the northeast the boundary follows the borders with the Caprivi Region and Botswana. The northern boundary coincides with the border to Angola.
2.14.4. Infrastructure, Socio-Economic and Cultural Units

The B2 tar-road runs through the upper and lower basin and interconnects the Omatako and Okavango catchment areas, enhancing socio-economic exchange. The road is part of the Walvisbay Corridor and as such an important transport route for cargo from the Namibian harbour town to Zambia, Zimbabwe and beyond.

2.15 ZAMBESI-KWANDO-LINYANTI BASIN

2.15.1. Physiographic Parameters

The basin includes the intra-Namibian surface catchments of the Kwando, Linyanti and Zambesi rivers. The drainage systems are separated from the drainage system of the Okavango River, which discharges into the intra-continental Okavango Delta, while the Zambesi-Kwando-Linyanti (ZKL) river system drains into the Indic Ocean.

2.15.2. Population Density and Political/Administrative Areas

The basin is confined inside the political borders of the Caprivi Region, including the eastern part of the Caprivi Game Park.

2.15.3. Infrastructure, Socio-Economic and Cultural Units

The basin is populated mainly by people of the Caprivi language group.
3. ACTIVITIES FOR A DETAILED PROFILE OF THE SELECTED CUVELAI-IISHANA SUB-BASIN

A detailed schedule of activities for a detailed profile of the selected Cuvelai-Iishana Sub-Basin should be discussed with the consultants responsible for the other three components of the task. However, some activities aimed at the improvement of the knowledge base and update of the present GIS database are listed below. These activities are considered as crucial for the long-term establishment of a sub-basin authority. In co-operation with the Client and the other consultants it must be decided to what extent the proposed activities can be carried out by the community/stakeholders themselves and what the input of consultants should be. Training of the Cuvelai-Iishana Sub-BMC would be a strong component.

The recommended activities for the improvement of the knowledge base and database update are as follows:

Hydrocensus of water points including boreholes and pipeline off-takes.

Update of the ArcView (GIS) database with infrastructure, socio-economic and environmental data.

Determine historical, actual and predicted of water production and consumption figures for sub-basin.

Determine water consumption for each abstraction point.

Establish a monitoring system for surface water run-off and groundwater table fluctuation.

4. PROPOSALS FOR THE SELECTION OF 5 BASINS FOR COMPLETION OF BASIN PROFILES

4.1 SWAKOP-OMARURU BASIN

The MAWRD plans to launch the investigation of the Omaruru River catchment in January 2005 as part of a basin management profile, and therefore, this basin has first priority. Together with the Okavango-Omatako Basin the Swakop-Omaruru Basin forms the backbone of the Namibian water supply. The central area including the capital Windhoek and the coastal town Swakopmund is supplied from surface and groundwater sources within these two basins, whereby the actual abstraction is mainly taking place in the Swakop-Omaruru Basin. Future development like the new Uranium Mine at Langer Heinrich will put more stress on the Omaruru Delta scheme to supply in the growing demand. At the same time bulk abstraction from dams in the Swakop and Omaruru rivers as well as from aquifers has a potential detrimental effect on downstream aquifers and development. These issues should be addressed and managed in co-operation with stakeholders in the upper and lower catchment areas.
4.2 OKAVANGO-OMATAKO BASIN

The Okavango-Omatako Basin comprises as mentioned above some of the most important surface and groundwater resources in Namibia. The Okavango River on the border to Angola is tapped for irrigation projects along the river and a planned bulk water pipeline from Rundu to Grootfontein would secure the sustainable water supply to the central area. The groundwater resources in the Grootfontein Karst Area, represent the most productive aquifers in Namibia and are considered a strategic reserve and emergency source in case the main water supply dams of central area fall dry. The Grootfontein Karst Area is connected to the central area by the Eastern Water Carrier, which allow the gravity flow of the groundwater to the Omatako Dam and from there to the Von Bach Dam at Okahandja.

The above bulk water supply projects are partly opposed by farmers in the Karst Area, who are afraid of groundwater mining and over abstraction with negative effect on the local groundwater table and pumping costs. The abstraction from the Okavango River is of international concern because of the possible influence on the Okavango Delta. The Okavango-Omatako Basin has like the Swakop-Omaruru Basin high priority regarding a water basin profile. An inauguration meeting should be organized and held in Rundu.

4.3 ORANGE-FISH BASIN

The perennial Orange River is the most important water source of southern Namibia, an area that is known for arid climatic conditions and water scarcity. The river water is utilized for large-scale agricultural irrigation projects and for mining operations. The economically very important base metal mines at Rosh Pina and Scorpion are supplied with fresh water via a bulk pipeline, operated by NamWater. The ephemeral Fish River is a tributary to the Orange River and feeds the largest dam in Namibia, the Hardap Dam. The water is used for the water supply to Mariental but mainly for irrigation projects in the surroundings. A tributary to the Fish River recharges the Naute Dam, south of Keetmanshoop. The water of this dam is also used mainly for agricultural projects.

The above bulk water sources are of great importance for the development of the sparsely populated but economically increasingly important southern part of Namibia. Future possible developments include a gas power station at Oranjemund, additional irrigation projects along the Orange River, a possible joint Namibian/South African Orange River Dam, and additional dams along the Fish River downstream the Hardap Dam. All these planned activities will have and effect on the environmental and socio-economic situation and the decision-making will have to be done in close co-laboration with the proposed basin management committee. An inaugurating meeting should be held at Oranjemund.

4.4 ZAMBESI-KWANDO-LINYANTI BASIN

The Zambesi, Kwando and Linyanti-Chobe rivers surround the Caprivi Region in the east, west and south. The population density is highest along the river courses because of the abundance of fresh water. The interior of the Caprivi region is often characterized by saline groundwater conditions and because of this, large areas are under-developed. Recent groundwater exploration studies have shown that this saline water is underlain by deeper freshwater and future development would include the sustainable exploitation of the newly detected source. Groundwater is a cost effective alternative to pipeline water from the rivers and should be encouraged through the proposed basin management committee.
The Zambesi River is one of the largest river systems in Africa and Namibia is one of the many countries having access to it. The Zambesi River Basin is subject to a research project supported by the SADC. Main aim is the development of an integrated water resources management strategy and the establishment of a river basin institution involving all Riparian states. The headquarters of the Zambesi River Authority are in Lusaka, Zambia. The ZKL Basin management committee should be established with the support of the Zambesi River Authority, which is assisted by the Scandinavian donor agencies DANIDA, NORAD and SIDA and it is likely that funds are made available for the institution building on national level. A stakeholder meeting should be organized at Katima Mulilo for the assessment of the present situation the planning of the way ahead.

4.5 KUNENE BASIN

The Kunene Basin has the lowest priority for the implementation of a basin profile compared to the other four above basins. The planned hydropower plant at Epupa Falls is at this stage and most probably also in the long term not considered viable also because the development of the Kudu gas field and the establishment of a power plant at Oranjemund are in an advanced stage.

A new harbour town is planned at Cape Fria, which would need a bulk water supply scheme, most probably a pipeline link form the Kunene River. These tasks, rural water supply issues and planned agricultural projects along the Kunene River will have to be discussed and dealt with as part of the basin profile. The administrative centre is Opuwo and in a first step stakeholders should be invited to an inauguration meeting in Opuwo.
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APPENDIX

APPENDIX 1

Appendix 1.1: Proposed Demarcation of 11 Water Basins in Namibia
Appendix 1.2: Demarcated Water Basins in relation to Groundwater Basins
Appendix 1.3: Demarcated Water Basins in relation to River Catchments
Appendix 1.4: Demarcated Water Basins in relation to Groundwater Potential
Appendix 1.5: Surface Geology in the Demarcated Water Basins
Appendix 1.6: Water Supply within the Demarcated Water Basins
Appendix 1.7: Political Regions and Demarcated Water Basins
Appendix 1.8: Infrastructure within the Demarcated Water Basins
Appendix 1.9: Demarcated Water Basins in relation to Land Use
Appendix 1.10: Population Density within the Demarcated Water Basins
Appendix 1.11: Distribution of Language Groups within the Demarcated Water Basins
Appendix 1.12: Namibia Landscapes in relation to the Demarcated Water Basins
Appendix 1.13: Proposed Sub-Basin Delimitation in the Etosha and Omaruru-Swakop Basins

APPENDIX 2

Appendix 2.1: Proposed four Etosha Sub-Basins and Political Regions
Appendix 2.2: Etosha Sub-Basins, Groundwater and River Catchments within the Etosha Basin
Appendix 2.3: Geological map of the Etosha Basin
Appendix 2.4: Groundwater Salinity and Water Supply within the Etosha Basin
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Appendix 1.12: Namibia Landscapes in relation to the Demarcated Water Basins
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APPENDIX 2

Appendix 2.1: Proposed four Etosha Sub-Basins and Political Regions
Appendix 2.2: Etosha Sub-Basins, Groundwater and River Catchments within the Etosha Basin
Appendix 2.3: Geological map of the Etosha Basin
Appendix 2.4: Groundwater Salinity and Water Supply within the Etosha Basin