Volume 2 of the Kuiseb Basin Water Resources Management Plan contains 10 narrative reports. These are presented in the following order:

1. F. Wittneben and P. Klintenberg ‘Agriculture and related issues in the Kuiseb Basin’
2. S. Bethune ‘Environmental issues in the Kuiseb Basin’
3. P. Heyns ‘Water planning and utilisation in the Kuiseb Basin’
4. M. Falke ‘Geohydrology’
5. F. Oosthuizen ‘Socio-Economic Assessment in the Context of Vision 2030 and Millennium Development Goals’
6. S. Bethune ‘Water education’
7. M. Seely ‘Institutional development and capacity building’
8. P. Klintenberg ‘Databases for improved management of the Kuiseb River Basin by the KBMC: considerations, recommendations and an Action Plan’
9. J. & J. Kinahan ‘Khuiseb Basin archaeological baseline study’
10. P. Heyns ‘Legislation for water abstraction’
Agriculture and related issues in the Kuiseb River Basin

By:

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Many facts mentioned in the text are not based on secondary sources but on personal knowledge gained over 22 years of practical field work as agricultural extension technician in the Khomas Region and especially the Kuiseb catchment area by Frank Wittneben.
## Table of contents

### A. Baseline information and gaps analysis
- Topography .................................................................................. 1
- Geology ......................................................................................... 2
- The Kuiseb River ........................................................................... 2
- Climate ............................................................................................ 3
- Rainfall in the Kuiseb River Basin .................................................. 4
- Fog ..................................................................................................... 6
- Temperature ........................................................................................ 6
- Wind ................................................................................................... 7
- Wildlife in the Kuiseb River Basin .................................................. 7

### B. Impacts on environment of continued land use and future development

- Commercial farming in the Kuiseb River Basin ................................ 9
- History of commercial farming in the Kuiseb River Basin ............... 9
- Present day commercial farming in the Kuiseb River Basin .......... 9
- Carrying capacity of farms in the Kuiseb River Basin .................... 10
- Bush encroachment .......................................................................... 11
- Cattle breeds .................................................................................... 11
- Rangeland management, the use of camps .................................... 11
- Marketing of livestock (auctions in the upper catchment) ............... 11
- Government and Extension services .............................................. 12
- Water supply .................................................................................... 12
- Boreholes ........................................................................................ 13
- Water consumption .......................................................................... 13
- Farm dams ....................................................................................... 14
- Dam construction ............................................................................ 14
- Large scale dams ............................................................................ 15
- Communal farming in the Kuiseb River Basin ............................... 15
- Harvesting of the !Nara melons ...................................................... 16
- Water supply to the Topnaar communities .................................. 17
- Diversification of the agricultural sector in the Kuiseb River Basin ... 17
- Conservancies in the Kuiseb River basin ....................................... 18
- Schools in the Kuiseb River basin .................................................. 18
- Mines ................................................................................................. 18
- Lodges in the Kuiseb River basin .................................................... 18
- Observatories .................................................................................. 18

### C. Environmental issues to be addressed

- Bibliography ....................................................................................... 19

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A. Baseline information and gaps analysis
The following section is mainly based on Botes et al. (2002), Manning et al. (2002), Manning et al. (2004), Manning and Pallett (2004), Roberts (in prep) and expert inputs from F. Wittneben and P. Klintenberg. The Kuiseb River Basin shows great variation in the distribution of natural features as geology, geomorphology, and geography. Climatic features vary both in space and time within the basin, contributing to an already varied distribution of vegetation and fauna. The Basin encompasses an area of +/-21,940 km² (2.194 million hectare).

The basin is divided into three catchment areas (Figure 1):

1) Upper catchment 9620 km²
2) Middle catchment 11250 km²
3) Lower catchment 1070 km²

1.1 Topography
The topography in the Kuiseb Basin varies from extremely steep mountainous areas in the upper catchment to completely flat gravel plains and undulating dunes in the lower catchment areas (Figure 2). The topsoil in the upper catchment area is very shallow due to pronounced water erosion, which also determines the type of plants growing there. Because of the thin soil cover and the steep topography rainwater has little chance to infiltrate. Where vegetation cover is low and slopes are steep the run off is generally very fast. The result is that very little rainwater will reach the groundwater table compared to flatter and sandier areas elsewhere in the country. As a result surface water is almost non-existing except for single pools of water in very steep and shady canyons and a few fountains.
Agricultural aspects of the Kuiseb River Basin

The rugged terrain of the upper catchment results in clear differences in distribution of plants. An example of this is the distribution of Acacia erubescens (withaak), which predominantly occurs at an altitude of 1500 m.a.s.l. and below. The Acacia reficiens (rooihaak), on the other hand is most common at an altitude of 1400 m.a.s.l. and above. Differing climatic and soil requirements for these two plants most likely cause these differences in distribution. At higher altitudes the annual average temperature is lower and fluctuations more extreme. On the other hand, soil depth also tends to be lower at higher altitudes. Observations have shown that bush encroachment is less of a problem on farms located at high altitudes in the Kuiseb River Basin. This is due to the extremely cold conditions during the winter, which controls the encroachment of bush.

1.2 Geology

The rocks in the basin are dominated by schists and sandstones. In the middle and lower catchment granites occur together with schist’s and dolomite, sand and calcrite (Schneider, 2004) (Figure 3). An interesting observation is that, due to the high copper content in the rocks in some parts of the upper catchment, lightings are very common there during rain storms. This leads to an increased risk of veld fires. Something that is evident in the number of veld fires recorded in this part of Namibia compared to the numbers recorded in other parts of the country. Another effect of the high mineral content in the rocks and the soils of the upper parts of the Kuiseb River basin is that the grasses have a high mineral content, making them comparatively nutritious.

Figure 3. Geology of the Kuiseb River Basin.

1.3 The Kuiseb River

The Kuiseb River is an ephemeral river that follows a path originating in the Khomas Hochland mountain range, flowing through the Namib desert. The river originates approximately 30 km west of Windhoek at an altitude of 2081 m.a.s.l. and reaches sea-level at Walvis Bay (Jacobson et al., 1995). The river course is approximately 420 km long (Figure 4). The river is only flowing for a short period following rainfall within the Kuiseb Basin. The length and intensity of the flow mainly depend on the amount of rainfall received in the catchment area. For most of the year the river therefore has no surface water. It is important to note that the river might not flow every year, nor flow throughout the entire length of the river. Even though the Kuiseb River is an ephemeral river, water is captured, moved and stored in many different ways in and around the main river path, which contribute to the presence and subsequent support of vegetation, wildlife and domestic animals, people and their livelihoods as well as industry throughout the Kuiseb River Basin.
The upper reaches of the Kuiseb River is shown in Photo 1. Note the small culverts under the road, to be compared to the size of river crossings further down into the basin. This is a good measure of the amounts of water that is transported by the river. The amount of run off is determined by the steepness of slopes, area of sub-basins feeding a specific tributary, soil depth, soil type and vegetation cover. In general run-off is high in the upper reaches of the basin as the soils are shallow, slopes are steep and the ground cover is sparse, at least during the onset of the rainfall season. Another factor that is of importance is the intensity of rainfall. Rainfall records show that rainfalls in the upper parts of the basin commonly are intense, also contributing to limited infiltration and increased runoff.

1.4 Climate
The climate of the Kuiseb River Basin is determined largely by its geographic position. Lying on the west coast of southern Africa, the climate of Namibia is influenced by three climate systems: 1) the dry, high-pressure anticyclones which drive the Benguela Current along the coastline, 2) the rain-bearing Inter Tropical Convergence Zone (ITCZ) that brings moisture from the Indian Ocean to Namibia in summer, and 3) the low-pressure system of cold-fronts that occasionally brings winter rainfall to southern Namibia. Straddling the Tropic of Capricorn, the effects of these systems are clearly manifested in the Kuiseb River Basin.

In summer, the systems move southwards, placing the ITCZ sufficiently far south to bring rain to Namibia, as the subtropical anticyclones are less effective at blocking it. In winter, the systems move northwards and the dry subtropical anticyclones dominate over southern Africa preventing
moist air from moving into Namibia. However, cold fronts can sweep across the Atlantic Ocean, occasionally bringing rain behind them to southern Namibia.

The anticyclone drives the Benguela Current northwards along our coast from the cold southern Atlantic Ocean. This system has a strong influence on the climate, particularly in the western part of the Kuiseb River Basin, where it causes the extremely arid conditions prevailing there. The cold waters cool the air above the sea to such a degree that it prevents rain-bearing clouds from developing. Rainfall in the basin is largely dependent on moisture bearing clouds, originating thousands of kilometres eastwards over the Indian Ocean. However, these clouds have lost most of their moisture by the time they reach Namibia. Consequently, low rainfall in the eastern reaches of the Kuiseb River Basin, decreases to virtually nothing further west. Together with low humidity, intense radiation and high temperatures, this lack of rainfall creates the arid conditions that characterise the area.

In spite of the generally drying influence of the Atlantic Ocean along Namibia’s coast, it does provide moisture in the form of fog. The precipitation from fog can be significant and, although not easily accessible to people, provides a regular source of water to many plants and animals living in the desert. The fog is reaching as far as about 100 km inland from the coast (see separate section below).

1.5 Rainfall in the Kuiseb River Basin

The Kuiseb River Basin is characterised by low rainfall coupled with high evaporation rates. As was stated above, most of Namibia’s rain falls in summer from moisture-bearing clouds blown in from the north-east as the ITCZ moves southwards. As the clouds move further and south and west, they carry less moisture and rainfall decreases. As a result rainfall in the Kuiseb River Basin follows a distinct east-west gradient. Rainfall is highest in the eastern area, where over 300 mm can be expected per year, dropping drastically at the edge of the escarpment, and decreasing to almost nothing in the most western parts. Because so little rain falls in the west, the flow of the Kuiseb River there is almost totally dependent on the amount of rain falling in the eastern parts of the Basin. The average annual rainfall is 350 mm in the upper catchment to less than 50 mm in the lower catchment (Figure 5). In the eastern part of the Basin, above the escarpment, rainfall is seasonal albeit in variable amounts, whereas the west which lies in the central Namib Desert receives very little rain.

Rainfall in the Kuiseb River Basin does not only vary geographically, but also varies from year to year. Some seasons receive only a fraction of the rain that falls in other seasons - for example, in 1981/82 Windhoek received only 20 % of the rain that fell in 1999/2000 (Figure 6). It is only in season with relatively high rainfall that the Kuiseb River can be expected to flow all the way to its lower reaches and recharge the aquifers in this area.
Rainfall commonly also varies substantially within short distances. Topography is one factor that influences this, e.g. mountain peaks as the Gamsberg and koppies (inselbergs) found on the plains west of the escarpment cause updrafts, forcing clouds upwards, leading to condensation and rain on the windward side, and a rain shadow on the opposite side of the mountain.

Apart from the variation from season to season, long-term records of rainfall also show periods of higher rainfall being followed by periods of lower rainfall, as depicted by the five-year running mean for Windhoek and Claratal (Figure 7). These periods of wetter or drier conditions are about 15 years long.

Although rain in the Kuiseb River Basin might fall from as early as September, rainfall mostly occurs between January and April throughout the Basin. Precipitation can occur during the winter as well following occasional massive cold fronts. Although these rainfall events contribute very little to the rainfall in the eastern parts of the Basin, these events can be significant in the areas further to the west. This is illustrated by Pelican Point where these winter rains contribute almost a quarter of the total rainfall received over the past 40 years. Snow was reported at Claratal in July 1982 and June 1994.

The rainfall pattern is often described as having a small peak in early summer, followed by a second, larger peak bringing the main rains later in the season. This can be seen in the records from Claratal 1999/2000 and 2003/2004. These patterns vary between years, e.g. some years most rainfall falls in the early part of the rainfall season, other years the rains come late, towards the end of the rainfall season, or is spread more evenly throughout the rain season. The amount and intensity of rainfall determines both amount of run off and veld condition. Early rainfall triggers germination, and has to be followed by more rainfall, to enable grass and seedlings to establish.
On the other hand, rain falling in March does not leave enough time for regeneration of vegetation before the winter starts. In some years the rainfall is very low, or experience extended periods with less than average rainfall. These periods are referred to as droughts. Droughts can be devastating to both water supply and agriculture. The high variability of rainfall in the Kuiseb River Basin can lead to other kinds of droughts as well.

A form of drought referred to as grazing drought can occur in the Kuiseb River Basin. This drought occurs when the rainfall is too little or too late for grasses to grow. In the Kuiseb River Basin the natural system and land uses are relatively robust and adapted to these conditions. These drought years do therefore not necessarily pose a serious problem to the farmers or the environment, especially when they occur in isolation. However, a few seasons of unfavourable conditions can have devastating effects on agriculture, especially if coupled with other stresses such as overgrazing. If there is no runoff for a number of years, the alluvial aquifers in the Kuiseb River Basin are not recharged and water levels drop, putting pressure on both the woody vegetation along the river and the animals depending on this system.

1.6 Fog
In the western reaches of the Kuiseb River Basin fog brings moisture to an area that otherwise receives little to no precipitation. The fog is an essential source of water for lichens, plants and animals living there. The fog also cools the air, increases air humidity and reduces solar radiation, which contributes to a lower rate of evaporation where it occurs. At the coast fog most often occurs between March and September, while inland fog occurs between August and December. Records from Gobabeb show that fog precipitation is less variable than rainfall in the areas reached by the fog (Figure 8).

![Figure 8. Fog recorded at Gobabeb.](image)

1.7 Temperature
Due to different climate conditions and their influences across the east-west gradient, temperatures show very different characteristics and trends too. Generally the hottest temperatures are measured in the central Namib Desert. Cooler temperatures occur further inland, to the east, especially on top of the great escarpment. Coolest temperatures are experienced along the coast (Figure 9). Windhoek, being at fairly high altitude, experiences high summer temperatures from November to January, but seldom reaching over 30°C. Winter time the
temperature can drop to 0°C and below. The clear skies lead to a wide daily range of temperatures throughout the year.

![Figure 9. Average temperatures in the Kuiseb River Basin.](image)

At Gobabeb, situated in the central Namib, temperatures are higher than in the inland. Clear skies and high radiation cause a wide daily temperature range. The hottest months, on average, are from February to April, but temperatures may reach over 40°C any month of the year.

Closer to the coast the average temperature show less variation between seasons, and the daily temperature range also decreases. The cold sea temperature and cooling effects of fog contribute to the moderate temperatures and frequent cloud cover. The average temperature in Walvis Bay is 20°C throughout the year. The warm east wind contributes to the lack of seasonal variation.

### 1.8 Wind
Winds in the Kuiseb River Basin are dominated by the cool southerly wind bringing in cold air from the ocean towards the desert. These winds turn into westerlies as they move inland, and can blow as far as Windhoek in the early summer months, when they are strongest. These winds commonly prevent moisture-bearing clouds from moving in from the north-east.

### 1.9 Wildlife in the Kuiseb River Basin
In the past wildlife used to migrate along the Kuiseb River, throughout the Basin in search for water and fodder. Since fences and camps were erected these seasonal movements of wildlife were limited. One effect of increased intensity of farming in the Basin was the improved availability of water at watering points, mainly in the upper catchment. This also made it possible for more wildlife to survive in the same area over extended time, not forcing the animals to migrate in search for water. This led to increased competition for grazing between livestock and wildlife. In the early days the farmers’ response was to try to decrease wildlife numbers, as there was no financial incentive to keep it on the land. This was the situation until the 1970s when all wildlife, independent of where it was located, belonged to the government. In 1972 the legislation was changed, transferring the ownership of wildlife located on a farm to the farmer owning the farm. This resulted in farmers being able to earn money on wildlife as well as on their livestock. This provided a strong incentive for conservation of wildlife on farmland in Namibia. Permanent water points and good rangeland management resulted in steadily increasing game numbers, which had to be managed to prevent over utilisation of the rangeland. This led to the introduction of trophy hunting on some of the farms in the Kuiseb River Basin. Some farmers even ventured into managed breeding of wildlife, which is sold to game farms in order to improve the quality of wildlife on these farms. Under normal conditions game will migrate during dry periods. However, game on game fenced farms cannot migrate and therefore has a great impact on the grazing, leading to these farms often having poor rangeland. In addition, due to the poor land cover on these farms, run-off and erosion is commonly much higher compared to farms with rangeland in a better state.
B. Impacts on environment of continued land use and future development

The Kuiseb River has been the focus of life from prehistoric times until the present day (Kinahan and Pallett, 1991). Particular relationships have been forged through the convergence of water, water related resources and the different resource users within the basin. Today several different land uses are practised in the Kuiseb River Basin (Figure 10). The upper catchment is primarily used for commercial activities. In the past commercial livestock farming used to be the most common land use there. However, recently game farming as well as tourism enterprises are becoming more common. The middle section of the basin falls within the boundaries of the Namib-Naukluft Park. The middle catchment also includes the Gobabeb Training and Research Centre as well as several settlements along the river occupied by members of the Topnaar community. The Topnaars living along the Kuiseb River practice communal farming, mainly by raising livestock and horticulture, as well as harvesting of the !Nara plant (Acanthosicyos horridus) which grows along specific stretches of the Kuiseb River. The lower section of the basin, the lower catchment encompasses the town of Walvis Bay.

A general feature in the Basin is that areas that receive more rainfall tend to be more actively utilised. This is evident in the upper catchment of the Kuiseb River Basin where farms, mines, lodges and other land uses are many and close to each other. In the more arid parts of the basin activities are fewer and less intense. The only exception is the Topnaar communities along the Kuiseb River in the middle catchment (Figure 11). Here we can see a relatively intense utilisation of natural resources, centred on the river and surrounding vegetation.
1.10 Commercial farming in the Kuiseb River Basin

1.11 History of commercial farming in the Kuiseb River Basin
In the early days of commercial farming in the Kuiseb River Basin there was one large company, the Liebig Company owning most of the land in the upper catchment. The Liebig Company was formed in 1907 by the Deutsche Farmgesellschaft of South West Africa. This company bought large areas of land on a nation wide scale, in order to establish a cattle farming and meat processing industry in Namibia. The Liebig Company was mainly interested in production of a meat extract called Bovril, which had an international market. What is of particular interest is that the centre of activities was at the farm Neu-Heusis some 50 km west of Windhoek well within the Kuiseb River Basin. During 1912/13 the so-called Liebig house was built in a ‘turn-of-the-century’ German architectural style. The house was an important stop over for travellers on the road between Windhoek and Walvis Bay. At that time the director of the Liebig Company occupied the house. Some other houses were erected on the farm, of which some are still in use by the owner of the farm. The farm had its own shop, post office, school and farrier. There was even a skittle-alley, the only one on a farm in Namibia. The Company owned land in excess of 130,000 ha in the Kuiseb River Basin, which was divided into several farms after the First World War (Schoman, 2005 and E. Hoff., personal communication, 2008). Today the house is abandoned and in a dilapidated state and said to be haunted and despite several offers the current owner has not sold it to interested parties for renovation.

Photo 2. The Liebig house which was the headquarter of the Liebig Company.

1.12 Present day commercial farming in the Kuiseb River Basin
The first farm in the Kuiseb Basin, driving from Windhoek, is located at a height of about 1850 m a.s.l. The most common form of agriculture in the upper catchment of the Kuiseb River Basin is large stock farming. In the upper catchment there are about 109 commercial farms (as registered on the map of the 1970s. One of the commercial farms has been bought for resettlement purposes in the Khomas Hochland; another nine farms belong to affirmative action loan scheme (AALS) farmers (MLR, 2005).

The commercial farms are owned by about 120 farmers which employ about 400 farm workers and support approximately 2000 people in total. However, there are just a few permanent commercial farmers in the Kuiseb River Basin below the escarpment. The reason is that the dry conditions, with the high variability of rainfall between and within years, do not make farming alone financially viable. Therefore farmers have to complement their farming with a second income, most commonly
Agricultural aspects of the Kuiseb River Basin

from work in Windhoek, Swakopmund or Walvis Bay. Economically speaking, productivity gradually decreases from relatively high close to Windhoek (net farm income estimated up to N$30 per ha) to very low below the escarpment, being the edge of the Namib.

As the Kuiseb River Basin is generally very rugged it is almost exclusively used for extensive large stock farming. The southern and south western parts of the Basin have also been used for small stock farming in the past when Karakul pelts were still strong in demand. Karakul sheep are the only small stock that are adapted to the extreme conditions typical for these areas and in those days many farms could make a good living on the edge of the Namib desert. Most of the farms used for Karakul farming were fenced off with jackal proof mesh wire in order to keep predators out. These fences restricted migration of game, especially along the Kuiseb River itself. The western parts of the upper catchment, as well as the middle catchment being below the escarpment and part of the Namib Naukluft Park were initially not divided into commercial farms but were used as emergency grazing for commercial farmers when droughts were encountered elsewhere. This holds true also for the rest of the western parts of Namibia. In other words much land beneath the escarpment that now has been divided into farms was former state land.

It must be noted, however, that production costs in the Khomas Hochland are far higher than elsewhere in the country.(fences, vehicles, pipelines, roads, maintenance, travel time, predators etc.).

1.13 Carrying capacity of farms in the Kuiseb River Basin

In order to make a living a farm must be able to sustainably produce a certain amount of livestock. For this a definite amount of fodder or grazing is needed per annum. In agricultural terms this is referred to as carrying capacity of the rangeland. As was stated before, the rainfall in the Kuiseb River Basin, and Namibia in general, increases from southwest to northeast. The rainfall in the Kuiseb River Basin is about 350 mm per annum in the eastern part, just outside Windhoek. Further towards the west, below the escarpment rainfall is about 100 mm per annum. The carrying capacity of the commercial farms in the area is directly correlated to the annual rainfall. The higher the rainfall the higher the carrying capacity is. According to the carrying capacity map of Namibia, a farm close to Windhoek, in the higher rainfall area would have a carrying capacity of 1:10, i.e. 10 hectares [ha] of land would provide enough fodder for one large stock unit (LSU). A farm situated on the edge of the Namib close to Solitaire has a carrying capacity of about 1:30. A large stock unit is defined as an animal weighing 450 kg.

However, nowadays carrying capacity is calculated scientifically. This more accurate calculation is expressed as kilogram grass yield per hectare (kg/ha).The available grass yield determines how many kg of meat (i.e. livestock) can be carried sustainably throughout the next year. Grazing assessments should be done annually and animal numbers adjusted accordingly. Soil characteristics also influence nutritional value as well as the carrying capacity (Figure 12) and water quality.

Figure 12. Carrying capacity map of the upper catchment of the Kuiseb River Basin.
In order to produce a specific number of animals (expressed as kg meat/hectare) a certain size of farmland is required. The higher the carrying capacity the smaller the farm can be for a given number of livestock (Coetzee M., personal communication 2007). The average farm size close to Windhoek is between 7 000 and 8 000 ha, while in the drier areas, where the carrying capacity is as low as 1:30, farms are commonly about 20,000 ha in size. Another aspect that influences the carrying capacity of a farm is the bush density. In the higher rainfall areas bush encroachment is commonly a problem. Bush encroachment drastically decreases the grass production due to the increased competition for soil moisture. Carrying capacity therefore decreases, which often turns economically viable farms uneconomical. In general, livestock numbers in the upper catchment have reached optimum levels. In times of drought farmers will reduce their livestock numbers on their farms by selling them or by renting alternative grazing elsewhere.

1.14 Bush encroachment
Bush encroachment is a huge problem in Namibia and also affects the Kuiseb basin. It occurs in areas with an average rainfall of 250mm per annum and more. As parts of the upper basin fall within this rainfall zone bush encroachment is also evident here (De Klerk, 2004). The main encroaching bush species are Acacia mellifera (blackthorn), Acacia reficiens (rooihaak) and acacia Erubescens (withaak). Bush encroachment is responsible for reduced water infiltration and competes directly with moisture against grasses, resulting in a less dense grass cover. In areas with heavy bush encroachment water runoff is faster and soil erosion is more severe than elsewhere which leads to faster siltation of earth dams and river beds, resulting in less recharge of underground water.

1.15 Cattle breeds
Due to the generally harsh conditions, farmers in the Kuiseb River Basin commonly make use of highly adapted cattle breeds. Cattle must be able to walk far in rocky terrain and to climb high into the mountains. A medium framed animal is therefore called for and typical breeds are Bonsmara, Simbra, Brahman, Simmental, Sussex, and several cross breeds of these. Furthermore, the animals must have strong mother instincts in order to raise calves under these adverse conditions and to be able to protect them from predators.

1.16 Rangeland management, the use of camps
Before colonisation only natural water points were available to humans and animals and natural resources were used in a nomadic way, as the elements permitted. Availability of water and grazing and veld fires were important factors determining the movements of these nomads. In these days there were no fences so game and livestock could roam freely. When commercial farming started, farmers became the owners of the land they occupied, fences were erected. Initially only border fences were used, demarcating the extent of each privately owned farm. Later farmers started to sub-divide their farms into smaller camps, allowing more controlled management of the grazing on the farm. Today most commercial farms are divided into camps. Camps are erected in such a way that different veld types, soil types and topographic features are separated allowing the farmer to utilise different camps during different times of the season and during specific conditions. Animals are rotated between camps in order to accommodate resting, seed production, stimulation and growth of grasses in the different camps.

1.17 Marketing of livestock (auctions in the upper catchment)
Due to the good quality of large stock production in the upper catchment (Khomas Hochland) farmers have created very sophisticated auction facilities including an electronic scale on farm Aub (Photo 3). Buyers from elsewhere in the country attend these auctions and farmers commonly obtain good prices for their animals due to the good quality and the proximity to the market.
Agricultural aspects of the Kuiseb River Basin

1.18 Government and Extension services
The extension service was generally more active in the past. A key factor for this was the favourable subsidies provided to commercial farmers by the government of the day for the development of infrastructure on farmland, which started in the 1950s and came to an end in 1989. Subsidies were granted if the farmers could show that they had improved their infrastructure to an acceptable standard, something that was accessed by extension personnel. One aspect of this scheme was that commercial farmers were encouraged to establish camps on their farms, to better control grazing and to improve the management of the range. The controlling role of extension resulted in more frequent interactions between farmers and extension services compared to the present situation.

Until recently government had a very sophisticated network of extension services countrywide and also in the Kuiseb River Basin. Regular visits and courses were conducted in order to train and inform farmers about various practices, e.g. technical support, livestock production and veterinary issues. Nowadays farmers that took part in these courses and that have worked closely with extension are getting old and often move out. Today the government does not always have the capacity to deliver the services and training to the younger generation of farmers.

1.19 Water supply
The division of farms into camps also required development of water supply systems, as each camp needs access to water. This is essential in the Kuiseb River Basin as natural surface water is very scarce there. Commonly boreholes were drilled and dams constructed in river tributaries to capture run-off. However, groundwater is generally very unreliable in the Kuiseb River Basin (Christelis and Struckmeier, 2001). Therefore many farmers also constructed dams close to their boreholes. These dams supplement the boreholes with water, and also contribute to increased recharge into the aquifers tapped by the boreholes. These dams are necessary to keep boreholes going in the Khomas Hochland. Livestock drink directly from the dam as long as it contains surface water, normally only during and shortly after the rainfall season. When the dam has dried up the farmer has to rely on his borehole to water his livestock. The same applies for game in the area, when the surface water is gone, wildlife also depend on access to borehole water. This illustrates the need for farmers in the upper catchment of the Kuiseb River Basin to construct small farm dams. Without them most farms would not have enough water to sustain their animals through the dry season. As not all camps are situated on top of productive aquifers, dams are often built in areas where there is no or poor access to groundwater. Camps only supplied with dam water are
grazed before camps with boreholes. The filling up of dams and recharge of aquifers depend on the rate of runoff. Only high intensity rainfall will produce runoff. The most efficient runoff takes place when rain falls early in the rainfall season, when there is little vegetation cover. In years with plenty of plant growth, the runoff is less, leading to little water accumulation in dams and downstream aquifers. This can be described as a runoff drought.

### 1.20 Boreholes

Boreholes are drilled into rock formations where vaults are expected to yield a sustainable water supply. This is a difficult task as water is only carried in isolated pockets that are often missed by the drill. Creating water installations in the Khomas Hochland is far more costly than elsewhere in the country due to the topography and geological features.

The number of boreholes in the upper catchment is given as 1292 (Oosthuizen F., personal communication, 2008). Due to the geological formations boreholes are generally quite deep; – up to 150 metres and more and the yield is usually weak, ranging from 200 to 2,000 litres per hour although stronger yields can be found occasionally in the upper catchment. Water quality is determined by the soil types and can sometimes be unsuitable for human and even livestock consumption.

### 1.21 Water consumption

It is difficult to give an exact figure for water consumption of livestock in the basin, but an attempt has been made to determine livestock and game numbers in the upper basin and to calculate their minimum water requirements.

The following table shows the estimations and calculations:

| The size of the commercial area, totals | 962,000 ha = 9,620 km² |
| Amount of farms | 109 |
| Farm size (varies) | 6,000 – 20,000 ha |
| Average farm size | 8,826ha |
| Recommended average stocking rate | 19 kg/ha or 24 ha/LSU |

Table 1: Water requirements for livestock and game within the Upper Kuiseb Basin, after M. Jakobs (personal communication, 2006).

The animal figures received were given as totals from a few farms only and had to be converted in order to try to make them representative for all the commercial farms concerned. They are as follows:

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<thead>
<tr>
<th>Livestock</th>
<th>S.S.U (small stock units)</th>
<th>LSU (large stock units)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(1 LSU=6 SSU)</td>
</tr>
<tr>
<td>Cattle</td>
<td>20,345</td>
<td></td>
</tr>
<tr>
<td>Sheep</td>
<td>26,393</td>
<td>4,398</td>
</tr>
<tr>
<td>Goats</td>
<td>4,526</td>
<td>754</td>
</tr>
<tr>
<td>Horses</td>
<td></td>
<td>634</td>
</tr>
<tr>
<td>Mules &amp; Donkeys</td>
<td></td>
<td>386</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>26,517</td>
</tr>
<tr>
<td>Rounded total</td>
<td></td>
<td>30,000</td>
</tr>
</tbody>
</table>

Table 2: Estimated livestock numbers, upper catchment after M. Jakobs (personal communication, 2006)

At an average daily water consumption of 30l per large stock unit, the estimated total number of 30,000 large stock units in the upper catchment of the Kuiseb basin consume approximately 900 000 l/day.
Estimated game numbers and water consumption are presented in the following table

<table>
<thead>
<tr>
<th>Game</th>
<th>Per farm (estimate)</th>
<th>Total number</th>
<th>Average daily water consumption (l)</th>
<th>Estimated total daily water consumption (l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zebra</td>
<td>55</td>
<td>5,995</td>
<td>12</td>
<td>71,940</td>
</tr>
<tr>
<td>Koedoe</td>
<td>40</td>
<td>4,360</td>
<td>7</td>
<td>30,520</td>
</tr>
<tr>
<td>Oryx</td>
<td>50</td>
<td>5,450</td>
<td>6</td>
<td>32,700</td>
</tr>
<tr>
<td>Others</td>
<td>10</td>
<td>1,090</td>
<td>3</td>
<td>3,270</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>16,895</td>
<td></td>
<td>138,430</td>
</tr>
</tbody>
</table>

Table 3: Estimated game numbers and average water consumption, upper catchment, after M. Jakobs (personal communication, 2006)

It must emphasized that the water consumption figures for game represent the minimum water requirements and that game will utilize more water if available. Information was gathered through reliable resources. It must also be mentioned that game figures are based on averages and may vary from season to season. Similarly, droughts play an important role as livestock numbers will decrease drastically and game will migrate where possible.

Based on these estimates, the total annual water consumption for livestock amounts to 328,500m$^3$ and that for game to 50,526m$^3$, resulting in an overall estimated total water consumption of livestock and game of 380,000m$^3$ per year. To satisfy this demand approximately 3,800 reservoirs with a capacity of 100 m$^3$ per reservoir are needed. This amounts to an average of 35 per farm.

1.22 Farm dams

Topographical farm maps show about 750 farm dams with a total surface area of ± 12.3Mm$^2$ exist in the upper catchment. The combined effect of all the dams was estimated to amount to a reduction of the average flow of the Kuiseb River by 21%. The effect is higher in drier years. Dams shown on satellite images do not reveal their volume and many are silted up to such an extent that they are insignificant in terms of storage capacity and effectiveness (DRFN, 2000).

Farmers do build new dams at times in order to replace old or broken dams and to develop new camps. They cost a lot of money and are only built if necessary.

1.23 Dam construction

In the Kuiseb River Basin different methods of building dams are encountered. The most common way of building dams in the upper catchment is by blocking a river by constructing an earth wall, which is referred to as an earth dam. The wall of an earth dam can be either of compacted soil or concrete where the whole structure is erected in one operation until the desired height of the wall is obtained. The dam must also have a professionally designed spillway to release surplus water (Stengel, 1963). The biggest problem with these open earth dams is evaporation. As much as 80-90% of the stored water will be lost to evaporation. Proper construction of an earth dam normally requires inputs from an engineer to design the structure. If the dam is not correctly constructed it is likely to collapse under flood conditions. A collapsed dam wall will result in stored water rapidly rushing downstream, which can cause other dams to collapse, resulting in a snowball effect of damage of infrastructure. The farmer responsible for this might be held liable if neglect can be proven.

Subsurface or sand storage dams are another type of dam. These are built by constructing a concrete wall that obstructs water, but with a maximum height of only 0.5 meters to a meter. The lower height of the dam wall will only hold back the heavier materials transported by the river, i.e. rocks and coarse sand. Finer particles, suspended in the flowing water are not trapped by the dam wall. This results in the dam being filled with coarser sediments and water, stored in the capillary
cavities under the soil surface. This limits the evaporation, allowing water to be stored in these dams for a year or even longer. Water can be abstracted by digging a well into the storage dam, or by connecting a pipeline to the dam wall, with a tap on the downstream side. When the dam basin is filled with sediments to the top of the dam wall, then the height of the wall can be increased with another 0.5-1 m, increasing the capacity of the subsurface storage dam each time the height of the wall is increased.

Other ways of obtaining water are to dig wells into riverbeds or to make use of natural springs and extract the water by pumps and then distributing it through pipelines. Another common practice is to drill boreholes into underlying aquifers. Water is commonly pumped by using windmills, solar or diesel powered pumps. The water from boreholes is then distributed via pipelines to strategic points on the farm. The major problem with drilling boreholes is that it is difficult to determine where the aquifers are. Furthermore, the quality of groundwater in the Kuiseb River Basin is often poor. Deep groundwater table and low yields of boreholes is another problem, making it uneconomic to pump.

1.24 Large scale dams
In the upper reaches of the Kuiseb River, on farm Friedenau there is an active copper mine, named Matchless Mine. This mine is part of the Ongopolo Mine. In order to supply the mine with water the Friedenau dam was built in the upper part of the Kuiseb River (Photo 4). The dam has a large storage capacity but is not big enough to contribute to the water supply of Windhoek, which has led to the dam being criticised. The critique was most prominent during 1983 and 2005 when the Matchless Mine was closed and no mining took place. Presently only the mine and a few adjacent farms make use of the water in the dam. Until recently Ministry of Basic Education, Sport and Culture had a facility here, which has been abandoned. Now the dam is the venue for a lodge and campsite named Hochland Nest.

1.25 Communal farming in the Kuiseb River Basin
The Topnaar community traditionally occupied the lower reaches of the middle Kuiseb River catchment. Today they are residing along the Kuiseb River and their settlements are located from Rooibank (about 40 km east of Walvis Bay) to Homeb (about 140 km east of Walvis Bay). There are 18 Topnaar villages along the Kuiseb River (Figure 11). The total population of Topnaars along the Kuiseb River is about 300. The Topnaars are led by their headman, Chief Kooitjie. The inhabitants of the Topnaar settlements along the Kuiseb River are commonly pensioners and young children. Many of the youth and the middle aged family members are staying in the coastal
Farming takes place along the Kuiseb River, mainly with approximately 200 cattle, 2,500 goats, 120 donkeys and about 50 sheep (Kootjie J., personal communication, 2008). The only source of fodder for the livestock comes from the riverine forest, supplying pods and leaves. The most common trees are Faidherbia albida (Ana tree), Acacia erioloba (Camel thorn), Euclea undulata (Fake Ebony). The Ana tree and the Camel thorn have different production cycles, i.e. the one is dormant while the other flowers and bears fruits. This ensures a regular supply of fodder. An interesting aspect of this high dependency on the pods from the Ana tree is that farmers commonly experience a ‘drought’ situation, i.e. lack of fodder for their livestock during and after a flood event as the pods are washed away, leaving less fodder available for the animals. Livestock movements are mainly restricted to the riverbed and riverbanks as the sand dunes to the south and the gravel plains to the north do not offer any significant amounts of fodder.

Livestock is commonly kept and bred with the objective to maximise the herd size rather than for regular marketing. Generally, livestock is only sold when there is an immediate need for money, e.g. for school fees, weddings and funerals. There are no reliable statistics for how many livestock there are in these communities. The small stock is of indigenous breeds and large stock is commonly a mix of European breeds and indigenous Sanga cattle. Donkeys are kept for transport purposes.

1.26 Harvesting of the !Nara melons
Apart from the livestock keeping the Topnaars are harvesting and processing the !nara plant, which produces a spiky melon like fruit. Traditionally !nara plants/fields were demarcated and individual plants owned by families. This system is now falling apart, being transformed into an open access system, in which everyone is in competition for the !nara fruits. In the early 1990s the average !nara yield was estimated to be 26,000kg. However, the total harvest volume declined by 30% during the 1990s. The decrease has been explained by declining interest in !nara business due to a lack of market incentives for the !nara harvesters. Another reason could be a decline in !nara productivity, something that has been claimed by both Topnaars and researchers investigating the ecology of the !nara plant (Henschel et al., 2004). The trend of workable members of the community moving to the towns could also be a contributing factor. Furthermore, change in harvesting methods and the shift from private ownership to communal commodity can also have led to the decreased production.
The Topnaars role in the !nara market is commonly restricted to the supply of raw material, i.e. !nara pits, and they are seldom involved in the further processing, value-adding and profit-making which is done by other entrepreneurs.

1.27 Water supply to the Topnaar communities

Earlier the Topnaar communities were depending on hand dug wells, which were dug in or close to the riverbed of the Kuiseb River for their water supply. The water table was originally shallow in this part of the Basin. However, in response to increased utilisation of the Kuiseb aquifer by mainly Rössing mine and Walvis Bay, the wells dried up, which not only resulted in problems with water supply for the Topnaars but also for trees and !Nara plants, resulting in some trees and plants dying. This was first documented in the 1970s. The lowering of the water table led to many hand dug wells being abandoned. As there was not enough water from the hand dug wells to sustain the livestock, a number of boreholes were drilled and infrastructure was put in place by the government at each of the Topnaar settlements. According to the present water policy, rural communities are expected to pay for the supply of water, something that the Topnaars have never done before, and therefore do not have the socio-economic mechanisms in place to do. This is an increasing problem, placing communities in debt to the water providers, which threatens the water supply to these settlements. This is an issue that needs to be addressed by Rural Water Supplies and the leaders of the Topnaar community.

One factor that is limiting the inhabitants of the Topnaar communities is that they live in a national park. This places restrictions on hunting game for consumption. However, some representatives from the Topnaar community are venturing into the field of ecotourism, which would make these communities less dependent on their livestock. Some Topnaars are consulted and contracted by tourism operators offering dune trips in the area. This development can lead to additional incomes to the Topnaar communities along the Kuiseb River, making them less dependant on the traditional farming practices.

1.28 Diversification of the agricultural sector in the Kuiseb River Basin

Several farmers have diversified their livelihoods by delivering various services to the farming community and the private sector countrywide (Hongslo and Benjaminsen, 2002). Some are drilling boreholes for other farmers or government and mines, while others are offering services like design and construction of water supply systems, maintenance of farm roads and building and maintaining earth dams. Three farmers do horse breeding for an extra income, very successfully and also sell and compete internationally. Many farmers close to Windhoek are working in town during the weekdays, commuting to work every day.

In the southern part of the lower catchment, the Gaub area rainfall is lower than in the northern part, making agriculture less financial viable. Instead of farming many landowners in that part of the basin are more involved in tourism than in agriculture. Some landowners that are still farming in these low rainfall areas are returning to farming with Karakul sheep. A practice that recently has increased as the market and therefore the price of pelts has increased. The Karakul industry collapsed in the 1980s. At the same time tourism gained momentum, especially in the western, more arid parts of Namibia, which have shown a great potential for tourism. This has resulted in many farms being turned into guest farms and hunting farms. The Kuiseb River basin has a great potential for these two forms of diversification. The farms closest to Windhoek are mainly doing cattle farming but many also offer game viewing and hunting. The farms below the escarpment are highly sought after by tourists due to the scenic landscape and their proximity to both Sossus vlei and the coastal recreation facilities. Several tourist operators are taking tourists into the Namib-Naukluft Park, and to other parts of the Basin. Most of these are marketing their ventures as eco-tourism, e.g. Mola - Mola, Uri Adventures, Charlie’s Desert Tours, Dare Devil and more.

When diversifying into game farming, livestock numbers are usually decreased, in order to accommodate larger game numbers. This implies that less water will be used as game needs less
water to survive than domestic livestock does. When diversifying into tourism, game and livestock numbers usually stay the same, but more water will be used for guests and gardens around the homestead. An estimated figure of 200 litres per person per day is accepted. Gardens on guest farms tend to be bigger than on normal farms and swimming pools are common.

More than 40% of farms in the basin have diversified into tourism and hunting.

1.29 Conservancies in the Kuiseb River basin
Today there are two conservancies in the basin, the Auas-Oanob and Khomas Hochland which are active in the upper catchment and responsible for sustainable game and rangeland management.

1.30 Schools in the Kuiseb River basin
There are two schools within the basin. These schools are mainly for children from the farms. One school is situated about 30 km west of Windhoek on farm Baumgartsbunn, which is a private initiative from the farm owner. The school is funded by the Friedrich Ebert Stiftung in Germany. The other school is located in Uduseb, a village situated about 50 km east of Walvis Bay, in the desert, next to the Kuiseb River. This school serves the children from the Topnaar communities living along the river. The government operates the school. Some farmers on the commercial farms also make use of the home schooling system, where the farmers themselves provide the schooling of their children, following a syllabus defined by the Ministry of Education.

1.31 Mines
Apart from the Matchless Mine just outside Windhoek in the upper catchment there are two more mines in the middle catchment, being the Gorob and Hope Mine. They are mining for copper. Several granite quarries are situated outside Walvis Bay along the road to Rooibank (Figure 13).

1.32 Lodges in the Kuiseb River basin
Next to the Friedenau dam a lodge has been established, the Hochland Nest Lodge and Campsite. The attractions here range from scenery, fishing game drives and camping. In addition, a wellness centre has been developed on the farm Weissenfels. It also offers horse trails to tourists. Another farmer offers horse and camel safaris in the Kuiseb River basin.

1.33 Observatories
Due to the altitude, commonly clear skies and the location on the southern hemisphere, Namibia is world famous for its stargazing potential. This has also led to the construction of several advanced
astronomic observatories in the Kuiseb River basin. Max Planck Institute has established an observatory on top of the Gamsberg Plateau (2347 m.a.s.l.). A second advanced observatory has been constructed on farm Göllschau close to the Gamsberg, the HESS Project. This observatory is monitoring the gamma radiation from outer space. Both these initiatives have provided opportunities for alternative incomes for the farmers in the area.

C. Environmental issues to be addressed

There are several gaps and shortcomings related to the agricultural sector in the Kusieb River Basin. The impact of earth dams, constructed on commercial farms in the upper catchment has been a central issue in the Kuiseb River Basin. There have been some studies of this, e.g. the Summer Desertification Programme 9 (DRFN, 2001). However, there is still a lack of understanding of the effects of earth dams on floods and runoff in the Basin. Another aspect of earth dams that would need further investigation is the siltation rate of these dams. Presently we do not know how much dams silt up after various rainy seasons and how their storage capacities decrease up to a point where evaporation will take up all the water within one year, i.e. before the next rainfall season.

The main problems farmers are faced with are: bush encroachment, high evaporation rates of dams, veld fires, droughts, meat prices, predators, land reform, water quality, high production costs, age of farmers who are not allowed to sell or transfer their farms to their children, high maintenance costs for infrastructure, lack of advice by qualified extension personnel, illness among livestock. The recent interest in uranium mining in the Kuiseb River Basin will also affect a few farms in the upper catchment, in particular the farms bordering to the Namib Naukluft Park. Due to the developing tourism industry many farms have changed from cattle farming to tourism or a combination of both. Water consumption is lower by tourists compared to livestock. The most central issues are summarised in Table 4 below.

<table>
<thead>
<tr>
<th>Field</th>
<th>Impact on the agricultural sector and the environment in general</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial farming</td>
<td>Earth dams</td>
</tr>
<tr>
<td></td>
<td>May have a negative effect on water supply downstream</td>
</tr>
<tr>
<td></td>
<td>No up to date information about how many earth dams there are in the Kuiseb River Basin</td>
</tr>
<tr>
<td></td>
<td>High siltation rate in earth dams makes lifespan of dams short and rapidly declining capacity</td>
</tr>
<tr>
<td></td>
<td>Causing less runoff, most noticeable during drier years</td>
</tr>
<tr>
<td></td>
<td>High evaporation rate</td>
</tr>
<tr>
<td>Water reservoirs</td>
<td>Groundwater stored in open reservoirs results in increased evaporation</td>
</tr>
<tr>
<td>Overgrazing</td>
<td>Can cause bush encroachment</td>
</tr>
<tr>
<td></td>
<td>Causes degradation of rangelands</td>
</tr>
<tr>
<td></td>
<td>Leads to increased runoff, increased erosion and increased siltation of earth dams</td>
</tr>
<tr>
<td>Game farming</td>
<td>When wildlife is fenced in they cause extensive degradation of rangeland</td>
</tr>
<tr>
<td></td>
<td>Overutilisation of key species of grasses and shrubs</td>
</tr>
<tr>
<td></td>
<td>Incest commonly occurs if breeding not controlled</td>
</tr>
<tr>
<td>Communal</td>
<td>Water supply</td>
</tr>
<tr>
<td>Category</td>
<td>Issues</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Agriculture</td>
<td>Several issues related to payment of water</td>
</tr>
<tr>
<td></td>
<td>Lowering of the water table due to extraction by Namwater</td>
</tr>
<tr>
<td></td>
<td>Poor quality of groundwater at places</td>
</tr>
<tr>
<td></td>
<td>Diversification</td>
</tr>
<tr>
<td></td>
<td>Need to identify alternative income sources to limit dependence on livestock and !Nara melons</td>
</tr>
<tr>
<td>Livestock</td>
<td>Change in traditional farming systems to be more market orientated</td>
</tr>
<tr>
<td>Extension services</td>
<td>Limited resources</td>
</tr>
<tr>
<td></td>
<td>Lack of manpower and expertise to serve the farmers in the Kuiseb River Basin</td>
</tr>
<tr>
<td>Tourism</td>
<td>Does not have much direct impact on the farming environment, except:</td>
</tr>
<tr>
<td></td>
<td>Diversification of income can allow farmers to keep less livestock on the rangeland</td>
</tr>
<tr>
<td></td>
<td>Job creation possible</td>
</tr>
<tr>
<td></td>
<td>Worth noting that off-road driving on the gravel plains in the middle and lower catchment can cause irreparable damage to the environment</td>
</tr>
<tr>
<td></td>
<td>Desert is very sensitive and can only accommodate a certain amount of controlled tourism activities</td>
</tr>
<tr>
<td></td>
<td>Guest farms usually have pools and lush gardens around the house, need more water for that industry</td>
</tr>
<tr>
<td>Mining</td>
<td>Heavy impact on the environment through pipelines, power lines, roads, actual mining activities, poaching, theft on surrounding farms</td>
</tr>
<tr>
<td></td>
<td>There are possibilities of uranium mines being established on farms in below the escarpment, which can have high financial gains but also adverse impacts on the environment</td>
</tr>
<tr>
<td>Large scale dams</td>
<td>Do alter the flow pattern of the Kuiseb River</td>
</tr>
<tr>
<td></td>
<td>Can create new recreational facilities and job opportunities</td>
</tr>
<tr>
<td></td>
<td>Will require construction of pipelines to transport water to Windhoek and Walvis Bay</td>
</tr>
<tr>
<td></td>
<td>Will require construction of new power lines that will have a negative influence on the scenery, i.e. touristic value will decrease</td>
</tr>
<tr>
<td>Resettlement farms</td>
<td>Sustainability</td>
</tr>
<tr>
<td></td>
<td>Most resettlement farmers have limited financial means and lack experience of farming in this part of Namibia</td>
</tr>
<tr>
<td></td>
<td>Resettled farmers do not have proof of ownership of farm and thus have no security to borrow money for farming purposes</td>
</tr>
<tr>
<td></td>
<td>Infrastructure cannot be maintained due to limited resources</td>
</tr>
<tr>
<td></td>
<td>Limited predator control often leads to greater livestock losses</td>
</tr>
<tr>
<td></td>
<td>There is a definite need for training in terms of basic farming methods, financial management and record keeping.</td>
</tr>
<tr>
<td>New trans-Kalahari</td>
<td>More traffic</td>
</tr>
<tr>
<td></td>
<td>Scenery disturbed/destroyed</td>
</tr>
</tbody>
</table>
| Highway via Us pass | New business opportunities  
Less tranquillity but new opportunities for guest farms |
|---------------------|-----------------------------------------------------|
| Large scale water abstraction | Negative impact on groundwater levels, leading to hand dug wells drying up  
Trees and !Nara plants have been shown to die |
| Alien vegetation | Prosopis spp.  
Is encountered throughout the basin, present on every commercial farm  
Seeds and pods are washed downstream  
Very drought resistant plant, making it a strong encroacher  
So far Prosopis is not a major threat in the Kuiseb River Basin, but its presence is increasing |
| | Wild tobacco (Nicotiana glauca)  
Poisonous plant which can form thick stands with a deep root system  
Mainly found downstream in the middle and lower catchment |
| | Thorny apple (Datura spp.)  
Poisonous plant with a shallow root system |
| | Rhizinus (Richinus communis)  
Poisonous plant with a shallow root system |
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Hoff, E. Owner of Farm Neu Heusis


Jacobs M., Farm Harmonie, Western Khomas, Kuiseb catchment, member KBMC


Klintenberg, P., Research and Training Coordinator, Desert Research Foundation of Namibia

Kooitjie J. Extension technician, Directorate Extension and Engineering Services (DEES), Ministry of Agriculture Water and Forestry, Walvisbaai ADC, Erongo Region.


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WATER RESOURCES MANAGEMENT PLAN FOR THE KUISEB BASIN

ENVIRONMENTAL ISSUES IN KUISEB BASIN PERTINENT TO RIVER BASIN MANAGEMENT

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1. INTRODUCTION

This narrative report explores the environmental issues pertinent to the management of the water resources of the Kuseb Basin in terms of the general ecology of the Kuseb River and its basin as well as water quality and pollution management. Current and potential environmental impacts as well as ecologically sensitive areas are identified as are gaps in existing information. The report is intended to inform the Kusib Basin Management Committee about our current understanding of the Kusib Basin environment to help them to better understand and manage the river basin they are responsible for and to help them think about and plan for future changes and threats. This narrative report is written in support of the Action Plans that make up the Water Resources Management Plan for the Kusib Basin, particularly Action Plan 3 Water Quality and Pollution Prevention Management.

Environment is a very broad concept encompassing a comprehensive and dynamic system of different, interdependent physical, ecological, social, economic and political components. For the purposes of this report on the environmental issues in the Kusib River Basin, it is used in a somewhat narrower way that focuses mainly on the bio-physical or ecological components.

All water resources are closely linked to the hydrological cycle and 24 hydrological basins can be identified in Namibia (Bittner & Dierkes 2004). One of these is the Kusib River Basin, which drains the Khomas Hochland Mountains near Windhoek. It continues westwards over the steep escarpment onto the Namib Desert plains, where it takes a southward loop before disappearing into the sand close to the Atlantic Ocean near Walvis Bay. Figure 1 on page 2 shows all the main hydrological basins in Namibia and their boundaries.

The new Water Resources Management Act 24 of 2004 makes provision for Basin Management Committees to manage each river basin. As it would be difficult to have committees for all 24 basins, experts have proposed to reduced these to eleven water management units. This was done using agreed criteria that take into account both surface and groundwater sources as well as present water transfer schemes, so combining the water source, water use and water users. Figure 2 on page 2 shows these proposed main basin management units, (Bittner & Dierkes 2004), one of which is the Kusib Basin under the care of the Kusib Basin Management Committee, KBMC.
According to the new Water Resources Management Act, the aim of river basin management committees, like the Kuiseb Basin Management Committee, is integrated river basin management “to ensure equitable access to, and sustainable use of, water resources without detriment to the environment or functioning of the water cycle.” (MAWF, 2004). Such an integrated management
approach takes the water resources, their uses, all users and their impacts into account. This integrated basin management approach is a community-centred, environmental approach that links people, water, land, plants, animals and the whole basin ecosystem, that aims “to ensure equitable access to and sustainable use of water resources; to decentralise water resources management to communities; to recognise the unity of the hydrological cycle and to encourage stakeholder participation in the management of our national water resources.” (MAWF, 2004)

To devolve water resource management to the lowest appropriate level, the Water Resources Management Act makes provision for River Basin Management Committees that will allow stakeholders within each designated river basin to manage their own water resources. To date, two have been officially established and approved by the Minister. The first was the Kuiseb Basin Management Committee (KBMC) established in 2003 as a pilot example prior to the Act being passed (Botes et al. 2003, Manning and Pallett 2004). Since then the Ishana sub-basin Management Committee (IBMC) was established in the Cuvelai in 2005. Now several more, for the Omaruru, Okavango, Fish and Ugab rivers have been initiated. There are two active groundwater basin committees, one for the Karstveld aquifer and another for the Stampriet aquifer. Currently, the KBMC includes representatives from twelve different institutions: the Coastal Environmental Trust of Namibia CETN, the commercial and communal farmers, NamWater, Government service providers – DEES, DWAF, MET, RWS, the Erongo and Khomas regional councils, the Walvis Bay Municipality and the Gobabeb Research and Training Centre (Usurua 2008).

This new law states that the establishment of basin management committees can be initiated by Government or by interested persons. It further requires that: it should be an open and transparent process with the focus on hands-on management; the members should undertake to communicate with the communities they represent and that although their main task is advisory, their active support with data collection, water use monitoring, planning of water-related development activities and financing the committees is encouraged (MAWF, 2004, DRFN, undated).

### 1.2 Ephemeral rivers in Namibia

As shown in Figure 1, all Namibia’s perennial rivers border on neighbouring countries, whilst the ephemeral rivers are within the country. Ephemeral means that they flow only in direct response to good rains, usually for a few days to a few weeks, and sometimes not for several years or in good rain years, they may flow several times (Bethune et al. 2008). These rivers, although dry, serve as “linear oases” in that they recharge groundwater and thus maintain a dense strip of riparian vegetation alongside the rivers in otherwise arid conditions (Heyns et al. 1998). This narrow strip of vegetation and good groundwater is essential to the health and productivity of the riparian vegetation and wildlife associated with these rivers as well as the survival of man and his livestock particularly where these rivers cross deserts and semi-arid areas (Jacobson et al. 1995, Seely et.al 2003). Good floods in these rivers are essential for the germination of plants and to recharge the alluvial aquifers. Often too many dams upstream can severely reduce these floods to the detriment of the downstream aquifers and riparian vegetation. Already there is evidence that reduced flooding in rivers such as the Swakop River, where the Von Bach and Swakoppoort dams often hold back all of the annual floods, trees like the Ana tree, *Faidherbia albida*, are dying. Scientists working on the Kuiseb River think that consistently less water reaches the Kuiseb Delta aquifers that sustain coastal towns and mines (Seely et. al. 2003).

### 1.3 The Kuiseb River Basin

The Kuiseb River is one of Namibia’s twelve westward flowing ephemeral rivers. It links the wetter Khomas Hochland plateau, where most of the rainfall feeding the river occurs, to the dry coastal plains of the Central Namib. On its way it traverses through commercial farmlands in its upper reaches, through the Namib Naukluft Park where it keeps the extensive Namib Sand Sea at bay, past Gobabeb, home of the Gobabeb Research and Training Centre, and ten communal villages settled by
the Topnaar people in the middle, to finally form the important alluvial aquifer at the Kuiseb Delta that supplies water to the city of Walvis Bay, other coastal towns and mines.

The Kuiseb Basin covers an area of 21 877 km$^2$ and can be divided into three sub-basin sections (Gardiner et al. 2008) as shown in Figure 3 below.

![Figure 3. The Kuiseb Basin showing the Upper, Middle and Lower sub-basins. (Gardiner et al. 2006) Prepared by Carole Roberts for the Kuiseb Profile.](image)

According to the latest information gathered for the Kuiseb Profile and used by Gardiner et al. (2006) for the WADE study, the Upper Kuiseb, covers an area of 9 995 km$^2$ coinciding roughly with the commercial farm land in the Khomas Hochland and extending to the bottom of the escarpment. The Middle Kuiseb covers a slightly larger area of 11 222 km$^2$. Its eastern edge is the Namib Naukluft Park border. In the south it follows the Kuiseb River to near Natab before cutting through the dunes to the sea to include the groundwater system beneath them. The Lower Kuiseb sub-basin covers 1 060 km$^2$ and includes the Kuiseb Delta area and the Kuiseb Water Supply scheme.

2. ENVIRONMENTAL ISSUES

To share information about the river amongst the diverse stakeholders in the Kuiseb Basin, the Desert Research Foundation of Namibia, DRFN, has started to compile information to produce a Kuiseb Basin Profile (Roberts, in prep.) It will outline the water and other natural resources of the basin and highlight current concerns such as the high water supply requirements of the new and proposed Uranium mines. It is strongly recommended that funding be found so that work on this can proceed and that new or pertinent information from the Water Resources Management Plan for the Kuiseb Basin reports be incorporated into the Kuiseb Profile as appropriate. Material collected and maps compiled for the Kuiseb Profile have already proved valuable to the international project to determine floodwater recharge of alluvial aquifers in dryland environments or WADE.
One of the documents produced for the WADE project (Gardiner et al. 2006) on “Site Characterisation for Kuiseb Riparian Ecosystems” captures most of the pertinent information on the geography, climate, hydrology, riparian habitat and users of the Kuiseb Basin resources. As there is no point in repeating the contents of that report here, it is recommended that the KBMC request DRFN to obtain permission from WADE to print and bind copies of the WADE site characterisation report by Gardiner et al. (2006) to use as background information to the Kuiseb riparian ecosystems until the Kuiseb Profile is available.

2.1. General Ecology of the Kuiseb Basin

Useful background information on the ecology of the Kuiseb Basin is contained in several books and articles that have been published on Namibian water resources (Bethune, 1996, Heyns et al. 1998, Namibian wetlands (Shaw et al. 2004, Shigwedha and Bethune, 2006, Bethune et al. 2008) and their biodiversity (Barnard et al. 1998, Curtis et al. 1998), on ephemeral rivers (Jacobson et al. 1995), on the Namib desert and its ecology (Louw and Seely, 1982, Huntley, 1985, Seely, 1987), southern African deserts (Lovegrove 1993) and Namib plants (Craven and Marais 1986, Curtis and Mannheimer 2005). There are also now over 1000 scientific publications that refer to scientific studies undertaken at Gobabeb or by the Desert Research Foundation of Namibia. It is not within the scope of this report to review them. Instead some information on the ecology of the Kuiseb River Basin that may be useful to the KBMC to managing the water resources of the Kuiseb Basin is given, based mainly on the information analysed for the Kuiseb profile (Roberts in prep.)

Figure 4 on page 6 shows the five main landscapes that the Kuiseb Basin can be divided into, each supporting distinctly different types of plants as the river descends from the highlands to the coast. They are:

- The hilly, Khomas Hochland Plateau, where the altitude varies from 1, 700 – 2, 000 m, with typical highland savanna vegetation with trees such as Combretum apiculatum and Acacia hereroensis and good grazing grasses such as Brachiaria nigropedata (Muller, 1985);
- The small section of the Rehoboth Plateau around Weissenfels, where the deeper sand supports a grassland savannah with camel thorn trees, Acacia erioloba;
- The steep escarpment steeply descends 1000m to the coastal plains and is characterised by shallow soils supporting plants typical of the semi-desert savanna transition zone, Ozoroa and Commiphora species and the well known resurrection plant, Myrothamnus flabellifolius.
- The gravel desert plains with isolated Inselbergs, gradually descend westwards to the coast, here the river forms a 200m deep canyon for some of its length, rainfall is low and only a few desert adapted plants can survive, although the “inselbergs” support a greater diversity of life as they provide more habitats and receive more moisture from fog.
- The Namib sand sea of dunes south of the Kuiseb River supports virtually no vegetation.
2.1.1 Khomas Hochland and Escarpment farms – ecology

The rolling topography of the Khomas Hochland provides many suitable sites for small, fairly deep farm dams, but the high erosion rates have caused many of these dams to silt up with time, they are also prone to break during flash floods. Most of the commercial farms are managed for beef production yet an increasing number are diversifying to include game farming and run guest farms that cater for hunters. Some farms nearer to Windhoek provide tourist accommodation and game viewing and several on the edge of the escarpment also cater for tourists offering exceptionally clear views of the night sky. A separate report on the impact of Agricultural land use has been prepared by Frank Wittneben and Patrik Klintenberg for the KBMC Water Resources Management Plan.

Friedenau Dam lies within this upper catchment area and is mainly used for recreation. It is of ecological importance because, unlike most dams, it has developed a fairly stable marginal zone, more typical of lakes than dams. The low demands on the water has kept the water level fairly stable and allowed plants more typical of natural lakes to become established around the edges. The water is also very clear allowing good visibility of the aquatic plants and fish and its depth allows good practical demonstrations of limnological field techniques. All this makes it an ideal field site for teaching aquatic ecology. It is regularly used by the Polytechnic of Namibia for practical aquatic ecology classes and for five years was used a site for the SADC/UNAM Fisheries Management training course and until recently as a Youth Centre. It is recommended that the KBMC make NamWater aware of the ecological and educational value of Friedenau Dam and that it should not ever be used as a short-term emergency water supply as rapid draw-down will kill the marginal shallows that have taken several decades to become established and will dry out the nesting sites of the bass that inhabit the dam.
2.1. 2 The Kuiseb River as an linear Oasis

One of the major management challenges is to manage dams in the upper catchment of ephemeral rivers. Too large or too many dams reduces the quantity and frequency of downstream water flows. Even though the team of SDP students (Dausab et al. 1994) did not rate the impact of the over 400 farm dams at the time as significant to downstream flow. It would be important to re-evaluate this finding in the light of new research by the WADE group that shows that it is particularly the medium and large floods, with a depth of at least 15 – 20 cm that recharge the delta aquifer. One would assume that over 500 farm dams in the upper catchment would reduce both the magnitude and frequency of such flows to the detriment of the delta aquifers. Aquifer recharge is not only important for water supply but ecologically this provides the water that sustains the riparian woodlands typical of our ephemeral rivers and provides the seeps that allow wildlife to survive in the desert. Many animals rely on groundwater shallow enough to be reached by digging.

The flood dynamics of ephemeral rivers has been well described by Jacobson et.al (1995) and Barnard et al. (1998). Essentially summer thundershowers in the upper catchment cause runoff into the rivers. The amount of runoff generated is dependent on the intensity and duration of the rain, the soil type and compaction, vegetation cover and evaporation rates. In the highland areas this runoff is turbulent, turbid and rapid, often occurring as flash floods. The duration and distance of flow varies and can be altered by retention in farm dams. All along the distance of the flow, some of the water infiltrates into the river sand or alluviums and it is this water that supports the riparian trees and recharges the boreholes in and close to the river. The water also forms temporary pools in deeper or shaded sections of the river and where the groundwater is shallow seeps may feed these pools. These are essential to the wildlife living in and near the river. It is not only water that is transported downstream by these floods but also nutrients, silt, seeds and debris, all important to the productivity of the river downstream and to plant recruitment. For much of its length the Kuiseb River also has the ecological function of scouring the river bed and stopping dune encroachment. This ecological process sustains a narrow band of vegetation all along the river that is referred to as a linear oasis, because it provides a long narrow line of water, shelter and food to desert organisms and to man.

Trees typical of these linear oasis, are Faidherbia albida, the Ana-tree, Combretum imberbe, the leadwood tree, Acacia erioloba, the camelthorn, Ziziphus mucronata, the buffalo thorn, Salvadora persica, the mustard bush and Tamarix usneoides, the wild tamarix (Curtis and Mannheimer, 2005). Also dependent on the infrequent flows of the Kuiseb River is the !Nara bush, Acanthosicyos horridus, that has sustained the Topnaar people living in the Namib for hundreds of years. This riparian vegetation is extremely important to people and wildlife living alongside the river, in fact the pods, shade, shelter, wood and fodder they provide allow their survival in an otherwise hostile environment. A 1996 it was estimated that there were some 10 000 Ana-trees in the lower Ugab River, each tree can produce 10 – 50 kg of pods/year, some large trees producing over 150 kg and that the pods from a single tree was worth N$ 200 then as fodder. As Faidherbia is a legume, these trees also fix nitrogen and so improve soil fertility. Should the flow in these rivers be held back by dams, new trees would not germinate, groundwater would not be recharged, productivity would decline, there wood be less fodder and fewer pods for livestock. Of ecological concern is the growing number of alien invasive plants also supported by these linear oasis. Typical species found alongside the Kuiseb River are, Prosopis glandulosa, the mesquite from central America, Ricinus communis, the castor oil bush with dense stands near Gobabeb, Nicotiana glauca, wild tobacco and a variety of Thorn apples or Datura species (Bethune et. al 2004, Henderson 1995, Brown et al. 1985). In South Africa the working for Water programme has successfully improved groundwater resources by removing alien invasive trees. At Okombahe youth are involved in a IWRM project harvesting Prosopis trees both to improve groundwater levels and to provide employment and an income from selling the charcoal, poles and planks made from the wood.
2.1.3 Protected areas Namib Naukluft Park and conservancies

The northern section of the Namib Naukluft National Park is a century old and the entire park now covers an area of 50,000 km², making it the third largest in Africa. Until recently it was the only national park that had people living inside it. There are ten Topnaar villages alongside the Kuiseb River as well as the Gobabeb Training and Research Centre originally established as the Namib Desert Research Station in 1962. The park is home to a diversity of well-studied desert adapted plants and animals (Friends of the Namib 2007). Because they live within the park, the Topnaar community have not been able to join the 50 other Namibian communities that have set up communal conservancies to benefit from their wildlife (NACSO, 2007).

2.1.4 Coastal wetlands of international biodiversity importance

As a signatory to the Ramsar Convention, Namibia is committed to the conservation of its internationally important wetlands (Kolberg undated). The main aims of the convention are to prevent the loss and degradation of wetlands worldwide and to ensure that they are used wisely and sustainably, while conserving their biodiversity values and ecosystem services. Namibia acceded to the convention in December 1995 designating the Walvis Bay wetlands, Sandwich Harbour, the Orange River Mouth and Etosha Pan as its first four Ramsar sites (Shaw et al. 2004, Bethune et al. 2008, Kolberg & Kolberg undated). The Walvis Bay and Sandwich Harbour wetlands are both within the Kuiseb Basin. These wetlands are thus important to the KBMC who should continue to cooperate closely with the Coastal Environmental Trust of Namibia, CETN, to conserve and wisely manage these internationally important wetlands. The Walvis Bay wetlands include the lagoon, supporting for than 40 wetland bird species as well as mudflats, shore, salt pans and sewage works. Together they support 70,000 – 100,000 birds in winter and up to 250,000 when the migrants return in spring (Bethune et al. 2008). Unfortunately the Walvis Bay wetlands do not yet have any official protective status. The Sandwich Harbour wetland, that supports some 4,000 – 5,000 birds of 37 different species is fortunately protected within the Namib Naukluft Park. The KBMC should lobby MET to have the Walvis Bay wetland, which is increasingly threatened by coastal development, officially proclaimed as a protected area.

2.1.5 Archaeology of the Kuiseb River Basin

The Kuiseb Basin is one of the most important archaeological environments in the country. The entire archaeological sequence is represented, from terminal Pleistocene artefact-scatters associated with pans along the lower reaches of the river, to evidence of the contact period, which in the especially isolated example of Nambia, began in the late 18th century and continued into the early 20th century (Jill Kinahan, pers. comm.. 2008).

The sequence of archaeological sites in the Kuiseb Delta yields uninterrupted evidence of the early acquisition of pottery in the 4th century AD, to the indigenous response to contact arising from the global spread of Western commerce. The Kuiseb Delta is unique in that the limited growth and development of Walvis Bay over an extended period, along with the difficulty of access to the dunefields has preserved archaeological evidence whereas, in other parts of southern Africa, and indeed the world, this evidence long disappeared under the foundations of cities which grew fast at the trading entrepôts of the coast. On private farmland in the upper reaches of the Kuiseb Basin, archaeological sites are significant for evidence of both pre-colonial and historic copper-working. Indigenous copper-working inland produced beads that passed through networks of trade and alliance down to the coast, and are found on contact sites in association with the glass trade beads of Europe (Jill Kinahan, pers. comm. 2008.). For more detail please see the separate specialist report by J. and J. Kinahan, Archaeology of the Khuiseb River Basin and the map they compiled which show the sensitivity of different areas in the basin and includes a comprehensive bibliography of published and unpublished sources.
2.2 Water Quality

As elsewhere, water quality in Namibia depends on both natural factors, such as the chemical composition and solubility of rocks, the gradient and vegetation of the catchment area, as well as rainfall, water temperatures and decomposition of debris and man-made factors such as pollutants or contaminants from domestic and agricultural waste or runoff, mine and factory effluents and fuel leaks or spills (Tarr and National Water Awareness Campaign 2002, Roberts et al. 2007).

2.2.1 Water Quality Requirements

The drinking water quality guidelines (NamWater 2008, DWA Undated), are based on requirements set out in the old Water Act, No 54 of 1956, and classify drinking water into 4 classes:

- Class A – excellent,
- Class B- good or acceptable,
- Class C- low health risk, not yet critical but should receive attention
- Class D- a higher health risk, or unsuitable for human consumption – needs urgent attention

These are currently being revised and will form part of the new regulations under the new Water Resources Management Act No 24 of 2004. However, given that the health issues associated with the concentrations of different chemicals in the water do not change with time, the guidelines should not be considered in any way inappropriate as they provide a sound indication of water quality. Throughout this discussion, the water chemistry measurements collected are related to these guideline limits and the four classes of drinking water. (See Annexure 1: The NamWater Guidelines).

The concentration of Total Dissolved Solids, TDS, provides a good indication of the concentration of chemicals e.g. Calcium, Magnesium, Sodium, Nitrates, Sulphates and Fluorides dissolved in the water i.e. its mineral content. Generally, the lower the TDS concentration is, the purer the water. Rainwater and thus the water flowing into our rivers have a relatively low TDS. But, as water is a universal solvent, minerals contained in the soil and surrounding rock slowly leach into the water and in some places such as the Karstveld, this causes extremely high TDS values. Drinking water should have a TDS lower than 2 000 mg/l, whilst it is safe to use water with a higher TDS for stockwatering.

Although there are no legal chemical concentration limits for Stockwatering, the NamWater guidelines include a table for these. See Table 4 in Annexure 1. These limits for livestock are all well beyond the range of groundwater concentrations found in the Kuiseb River Basin e.g. the TDS limit is 6 000 mg/l. Although NamWater sets this upper limit of 6 000 mg/l for stockwatering, it is better to be cautious and follow the advice of the groundwater quality map given in the Atlas of Namibia (Mendelsohn et al. 2002) that highlights areas with a TDS above 5 000 mg/l as unusable even for livestock. In due course, water quality requirements will also be developed for wastewater, water re-use and irrigation water (Cynthia Ortmann pers.comm 2008).

2.2.2 Groundwater Quality in the Kuiseb Basin

Most of the water used in the Kuiseb Basin is groundwater. Groundwater quality is largely determined by the underlying geology of the catchment, as different amounts and proportions of minerals from the rocks and soils leach into the water flowing over, or percolating through, them (Davies and Day 1998). Within the Kuiseb Basin the groundwater is generally considered to be suitable for drinking.

The groundwater quality map included in the Atlas for Namibia (Mendelsohn et al. 2002) shows that most of the Kuiseb Basin has potable quality groundwater, i.e. suitable for drinking and domestic use.
Some higher TDS concentrations of 2 000 – 2 600 mg/l are found closer to the escarpment and at one site in the lower Kuiseb (possibly Gobabeb or Klipneus). It also shows that for much of the middle Kuiseb there was no data and cautions that there is much variation at a more local scale. The earliest national water quality maps are the 1982 set of four national groundwater quality maps, one each for TDS, Flouride, Sulphate and Nitrate-Nitrogen. These were derived from detailed surveys conducted by the Council for Scientific and Industrial Research, CSIR, during the 1970s. Unfortunately the data on which these maps are based seems no longer to be available and are unlikely to be in digital format. Although these maps cover the entire country some areas were not surveyed. Within the Kuiseb River Basin, the survey covered the entire upper commercial farmland area, and then a section along the Kuiseb River from Gobabeb to Urusus and a strip alluvial aquifer between Dorob southwards to Sandwich harbour following this branch of the alluvial aquifer.

Based on visual inspection of the maps that are on display at the Division Water Environment, TDS concentrations in the groundwater, in the upper catchment ranges from below 1000 mg/l increasing up between 1000 – 2000 mg/l at some sites along the escarpment. Between Gobabeb and Urusus, TDS values are again less than 1000 mg/l with the exception of around Klipneus where the map indicates a TDS of 2000 – 3000 mg/l. TDS varies greatly in the section between Dorob and Sandwich Harbour with values in the extreme south exceeding 10 000 mg/l.

The Flouride map shows mainly low concentrations within the basin, lower than 1 mg/l in most of the upper catchment and in the desert (Class A - excellent), with a few pockets in the upper catchment having concentrations between 1 and 2 mg/l (Class B – good) and isolated cases between 2 – 3 mg/l (Class C – low health risk. A concentration of about 1 mg/l is considered beneficial to prevent tooth decay and is sometimes added to drinking water where natural concentrations are low. Sulphate concentrations shown are mostly below 250 mg/l (Class A – excellent) although west of Dorob this increases 500 – 1000 mg/l and in patches to 1000 – 2000 mg/l (Class C – low health risk) Nitrate levels are shown as 0 – 20 mg/l throughout the basin (< 10 =Class A - excellent, 10 – 20 Class B- good).

Blom and Bouwer (1985), monitored TDS levels in a series of boreholes along the Kuiseb River between Narabeb and the Sout River confluence, and compiled a Kuiseb River regional ground water
quality map dated March 1982, showing TDS concentrations measured as ppm (parts per million), for the area from Klipneus to the sea. Up to Rooibank and then along the river to Swartbank the concentrations are below 600 ppm but westwards beyond Rooibank and south of the river the water quality decreases to TDS values between 600 and 2000 ppm, with the most saline groundwater found as expected closest to the sea – 2000 - >6000 ppm. However, they found no evidence that the inferior water quality entering the production boreholes. High TDS near one of the Swartbank recorders was explained by excessive salt concentrations due to evaporation from an open pan nearby. (See the map in Figure 5 on page 9 to locate Swartbank and Rooibank)

A more recent detailed study of groundwater quality in the lower Kuiseb, undertaken as part of the BGR investigation in 1993/94 (BGR 1995), confirms that, the water quality in the alluvial aquifer is better than elsewhere in the basin and most saline near the coast. They report TDS levels of up to 500 mg/l in the river floodwater and average TDS levels of 600 mg/l at Swartbank, 950 mg/l at Rooibank A and 1450 mg/l at Klipneus. Marked variations in groundwater quality provide evidence that his aquifer is more likely to be discontinuous than continuous.

Water Quality records obtained from the NamWater database, were studied for this report. The Kuiseb record covers the last decade, from late 1997-2008 and includes some 475 samples each analysed for 22 different water chemistry parameters. The record covers mainly the production boreholes at Swartbank (max. 20 boreholes), Rooibank A (max. 8), Rooibank B (max. 8) and Dorop South (max. 10 boreholes) as well as the reservoirs at Rooikop Airport and Mile 7. Figure 5 on page 11 shows the location of these sites.

Figure 5. Schematic map of the Kuiseb Water Scheme from Heyns (2008)

According to the Water Resources Management Plan for the Kuiseb Basin report by Heyns (2008) on water planning and use, the Kuiseb Water Scheme consists of the Lower Kuiseb Aquifers and all bulk
water infrastructure up to and including the Mile 7 reservoirs near Walvis Bay and the terminal reservoir at Swakopmund. The green numbers refer to the capacity of each reservoir in m$^3$.

NamWaters’ frequency of sampling varied but was usually twice a year for the boreholes and the reservoirs. No samples were analysed from Rooibank A and Dorop S after December 2005 or from Rooibank B and Swartbank after December 2006. The reservoirs were sampled twice a year until 2006 and quarterly after that, possibly because regular sampling of the individual boreholes had been discontinued. Also included were ad hoc analysis for “Kuiseb flood water” (Feb 05), borehole No 10012 in the “Kuiseb area” (5 – 12 April) and Walvis Bay town (May 07) presumably in response to perceived problems. Although time did not allow for any statistical analysis of the data some conclusions could be made. See Table 1 on page 12. It sums up these main preliminary findings.

As can be seen in Table 1, the water quality of the boreholes in the lower Kuiseb and the reservoirs where this water is collected is usually either excellent (Class A) or good (Class B) for all the parameters tested. Occasionally, in the drier years, this can deteriorate to Class C particularly for those chemicals associated with hard water. By comparing the analysis results over the decade monitored by NamWater there is no evidence of salinisation or sea water intrusion even at Dorop South. Changes are more likely to simply be concentration of salts in the drier years when there is no or little recharge and dilution following major flood events. This was confirmed in discussion with the water chemist at NamWater (Merylinda Conradie pers.comm. 2008). The State of the Environment Report on Water in Namibia (WET, 1999) recommended that NamWater analyse groundwater samples from “sentinel boreholes” at the end of the dry season each year to detect changes in groundwater salinity/TDS. This has been done twice a year for the Kuiseb delta aquifers.

### Table 1. Water Chemistry of Kuiseb Aquifer boreholes based on NamWater samples 1998 – 2006 and for the reservoirs at Rooikop and Mile 7 1997 – 2008 for parameters included in the drinking water guideline. (no class limits for TDS, alkalinity, silicate SiO$_2$ nor Nitrite NO$_2$ – N)

<table>
<thead>
<tr>
<th>CHEMICAL PARAMETER</th>
<th>MAIN TREND</th>
<th>QUALITY COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.7 – 8.8</td>
<td>6 – 9 = Class A – excellent</td>
</tr>
<tr>
<td>Colour mg/ l platinum units</td>
<td>&lt; 20, few up to 24</td>
<td>&lt; 20 = Class A – excellent</td>
</tr>
<tr>
<td>Turbidity Nephelometric turbidity units NTU</td>
<td>&lt; 1, Dorop S up to 10 Swartbank 25 in June 02</td>
<td>&lt; 1 = Class A – excellent 1-5 Class B, 5 – 10 Class C</td>
</tr>
<tr>
<td>Conductivity mS/m 25° C</td>
<td>Usually 50 – 150, 140 – 190 Dec 05 Dorop S, and Jan 05 Rooibank A 374 Rooibank A Dec 05</td>
<td>Class A – excellent  Class B (up to 300) – good  Class C – low health risk</td>
</tr>
<tr>
<td>Sodium Na$^+$ mg/ l</td>
<td>Usually below 100 Dorob S often 170 – 205 Rooibank once 340 + 363</td>
<td>Class A – excellent  Class B – (100 – 400) good</td>
</tr>
<tr>
<td>Potassium K$^+$ mg/ l</td>
<td>9 – 29</td>
<td>Class A (up to 200) – excellent</td>
</tr>
<tr>
<td>Calcium Ca$^{++}$ mg/ l as CaCO$_3$</td>
<td>Mostly 90 – 300 Rooibank A once 500 Rooibank A once 577</td>
<td>Class A (up to 375) – excellent  Class B (up to 500) - good  Class C (up to 1000) – low risk</td>
</tr>
<tr>
<td>Magnesium Mg$^{++}$ mg/ l as CaCO$_3$</td>
<td>Mostly &lt; 70 Dorop S up to 160</td>
<td>Class A (up to 390)- excellent</td>
</tr>
</tbody>
</table>
### Sulphate SO₄²⁻ mg/l
- Usually below 200 but can be to 600
- Class A (up to 200) – excellent
- Class B (up to 600) – good

### Nitrate NO₃ – N mg/l
- Mostly below 10
- Occasionally up to 20
- Class A – excellent
- Class B – good

### Flouride F mg/l
- Usually 0.1 – 0.2,
- Once 0.3
- Class A (up to 1.5) – excellent
- Class B (1.5 to 2) – good
- Class C (2 – 3) – low risk

### Chloride Cl mg/l
- Usually 50 – 200
- Dorob S occasionally 300 +
- Class A (up to 250) – excellent
- Class B (250 – 600) – good

### Iron Fe mg/l
- Usually less than 0.1 mg/l
- Occasionally up to 0.96
- Class A (< 100 µg/l = 0.1 mg/l)
- Class B 100 –1000 µg/l

### Manganese Mg µg/l
- Mostly only traces < 10 µg/l
- Occasionally up to 46
- Class A (1 – 50 µg/l)
- Class B (50 – 1000 µg/l)

### Copper Cu µg/l
- Usually only traces, but up to 0.03 mg/l = 300 µg/l
- Class A (< 500 µg/l = excellent

### Zinc Zn mg/l
- Usually below 0.1 mg/l
- Class A (< 1 mg/l)

### Cadmium mg/l
- Undetectable < 0.01 mg/l
- Class A (< 10 µg/l = 0.01 mg/l

### Lead Pb mg/l
- Undetectable < 0.02 mg/l
- Class A (< 50 µg/l = 0.05 mg/l

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As no water quality database yet exists at the Department of Water Affairs only a few records of water analysis for the Kuiseb River could be found and all for the period 2001 – 2005, mostly related to particular problems, half of them were for sewage water analysis. One was for drinking water at Walvis Bay (March 01) finding that it was of good quality. Two dealt with boreholes at Swartbank, which in March 2002 were unacceptably saline with a Conductivity of 466 mS/m equivalent to a TDS of over 3000 mg/l, a Chloride concentration of 1050 mg/l (Class low risk), and Calcium and Magnesium concentrations of 500 mg/l and 375 mg/l respectively, that were within the Class B or good/acceptable/range. The second Swartbank analysis 4 years later showed that the water quality had improved and was considered good.

The only other analysis were two drinking water samples taken at Gobabeb in November 2004, showing that at that time the hardness of the water classified it as Class C, with an overall conductivity
of 340 mg/l and concentrations of Sulphate (350 mg/l), Chloride (650 mg/l) and Sodium (450 mg/l)
just beyond the allowable range for Class B. The main problem identified was scaling. Although no
recent records were found, one can safely assume that the excellent recharge since then has
improved the water quality at Gobabeb to at least, the more acceptable Class B.

2.2.3 Surface water quality in the Kuiseb Basin

Surface water quality is determined by the geology and vegetation cover of the catchment area and in
the case of water stored in an impoundment, by the physical, chemical and biological reactions in the
dam, particularly to stratification patterns. The only major surface water impoundment on the Kuiseb
River is Friedenau Dam, close to Windhoek, originally built to supply water to the Matchless Copper
Mine and now used mainly for recreation and to supply water to some nearby farms and the school at
Baumgartsbrun.

According to a DRFN report there were some 109 commercial farms with 407 farm dams in the upper
Kuiseb catchment in 1994 (Dausab et al. 1994), Roberts (in prep) has since revised this based on
aerial photographs and estimates that there are 503 dams with storage capacities ranging from 94 m$^3$
to 59 000 m$^3$. The Hydrology Division of the Department of Water Affairs and Forestry is planning to
conduct a detailed survey to assess the numbers and sizes of all farm dams.

There are no water quality analyses available for any of these farm dams but they can be expected to
hold good quality water during the rainy seasons and in the months following, and for chemical
concentrations to gradually increase as the dams dry out due to evaporation. Renewed inflows will
again dilute this. Due to the high turbidity associated with most river floods, the water is expected to
be turbid immediately following inflows, but results from the larger impoundments show that this
usually settled out within the first fortnight (own observation). As these dams are often used for both
human and livestock, care should be taken to avoid contamination by dung. Shallow dams heavily
utilized by livestock tend to become increasingly eutrophic due to this as they dry out.

No water quality data could be found for Friedenau Dam, but it is expected to be similar to that of the
other dams nearby. Detailed studies of Swakoppoort, Von Bach, Omatako and Oanob dams reveal
good quality water with the expected fluctuations of dilution with rain and concentration due to
evaporation in the dry season (Bethune, 1992 and Schachtschneider 1997). Temporary high nutrient
levels and often algal blooms followed the breakdown of stratification at the end of summer and the
return of warmer temperature in spring. Table 2 on page 14 gives the range of water quality
parameters for Von Bach, Swakoppoort and Oanob.

Assuming that the climatic and geological factors for Friedenau or any future large impoundment in the
upper Kuiseb catchment will be similar to these three nearby dams, the water quality is expected to be
as good. The maximum conductivities and chemicals concentrations were measured during extremely
dry years when water levels in the dams were very low and can be considered exceptions. Based on
the drinking water quality guidelines used by both NamWater and the Department of Water Affairs and
Forestry (Namwater 2008, DWA, undated) still based on the requirements of the Water Act No 54 of
1956, the water chemistry of these dams would classify the water as Class A – excellent i.e. having a
pH between 6 and 9 (excellent), Chloride well below 250 mg/l (excellent), Sodium well below 100
mg/l (excellent), Potassium below 200 mg/l (excellent), Sulphate well below 200 mg/l (excellent),
Calcium well below 375 mg/l (Excellent) and Magnesium well below mg/l 290. The conductivity
and TDS levels tend towards Class B – water of good / acceptable drinking quality i.e. the dam water conductivity is usually below 300 µS/cm , although in dry years this can be even higher shifting to Class C, suggesting a temporary low health risk.


<table>
<thead>
<tr>
<th>CHEMICAL</th>
<th>VON BACH DAM</th>
<th>SWAKOPPOORT DAM</th>
<th>OANOB DAM *</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONDUCTIVITY µS/cm</td>
<td>117 – 315</td>
<td>202 – 580</td>
<td>141 – 264</td>
</tr>
<tr>
<td>TDS mg/l</td>
<td>73 – 209</td>
<td>200 – 425</td>
<td>93 – 174</td>
</tr>
<tr>
<td>Total alkalinity mg/l</td>
<td>57 – 139</td>
<td>99 – 215</td>
<td>62 – 130</td>
</tr>
<tr>
<td>pH</td>
<td>6.9 – 8.3</td>
<td>6.9 – 8.8</td>
<td>6.9 – 8.3</td>
</tr>
<tr>
<td>Cl− mg/l</td>
<td>0.5 – 15</td>
<td>8 – 46</td>
<td>0.5 – 9</td>
</tr>
<tr>
<td>Na+ mg/l</td>
<td>1 – 18</td>
<td>5.5 – 64</td>
<td>&lt; 1 – 20</td>
</tr>
<tr>
<td>K+ mg/l</td>
<td>5 – 14.5</td>
<td>7.6 – 31</td>
<td>5 – 12.8</td>
</tr>
<tr>
<td>SO4²− mg/l</td>
<td>&lt; 1 – 20</td>
<td>&lt;1 – 35</td>
<td>&lt;1 – 17.5</td>
</tr>
<tr>
<td>Ca ++ mg/l as CaCO3</td>
<td>37 – 76</td>
<td>48 – 90</td>
<td>45 – 93.5</td>
</tr>
<tr>
<td>Mg ++ mg/l as CaCO3</td>
<td>12 – 39</td>
<td>15 – 59.5</td>
<td>15 – 25</td>
</tr>
<tr>
<td>SiO2 mg/l</td>
<td>&lt; 0.5 – 6.5</td>
<td>&lt; 0.5 – 8</td>
<td>0.5 – 9</td>
</tr>
</tbody>
</table>

2.3 Potential Water Pollution

The main concern is potential groundwater pollution particularly from the new Uranium mines. One of the impacts identified in scoping meetings and reports on the possible impacts of the current surge in exploration for Uranium in the area is groundwater contamination particularly from accidental seepage from the tailings dams (Swiegers, 2008, Pallet, 2008, Kohrs 2008). It is recommended that in addition to each mine carefully monitoring any contamination of the groundwater downstream of their operations a joint environmental monitoring programme for all mining and associated development activities be implemented by an independent authority to regularly check and control these impacts (Kohrs, 2008). The KBMC, as representative of all the stakeholders in the Kuiseb Basin could take the lead and possibly appoint an organisation within the basin such as the GTRC to co-ordinate such
a long-term monitoring programme and keep the stakeholders informed of the results though KBMC meetings.

2.3.1 Prevention of water pollution:
The Division Water Environment within Water Affairs in the Ministry of Agriculture, Water and Forestry is legally responsible for the control of water pollution and they exercise this control through issuing waste water and effluent disposal exemption permits. All water users engaged in any activity that produces waste water is required by law to apply to the Water Environment Division for exemption to dispose of this wastewater or effluent. The permit conditions specific to each case control the safe disposal of this waste water. The application involves completing a standard form requesting technical information pertinent to the water use and activity that produces the waste water and usually a limited period permit for one year is granted pending the gathering of all the necessary information (Gracy Tshipo, pers.comm. 2008).

Once this information is submitted, it is forwarded to both the Ministry of Health and Social Welfare and to the relevant ministry that deals with the particular activity e.g. the Ministry of Mines and Energy for mining activities, the Ministry of Fisheries and Marine Resources for fish factories and the Ministry of Environment and Tourism for lodges, to allow comments from the affected stakeholders, a necessary step until the new Environmental Management Act 27 of 2007 is fully implemented. Their comments are incorporated into the particular set of conditions that the applicant will need to meet to insure safe disposal of effluent. These conditions are intended to protect the environment, specifically water resources from pollution. A permit is valid for 5 years.
Pollution officers from the Water Environment Division monitor the waste water disposal sites to ensure compliance with the conditions set. Each officer is in charge of particular regions, for example, Ms Gracy Tshipo, is responsible for the Erongo, Khomas and Omahake regions, thus the Kuiseb Basin falls under her. She expressed a particular interest in attending Kuiseb Basin Management Committee meetings and felt that the pollution officer responsible should be represented as an important stakeholder on the relevant basin management committee or at least the broader stakeholder forum. The pollution control officers are also responsible for investigating any complaints from any affected stakeholder. Of concern is that very few applications for waste water and effluent disposal exemption are received, for example not one has yet been issued to anyone in Walvis Bay and none of the Guest farms in the Kuiseb basin have one. Schools too need permits and one has been issued to Baumgartsbrunn School. The existing and new uranium mines on the other hand are working closely with Water Affairs to monitor their effluents and to prevent groundwater contamination (Gracy Tshipo pers.comm. 2008)

Once the Environmental Management Act No 7 of 2007 is fully implemented, the environmental clearance certificate that allows a listed activity to go ahead will be an essential requirement for the application of a wastewater and effluent disposal exemption permits. It will show that the necessary scoping of affected stakeholders has been complied with during the Environmental Impact Assessment and this should in future eliminate the need for each application to be first forwarded to other ministries, a procedure that currently slows down the granting of permits.

2.3.2 Water Pollution Monitoring
The Department of Water Affairs and Forestry has compiled specifications for water quality analysis that group sets of analysis to cover specific monitoring needs (DWAF 2008). “Group 1” analysis allow for quick basic monitoring of surface waters in rivers, testing only turbidity, conductivity and sediment load, whilst “Group 2” deals with drinking water and requiring a range of some 19 analyses linked to the drinking water guideline parameters. “Group 3” deals with effluent or waste- water analysis and includes the nutrient concentrations such as Nitrogen (Nitrate, Nitrite, Ammonia) and Phosphates as well as biological and chemical oxygen demand. “Group 4” is particularly geared towards groundwater and includes the “Group 2” (drinking water) analysis as well as elements such as Fluoride and Bromide that may be present in groundwater. “Group 5” analyses are intended to be used when testing the water quality of new boreholes to detect traces of potentially harmful elements such as
Arsenic, Cadmium and Uranium (Laura Namene pers. comm. 2008). Ms Namene, the chief water pollution officer at MAWF, advises using “Group 2” analysis for any monitoring project to detect possible contamination of groundwater plus special analysis for those contaminants used in the processing or activity likely to cause the contamination, e.g. Nitrates near cattle feedlots, minerals used in mining processes near mines, Sodium and Chlorides to detect salt water intrusion. Rössing Uranium Mine maintains such a monitoring programme in the Khan River to prevent groundwater pollution. Groundwater samples from monitoring boreholes at agreed sites in the Khan River are analysed for a full range of potential contaminants including the ratio of Ur 234 and Ur 238 and detailed annual reports are submitted to the Pollution Control section of the Department of Water Affairs (Gracy Tshipo pers.comm. 20080. New mines should consult Rössing and instigate similar precautions.

### 2.3.3 Water Quality deterioration and Pollution

Although for the most part, the water quality of the Kuiseb Basin is either excellent or good, there is a need to be vigilant as we cannot afford to pollute the little water that we have and groundwater once contaminated is virtually impossible to clean (Tarr and NWAC, 2002, WWGN, 2007). Similarly the little surface water within the basin as well as the wetlands in the river and in Walvis Bay and at Sandwich harbour should be protected from any environmental degradation including water pollution.

The main areas of concern in terms of water quality are:

- Possible groundwater contamination from the Uranium and other mines in the area. Although established mines such as Rössing Uranium have a good track record of co-operation with the water authorities and continuously monitor nearby aquifers in the Khan River to detect the slightest evidence of contamination, it is important that all new mines even during the exploration phase take care to monitor groundwater chemistry.

- Possible saline intrusion into the production area of the Kuiseb Aquifer, either from the surrounding more saline groundwater to the south and west or with time sea water intrusion may become a problem. Regular monitoring of the production boreholes and others beyond them needs to be done. It is worrying that the regular monitoring or the Kuiseb production boreholes seems to have stopped with only the reservoirs being monitored.

- Possible contamination to both surface and groundwater in the upper catchment area from cattle feedlots or other intensive farming practices. At present there is no regular monitoring of water quality in the upper or middle catchment areas.

- Possible contamination of Friedenau Dam water from the tailings dam at Matchless Mine. These tailing are dangerously close to Friedenau Dam and after years of closure are not being well maintained. Consideration is being given to re-opening the copper mine and this should be subject to an EIA that must include environmentally sound methods to prevent both the old tailings and the waste from renewed production from contaminating either nearby surface waters of the ground water.

- Sound waste water and effluent disposal by guest farms and lodges. As the number of guest farms and lodges increase both in the upper and middle catchment areas care must be taken that the proponents obtain the necessary waste water and effluent disposal permits and comply with the conditions set for safe disposal.

- Although probably beyond the scope of this report, harbour pollution and the possible contamination of the Walvis Bay lagoon and other wetlands both from the harbour and from land based pollution is of concern.

### 2.3.4 Water Quality and Pollution Prevention Action Plan

In an attempt to address some of the water quality and pollution concerns raised an Action Plan 3 on Water Quality and Pollution Prevention Management has been developed as one component of the Water Resources Management Plan for the Kuiseb Basin and is included as Annexure 2 to this report. (See Annexure 2)
The Action Plan recommends six short-term actions ranging from the establishment of a Water Quality database for the Kuiseb, identifying strategic sites for regular monitoring and enlisting the help of volunteers to collect samples, to an immediate investigation of the state of the tailings dam at Matchless Mine, improved awareness of water pollution and encouraging stakeholders to apply for wastewater and effluent disposal exemption permits and comply with the conditions. Longer term actions include keeping up monitoring and awareness, expanding the database, monitoring possible sea water or saline intrusion, putting in place a sound groundwater monitoring programme for the mines, checking potential pollution from intensive agricultural activities such as cattle feed lots and remaining vigilant with regard to potential pollution of the harbour and Walvis Bay wetlands.

2.4 Ecological Water Requirements

Ecological water requirements are essentially the water that is needed by the river itself to maintain the ecosystems dependent on the water of that river. For perennial rivers this is fairly obvious. It is the volume as well as the timing and duration of river flows that keep the aquatic and semi-aquatic systems linked to the rivers functioning and productive. For ephemeral rivers such as the Kuiseb, this is less obvious as there is seldom any visible flow. Nevertheless, the ecological flow requirement is the water needed as both surface flow and as groundwater to maintain a healthy, functioning river ecosystem or “linear oasis” that so depends on the groundwater and occasional medium to large floods in the river. As with perennial rivers and their floodplains the ecosystems dependent on ephemeral rivers extend not only in a line along the river-course but may extend for some distance on either side of the river too, depending on the direction of groundwater flows, e.g. the essential freshwater seepage that maintains the wetlands at Sandwich Harbour.

The process of determining the ecological water requirements of a river is called an environmental flows assessment and goes beyond strictly the ecological water requirement, taking into account broader environmental issues, be they hydrological, biological, social or economical. River scientists define the environmental flow as: “the water that is purposely left in a river or released from a dam to maintain the river in a desired condition” (Brown and King 2002.) The more natural this desired condition, the greater the proportion of the flow volume that will be needed to meet the environmental flow requirement. For example, for the Kuiseb River that flows through a National Parks and where it is essential that the occasional large floods reach far enough downstream to sustain and recharge an important alluvial aquifer near the mouth (Benito, 2008) this desired state would be to keep the river as natural as possible. This is what the KBMC should aim for.

As there is not yet a tested method to determine the ecological water requirements or to do environmental flow assessments for ephemeral rivers, and because even if there were, this would require at least two years of intensive field work by a multi-disciplinary team of experts it was not possible to attempt to determine the ecological water requirement of the Kuiseb River as part of this water resources management plan. However, it is recognised as an essential step to understand-ing and managing the river water resources and it is recommended that the KBMC continue to encourage river scientists in Namibia to co-operate with scientists elsewhere in southern Africa to work towards developing a method to assess the environmental flow requirements of ephemeral rivers and to test this on the Kuiseb River. Realising the need to work towards a method suitable for ephemeral rivers, the current National Development Plan, NDP3, includes “developing methods to determine environmental flow assessments and test this on one ephemeral river.” The KBMC should lobby to make this one river the Kuiseb River and continue to include the determination of the ecological water requirements of the Kuiseb as a long-term goal and seek funding for this work.

To assist the KBMC to understand what ecological flows or water requirements are, a brief overview based on a presentation (Bethune and Roberts 2008) given at the Healthy River Basins Conference in Rundu in April, is given. The realisation of the importance of ecological flow requirements came about some 50 years ago when around the world ecologists noted a decline in river health due to river flow
manipulation, increasing pollution and the worldwide tendency to focus on human benefits and direct costs rather than environmental health and long term benefits. Over the years the terminology used to refer to the water needs of rivers themselves has changed as our understanding of the role and importance of river flows increased. In the 1960’s and 70’s the emphasis was on ensuring “minimum” flows, in the 70’s and 80’s the “hydraulic habitat” was deemed important, in the 1990’s it was the maintenance of “in-stream flows” and “ecological water requirements” and since then it went beyond the river to include “environmental flows”. ’

In Namibia, the recognition of the importance of ecological water requirements and environmental flows can be traced through nearly two decades of national policies and legislation from the Namibian Constitution to the draft Wetland Policy (Amakali et al. 2002, Bethune et al. 2005):

- The Namibian Constitution includes the important “environmental clause” Article 95
- Compensatory releases from dams were included in Namibia’s Green Plan presented by the founding President at Rio in 1992;
- The National Water Policy of 2000 includes the principle of Ecosystem Values and Sustainability, it stipulates the need for “legislation to provide for environmental water reserves” and the need to ensure adequate water quality and quantity to sustain ecosystems;
- The Water Resources Management Act of 2004 calls for the protection of ecosystems” to the maximum extent” and makes provision for the “reservation of water resources to protect aquatic and wetland ecosystems”. It also sets out the duties of river basin management committees to protect and manage river basins.
- The MET Environmental Management Act of 2007 calls for “equitable access to sufficient water for ecological systems to ensure sustainability” and it makes Environmental Assessments prior to development activities mandatory for listed activities;
- the Vision of the draft Wetland Policy is that: “Namibia shall manage national and shared wetlands wisely by protecting their vital ecological functions, life support systems and biodiversity for current and future benefit of people’s welfare, livelihoods and socio-economic development.” and one of the legislative principles is to set aside water for aquatic ecosystems.

The determination of ecological water requirements through an ecological flow assessment requires time, a multi-disciplinary approach and adequate funding. A good flows assessment can be a valuable water resources management tool that can provide answers to long-term sustainable use and wise management of the water resources of the river. The aim is to manage the river in a way that will ensure sufficient flows, and, to time them to maintain the environmental integrity of the river whilst also allowing economic development and social justice (Bethune et al, 2008.).

Among the successful methods used for assessments in perennial rivers are the Building Block Methodology and DRIFT (Downstream Response to Imposed Flow Transformations), both holistic methods that compare a variety of probable development scenarios and their impacts on flows as well as the impacts of these altered flows on the river to determine acceptable losses and gains to all stakeholders (Brown and King 2002). In Africa, environmental flow assessments have been done for perennial rivers in South Africa, Lesotho, Tanzania and Mozambique, but none yet for ephemeral rivers.

Namibia is currently involved in a pilot study to assess the environmental flows of the perennial Okavango River. This project was initiated by the Harry Oppenheimer Okavango Research Centre, HOORC in Maun together with the BioKavango Project for the Okavango Delta and has now been expanded to cover the entire river basin with the assistance of the regional OKACOM GEF/EPSMO (Environmental Protection and Sustainable Management of the Okavango) project (Mazvimavi and King, 2008) Over the next year, teams of experts from the three riparian counties, Angola, Namibia and Botswana, will work together to conduct a preliminary environmental flows assessment. The results will be used to feed into the future Integrated Management Plan, IMP, of this shared river.
The WADE project and the results of these studies on the Kuiseb River, provide an important start for future assessments of ecological water requirements of this and other ephemeral rivers. Most importantly it has improved our understanding of the relationship between river flows and recharge.

2.4.1 The WADE Project

Recently the DRFN and the Hydrology Division of the DWAF co-operated with international scientists in a project known as WADE. They investigated floodwater recharge of alluvial aquifers in dryland environments in ephemeral rivers aquifers in four countries. The study sites were the Kuiseb River, the Buffels River in South Africa, the Nahal Arava in Israel and the Andarax in south- east Spain. One of the conclusions from this study is that the “water reserve”; i.e. the water that should remain in the river to meet the needs of people and the environment, should be quantitatively estimated and that priority uses be allocated to what remains of the groundwater. Benito (2008) adds that the WADE study results can be used to supply important groundwater information for assessing ecological water requirements. WADE has provided an improved understanding of groundwater and flood interactions for the water authorities that manage these resources. One of the outputs of the study in the Kuiseb has been the development of an integrated flood-groundwater model for use by NamWater and DWAF. The study took four years (2004 – 2008) and proved that the long-term behaviour of aquifers in response to rare flood events can be studied and quantified (Benito, 2008).

The WADE project investigated how dependent alluvial aquifers and the water resources they supply are on floodwater recharge. To determine this, the scientists had to measure and analyze the processes that control flood recharge and link these to long term climatic cycles (Benito et al, 2005). Fortunately during the study period the Kuiseb experienced several floods of different sizes that were then carefully monitored using sophisticated TDR (time domain reflectometry) probes installed in the river close to Gobabeb. Extensive fieldwork was also done to document and age paleo-floods. Direct measurements were taken at each site to monitor any surface flow, the groundwater levels and water infiltration through the “vadose zone” or the sub-surface area between the river bed and the saturated groundwater layer (Dahan 2006).

The main findings of the WADE project (Benito 2008) that provide a better understanding of the Kuiseb River system and would be of interest to the KBMC to guide future management of the river, include:

- The estimated infiltration rate is 8.5 mm/h.
- Recharge is mainly from medium to large floods.
- Recharge depends on: the duration of the flood, the width of the actively flowing channel and the alluvial soil composition. In the Kuiseb the unconsolidated sand grains and gravel allow for excellent water storage between the sand particles (Gardiner et al. 2006).
- Surface flow at least 15 – 20 cm deep is needed to initiate recharge.
- Infiltration under dams is surprisingly low and inefficient, in fact dams reduce groundwater recharge. (contrary to the popular belief that surface dams enhance recharge of boreholes).
- The alluvial aquifer has a “compartmental” structure and is thus discontinuous.
- For optimal management, exploitation of the aquifer along its entire length is recommended, although this may prove disastrous for the riparian vegetation dependent on this groundwater and to the desert animals such as warthog, oryx and baboons who rely on shallow groundwater in the riverbed that can be reached by digging.
- The total groundwater recharge potential at Gobabeb is 210 000 m$^3$/km/a.
- Transpiration by trees alongside the river uses 15 – 20% of the total aquifer volume.

2.5 Environmental Impact Assessments

Although the KBMC is unlikely to conduct Environmental Impact Assessments they may well be required to comment on EIAs undertaken within the Kuiseb Basin and need a clear understanding of what EIAs are and the new Environmental Management Act. Therefore a brief overview of both is given here. An EIA, is simply a way of finding out the probable impact that a project is likely to have.
on the environment and its significance (NORAD, 1993). EIAs are not "anti-development ", but are intended to encourage good management. To be most effective they need to be done early in the decision-making process so that key findings can be incorporated into the design of development projects. They are relatively inexpensive, usually costing only about 1% of the total project value, but the benefits of allowing early mitigation of any negative impacts far outweigh the costs. Good EIAs lead to environmentally and often economically sound choices. Whilst an EIA is extremely useful tool during the planning of a project, environmental monitoring should not stop there. An environmental management plan should be designed for the construction and operational phases and a clear decommissioning plan prepared for when the project ends. The Minerals (Prospecting and Mining) Act 33 of 1992 makes provision for environmental management (Schneider and Shivolo, 2008) and all mines now have to have clear decommissioning plans.

A comprehensive EIA should include studies of both the natural environment and resource base it supports as well as the man-made environment (cultural, urban, historical, archaeological, An EIA should look at the future management of natural resources as well as at future development plans, and include social factors and health issues. It should consider direct impacts, secondary impacts and cumulative impacts of the proposed development and related developments.

2.5.1 The Environmental Management Act No 27 of 2007 (MET, 2007)

Namibia recently passed its long-awaited Environmental Management Act. The main points of interest to the KBMC are summarised briefly in paragraph 2.5.1 below. For a more comprehensive explanation of the Act it is recommended that all the KBMC members be given copies of the excellent “Guide to the Environmental Management Act No 7 of 2007” recently produced in simple English for the layman by the Ministry of Environment and Tourism (Hubbard, 2008).

The stated aim of the Environmental Management Act includes, “to provide for a process of assessment and control of activities that may have significant effects on the environment”. To assist the Government to implement this Act, it makes provision for the establishment of a “Sustainable Development Advisory Council” and the appointment of an “Environmental Commissioner” and environmental officers. The Act requires “identified organs of state” whose functions may impact on the environment to prepare “Environment plans”. The list of organisations that will need to draw up such environmental plans has yet to be published in the Government Gazette. It is not known if Basin Management Committees will be included in this list. Once the plans are approved, the organisations will be expected to comply with their plans and will be monitored by the environmental officers under the Environmental Commissioner.

The Act sets out the steps to be followed in a consultative EIA process in Part 8 (MET, 2007). This basically starts with initial screening to determine if a project needs an EIA. All project proponents are required to apply for an “Environmental Clearance Certificate”. For projects that clearly have no significant environmental effects, an assessment will be deemed unnecessary and a environmental clearance certificate will be granted allowing the project to go ahead, possibly under stipulated conditions. Should an assessment be needed, the commissioner should assess the scope of the project, advice the proponent how to proceed and prescribe the EIA procedure to be followed. The final report is reviewed and if in order an environmental clearance certificate will be granted and conditions set under which the project may proceed. The Environmental Commissioner reserves the right to suspend or cancel this certificate if the conditions are not complied with.

2.5.2 Possible shortcomings of the Environmental Management Act 27 of 2007

Although in essence, the Environmental Management Act, if properly implemented, can help to ensure that future development and natural resource use is sustainable and should protect the environment, there are several loopholes for the less scrupulous that the KBMC should note.
Earlier drafts of the Act included a list of activities requiring EIA’s. The Act now passed does not. Although it makes provision for the Minister to publish a list of “activities that may not be undertaken without an environmental clearance certificate”, the Act itself is not specific enough about the types of activities that EIAs should be mandatory for. Within the Act it merely stipulates ten very broad activities that ‘may’ be included in the yet to be published list (MET, 2007). They are:

- land use and transformation,
- water use and disposal,
- resource removal, including natural living resources,
- resource renewal,
- agricultural processes,
- industrial processes,
- transportation,
- energy generation and distribution,
- waste and sewage disposal: chemical treatment,
- recreation.

As yet, no list has yet been published in the Government Gazette and even once an activity is officially listed, the Minister retains the right to remove it from the list. It is of further concern that the Minister may also grant exemption to a developer in respect to even listed activities.

Although the Act makes provision to establish a Sustainable Development Advisory Council and to appoint an Environmental Commissioner and environmental officers to assist with monitoring etc., there is unfortunately no stipulation that the commission be independent. It is most likely that the commissioner and his officers will be officials within the MET and, as stipulated in the law, at least half (4/8) the members of the Sustainable Development Advisory Council will be civil servants.

Earlier drafts set out the procedure for EIAs, now this is not specified but left to the Commissioner. Despite this, it is possible to link the provisions in the Act to the main stages in an EIA process:

- SCREENING – to assess projects needing EIAs and type of EIA needed, (List: Section 27).
- SCOPING – the definition of key issues, opportunities for broad consultation and for public participation of all interested and affected stakeholders, be they public, government or NGO (Consultative process specified section 33 and public hearing included in the review stage).
- EIA PREPARATION – the scientific investigation and analysis of the project and its impacts and rating the significance and importance of the impacts identified (Vaguely in Section 35).
- REVIEW – Review of the EIA document and findings by an independent panel to advice government (Review: Section 36 and possibly part of the duties of the Sustainable Development Advisory Council: Section 7).
- MONITORING – To check that recommendations are carried out and conditions complied with and to check for any environmental impacts or quality changes in the environment as a result of the project (Task of the Environmental Commissioner and officers: Sections 17-19).
- AUDITING – To check if the predictions made had been accurate, to test the value and success of any mitigations and to check on and if necessary update environmental management practises. To learn from past mistakes. (Although not specified in the Act could be assumed to be included in the tasks of the Environmental Commissioner).

2.6 Environmental Issues to be addressed in the Kuiseb Basin

Most of environmental concerns in the Kuiseb Basin at present are related to the potential impacts of mining. Other concerns include the impact of upstream dams on the riparian vegetation and on groundwater recharge to the alluvial aquifer, continued over-abstraction of these aquifers and the possibility of sea or saline water intrusion, the impacts of alien invasive plants and sand harvesting along the river, water contamination from intensive agricultural activities such as feedlots, disturbance of the wilderness aspect of the desert by to tourist activities such as quad biking and because of new power and water supply infrastructure and roads, as well as the impacts of increasing urban and industrial development at the coast on the wetlands.
2.6.1: Mining activities

Currently much concern is being expressed regarding both the potential water use and possible groundwater pollution of both the existing and the proposed Uranium mines within or close to the Namib Naukluft National Parks in the lower Kuiseb Basin. The two existing mines, Rössing and Langer Heinrich, as well as most of the areas covered by the exploration licenses are within the ecologically sensitive Namib gravel plains area and in some cases even within the Namib Naukluft National Park. Figure 6 below shows the locality of the present and proposed mines. These concerns prompted a special edition of the Namibian Environment and Wildlife Society newsletter, Roan News (NEWS, 2008). From the article by the Ministry of Mines and Energy (Schneider and Shivolo, 2008) it is clear that the Ministry is fully aware of its obligation to protect environmentally sensitive areas from potential damage by mining activities.

To assess the cumulative impacts of mining in the lower Kuiseb area, the Ministry and the Southern African Institute for Environmental Assessment, SAIEA, has initiated a Strategic Environmental Assessment, SEA, in addition to the Environmental Impact Assessments, EIAs, that each mine has to do (Roberts, 2008, Swiegers, 2008). These cumulative impacts will go beyond the impacts of mining in the Namib-Naukluft National Park. It should include: potential groundwater contamination; the co-ordination and provision of housing, schools, roads and other services for people attracted to the area; cumulative water and power demands; and options for alternative water and energy supplies; the fragmentation or even loss of the intrinsic value of the Namib wilderness; public health aspects including dust pollution and airborne radiation; as well as activities to ensure economic viability after the mining boom (Swiegars, 2008, Pallet, 2008, Kohrs 2008, Hoadley and Limpitlaw, 2008, Henshel
According to Swiegers (2008), DRFN is to assist with compiling “Guidelines for Environmental Management in Mining”, GEMM. The KBMC has an important role to play in ensuring that all these and other stakeholder concerns are fully taken into account in the Strategic Environment Assessment, SEA.

Concern has been expressed that Namibia should perhaps exercise caution and take into account the strategic value of the Uranium resources for the future. Developing all these non-renewable resources now when the life span of such mines is short (8 – 20 years) is perhaps short sighted. It is no accident that three of the countries seeking to exploit Namibia’s Uranium resources, Canada, Australia and Russia, have their own reserves, but are strategically keeping these in reserve for when the world supplies become even more limited (Schultz, 2008). Does it make sense to risk our desert environment and long-term potential tourism earnings for short term? (Schalken, 2008, Berry, 2008). The SEA should take the long-term strategic value of these resources into account too.

Whatever the outcome of the SEA, there will be some degree of mining development in the lower Kuiseb over the next few years, therefore it is essential that following the SEA, a very specific environmental monitoring programme be developed to regularly check and control the impacts of mining and other development activities (Kohrs, 2008). Here the KBMC needs to take the lead to ensure that stakeholders within the basin are monitoring these impacts. It is also important that this monitoring be undertaken by an independent body with no vested interest in the mining – possibly the GTRC. The results should be available to interested stakeholders and the general public.

### 2.6.2 Upstream dams and reduced flows

One of the concerns already discussed at some length in section 2.1.2 dealing with the Kuiseb River as a linear oasis on page 7 of this report is the impact of upstream dams on the riparian vegetation and on groundwater recharge to the alluvial aquifer. Despite suggestions that this may not be a major environmental concern in the Kuiseb Basin (Dausab et al. 1994), other accounts clearly see reduced floods as a threat reducing recharge, preventing germination, even killing established riparian trees (Seely et al. 2003). It is worth investigating further, particularly in the light of recent studies undertaken at Gobabeb (Benito 2008). It is recommended that such investigations should form part of an environmental flows assessment to attempt to determine the ecological water requirements of the Kuiseb River ecosystem.

### 2.6.3 Over-abstraction from the aquifers

According to the Geohydrological report prepared for the Water Resources Management Plan for the Kuiseb Basin, the most recent figures for the total sustainable yield of the active Kuiseb aquifers, based on NamWater calculations in 2001, is 7 Mm$^3$/a between Swartbank and the Delta (Falke, 2008). According to an earlier NamWater report (NamWater 1998) the lower Kuiseb aquifers (Dorop S, Rooibank A and B and Swartbank) were being overutilized to supply the demand. At that time the average abstraction was 8.34 Mm$^3$/a. Since then abstraction rates have declined. Although there is no evidence of sea water intrusion into the Kuiseb aquifer from the water quality analysis over the last ten year, it may be is possible that continued over-abstraction of these aquifers could cause saline water intrusion. There is anecdotal evidence that the productivity of !nara fields in the vicinity of the delta have declined and even been abandoned. Further upstream in the river, villagers have reported that they can no longer dig wells deep enough to reach the groundwater (WADE, 2005) and decreasing groundwater levels will also affect the wildlife that depend on groundwater seeps or being able to dig to reach water in the riverbed.

### 2.6.4 Alien invasive plants

Environmental concern that invasive plants, particularly those growing alongside rivers, reduce groundwater levels has led to some drastic suggestions that include removing all riparian vegetation.
A clear distinction needs to be made between naturally occurring or indigenous trees and alien invasive species. Both must transpire and both draw on groundwater for their moisture. The WADE project was able to detect daily fluctuations in groundwater levels in the Buffels River in South Africa that could only have been caused by evapotranspiration as the water levels dropped by day and rose again at night (Todd and Hoffmann 2006). Transpiration losses calculated for four indigenous tree species in the Kuiseb showed that about 15 – 20% of the available groundwater is lost in transpiration each year. *Faidherbia albida* had the highest rate (1.5 g H$_2$O/g/hr), and *Euclea pseudobenus* the lowest (0.54 g H$_2$O/g/hr) with *Tamarix usneoides* and *Acacia erioloba* being about the same (1.07 g H$_2$O/g/hr and 1.03 g H$_2$O/g/hr respectively) (Bate and Walker 1993).

But indigenous trees belong in the river and are well-adapted to living there and make up the important riparian vegetation that allows humans and animals to live there, whereas alien species have encroached on the natural vegetation and are often not well adapted to the arid conditions along our ephemeral rivers and may use larger volumes of water than the naturally occurring species would. Preliminary tests done in the Omaruru River at Okambahe this year seem to indicate that *Prosopis* transpiration rates are higher than that of other trees occurring in alongside the river, but that the rates for *Faidherbia* were also quite high. (Heimo Gariseb, pers.comm. 2008)

### 2.6.5 Sand harvesting

With growing development at the coast, the demand for building sand has escalated. Many construction companies are collecting sand from ephemeral river beds, creating concern about the impact this sand harvesting has on the river ecosystem. This year the sand harvesting diggings near Swakopmund prevented the river from reaching the sea as the water pooled up in the excavations left by the diggers. The Forestry Act makes it an offence to harm or damage any plant in or within 100m of a river-course. Inspection of this and other sites has shown that the islands with trees are left between the excavations but that it is only a matter of time before these will be washed away or erode. The DWAF is in the process of developing regulations to control sand harvesting and Municipalities such as Swakopmund are taking steps to curb excessive removal of sand (Dr Stephan de Wet. Pers.comm. 2008).

### 2.6.6 Intensive agriculture

As discussed in the section on Water Quality and potential pollution, there is a chance that water downstream of intensive agricultural activities such as cattle feedlots could become contaminated. It is not clear if such intensive farming occurs in the Kuiseb Basin though. What is more likely is that dung that has collected in the dry river beds during the dry months, as cattle and wildlife seek shade under the trees alongside the river beds, washes into farm dams and impoundments when it rains, causing temporary algal blooms that can cause taste and odour problems in treated water (Tarr and NWAC, 2002, Roberts and WWGN, 2007). This year Friedenau Dam experienced a bloom of filamentous algae as a result of nutrients washed in during the rains (personal observation).

### 2.6.7 Wilderness loss

One of the most difficult environmental concerns to quantify is loss of wilderness. One of the main attributes of the Namib is its sense of space and isolation and this is what attracts so many tourists. This serenity is easily shattered even by the tourists themselves as we have seen with the proliferation of quad biking since South Africa banned driving on beaches. Similarly the sight of new power and water supply infrastructure and new roads to supply the new mines and sound of vehicles will rob the area of its trademark tranquillity.

### 2.6.8 Urban and industrial expansion at the coast.
The coastal wetlands are under threat from increasing urban and industrial development both in Walvis Bay and up the coast towards Langstrand. Pollution from fish factory effluent and other land based activities also threatened the harbour and the bird life in the lagoon. Some years ago the DWAF initiated a pollution monitoring project in co-operation with the Walvis Bay Harbour Authority. It is not clear if this is still ongoing.

2.6.9 Archaeological sites

The Kuiseb Basin is archaeologically the most significant area of Namibia, as the whole archaeological sequence is represented, and many of these sites have been central to new approaches to key issues in southern Africa. The Kuiseb River Basin is well known as an area rich in archaeological remains that have been intensively researched and internationally published. All archaeological remains in Namibia are protected in terms of the National Heritage Act (27 of 2004), and this extends to objects and sites more than 50 years old that may be considered to have national heritage significance. Sections 51 (3) and 55 (5) of the Act require that an archaeological impact assessment is carried out where large development projects are intended in areas of known archaeological significance, and proper mitigation of archaeological impacts is required (J. Kinahan, pers. comm. 2008). For more detail please see the separate specialist report by J. and J. Kinahan, *Archaeology of the Khuiseb River Basin* and the map they compiled which show the archaeological sensitivity of different areas within the Kuiseb Basin.

It is essential that any development in the Kuiseb Basin in the fields of mining, road construction, power transmission, water supply, tourism, urban development, planning and research take account of the significance and vulnerability of the archaeology. Fortunately, in response to the accelerated development of the Namibian economy and infrastructure after Independence and recognition of the need to provide specialist archaeological consultancy services, *Quaternary Research Services* was established in 1990 (Jill Kinahan, pers. comm. 2008).

Although outside the Kuiseb Basin, a very significant recent archaeological find has been the uncovering of a Portuguese vessel carrying Spanish gold and ivory near to Oranjemund this year (Dieter Noli, pers. comm. 2008). Given that the Kuiseb Basin extends to the Atlantic Ocean and includes the only two safe harbour sites along over 1000 km of hostile coastline, often used by early mariners, there may be other significant finds hidden within the lower Kuiseb Basin. Even more reason to take care to include an archaeological component in future EIAs within the Kuiseb Basin particularly for developments that involve mining, roads, water and energy supply, tourism and urban expansion or development.

The role of the KBMC in this is to ensure that this archaeologically sensitive area is treated with the necessary respect and that all EIA’s investigate potential impacts on the vulnerable archaeological record and include archaeologists in the scientific investigations that form part of the EIA process.

2.7 Vulnerability assessment of environment

The ecologically sensitive and vulnerable areas within the Kuiseb Basin identified in the course of this review were many and varied. Potential impacts threaten all mine sites, the aquifers downstream of them and indeed the entire area that may soon be criss-crossed by power lines, water pipes and roads to supply these mines. The entire river-course is vulnerable due to water being held back in farm dams upstream, continued water abstraction, invasive plants and wood harvesting, that threaten its function as a linear oasis in a very arid area. The alluvial aquifer itself is at risk from over-abstraction, potential saline intrusion and groundwater contamination. The internationally important freshwater wetlands at Sandwich Harbour are rapidly dwindling as the amount of freshwater seepage decreases and the sand bar protecting the wetland gradually erodes. Intensive farming poses a threat to water quality in the rock aquifers as well as in the farm dams. Friedenau Dam too is vulnerable to an accidental spill from the tailings dam at Matchless mine and to eutrophication caused by nutrients
entering the dam with runoff. The wilderness aspect of sections of the Namib Naukluft Park, arguably its greatest asset may be lost. The Walvis Bay wetland, one of the top three coastal wetlands in Africa, is threatened by human development and disturbance of the birds at this Ramsar site. Significant archaeological sites are scattered throughout the Kuiseb Basin.

3. CONCLUSION

This report deals briefly with the ecology of the river basin, assesses the status of water quality of the Kuiseb Basin, explains what ecological water requirements are and the implications of the new Environmental Management Act. It highlights the major environmental impacts of present and future activities in the Kuiseb Basin and lists the ecologically vulnerable and sensitive area within the basin and make recommendations to the KBMC on environmental issues. This report provides the background that informed the development of Action Plan 3 “Water Quality and Pollution Prevention Management” for the Water Resources Management Plan for the Kuiseb Basin commissioned by the KBMC. This action plan is intended to advise the KBMC on sound water quality monitoring to prevent future water pollution. The recommendations made in the report are summed up below:

Recommendations
- The KBMC should find funds and commission DFRN to complete the Kuiseb Profile and in the meantime the KBMC should request DRFN to obtain permission from WADE to print and bind copies of the WADE report: Site Characterisation for Kuiseb Riparian Ecosystems by Gardiner et.al, (2006) as useful background information to the Kuiseb riparian ecosystems.
- It is recommended that the KBMC make NamWater aware of the ecological and educational value of Friedenau Dam.
- Two Ramsar wetlands, the Walvis Bay wetlands and Sandwich Harbour fall within the Kuiseb Basin and it is important that the KBMC continues to co-operate closely with the Coastal Environmental Trust of Namibia, CETN, to conserve and wisely manage these internationally important wetlands.
- The KBMC should lobby MET to have the Walvis Bay wetlands, that are increasingly threatened by coastal development, officially proclaimed as a protected area.
- The KBMC has an important role to play in ensuring that all the concerns that have been raised by stakeholders with regard to the expansion of mining in the Kuiseb Basin be taken fully into account in the Strategic Environment Assessment, that the MME is proposing to do.
- The KBMC, as representative of all the stakeholders in the Kuiseb Basin, could take the lead and possibly appoint an organisation within the basin such as the GTRC to co-ordinate a long-term water quality monitoring programme, to detect impacts of present and new mines and should keep the stakeholders informed of the results at KBMC meetings.
- The water pollution officer from the MAWF, responsible for the Erongo Region and thus the Kuiseb Basin, should be represented on the KBMC or at least on the broader Kuiseb Basin Stakeholder Forum. The KBMC should consider inviting this official from the Water Environment Division to participate in future meetings. All stakeholders should be informed of the need to apply for wastewater and effluent disposal exemption certificates and the procedure to follow.
- The KBMC should ensure that at all the mines in the Kuiseb Basin regularly monitor groundwater at agreed sites in watercourses downstream of any tailings dams. These should undergo “Group 2” analysis as well as tests for a full range of potential contaminants including the ratio of Ur 234 and Ur 238. Detailed annual reports should be submitted to the Pollution Control section of the Department of Water Affairs and KBMC. New mines should be advised to consult Rössing Uranium and instigate similar precautions.
- Similarly the little surface water within the basin as well as the wetlands in the river and the Ramsar sites at Walvis Bay and at Sandwich Harbour should be protected from any environmental degradation including water pollution.
- The KBMC should continue to encourage river scientists in Namibia to co-operate with scientists elsewhere in southern Africa to work towards developing a method to assess the
environmental flow requirements of ephemeral rivers and to test this on the Kuiseb River. The results of the WADE study should be used as a basis to start determining the ecological water requirements of the Kuiseb.

• The impact of the over 500 farm dams in the upper catchment should be revaluated and this should form part of the environmental flows assessment to attempt to determine the ecological water requirements of the Kuiseb River ecosystem.

• All the KBMC members should be given copies of the excellent “Guide to the Environmental Management Act No 7 of 2007” recently produced in simple English for the layman by the Ministry of Environment and Tourism.

• An environmental monitoring programme needs to be developed to regularly check and control the future impacts of mining and other development activities. Here the KBMC needs to take the lead to ensure that stakeholders within the basin are monitoring these impacts. The KBMC should be in a position to insist that this long-term monitoring be undertaken by an independent body with no vested interest in mining, possibly the GTRC, and that the results should be available to interested stakeholders and the general public.

• The KBMC should ensure that the rich archaeological heritage of the Kuiseb Basin be treated with the necessary respect and that all EIA investigations include impacts on the vulnerable archaeological record and that archaeologists be included in the EIA process.

At present the most pressing environmental concerns in the Kuiseb Basin are related to the potential impacts of Uranium mining. All KBMC members should read the special edition of Roan News on Uranium Mining and Mining in Parks (Roberts, 2008) to better understand the issues.

Other environmental concerns identified in the report include:

• The impact of upstream dams on the riparian vegetation and on groundwater recharge.
• Continued over-abstraction of alluvial aquifers and the possibility of sea or saline water intrusion, the impacts of alien invasive vegetation and sand harvesting along the river,
• Groundwater contamination and eutrophication of dams from intensive agricultural activities such as cattle feedlots.
• Disturbance of the wilderness aspect of the desert by tourist activities such as quad biking and because of new power and water supply infrastructure and roads.
• Impacts of increasing urban and industrial development at the coast on the wetlands.

Based on these discussions the main ecologically sensitive and vulnerable areas within the Kuiseb Basin can be identified as:

• All Mine sites and mineral exploration areas
• The areas downstream of mine sites, particularly the groundwater aquifers
• The entire gravel plain area criss-crossed by infrastructure to supply mines
• The entire river-course - Linear oasis
• The entire length of the alluvial quifer
• Sandwich Harbour wetland
• Areas downstream of intensive farming activites, particularly groundwater aquifers
• Friedenau Dam
• Namib Naukluft Park
• Walvis Bay wetlands
• All Archaeological sites

Action Plan 3 on Water Quality and Pollution Prevention was developed based on the findings of this report in terms of Water Quality. This Action Plan recommends six short-term actions ranging from the establishment of a Water Quality database for the Kuiseb, identifying strategic sites for regular monitoring and enlisting the help of volunteers to collect samples, to an immediate investigation of the state of the tailings dam at Matchless Mine, improved awareness of water pollution and encouraging
stakeholders to apply for wastewater and effluent disposal exemption permits and comply with the conditions. Longer term actions include keeping up monitoring and awareness, expanding the database, monitoring possible sea water or saline intrusion, putting in place a sound groundwater monitoring programme for the mines, checking potential pollution from intensive agricultural activities such as cattle feed lots and remaining vigilant with regard to potential pollution of the harbour and Walvis Bay wetlands.

The most serious gap identified in the preparation of this report is that the Water Resources Management Plan for the Kuiseb Basin does not include a specific environmental management Action Plan. The new Environment Act requires all “organs of state” to develop an Environmental Plan. Based on the definition of an organ of state as “any Government office, Ministry, or agency at national, regional or local level “including “any other institution or person who is exercising a power or a function under the Namibian Constitution, or any public office or function under any Namibian law” (Hubbard, 2008) the KBMC will be required to develop an Environmental plan in future. This plan will need to be backed up by a much more detailed review and field –based investigation of the plants, animals and ecology of the Kuiseb Basin and be able to identify species of particular value and vulnerability and recommend suitable monitoring and conservation measures.

4. ACKNOWLEDGEMENTS

I would like to acknowledge the assistance of Merylinda Conradie at NamWater, Gracy Tsipo, Cynthia Ortmann and Laura Namene of the Water Environment Division at MAWF for making available water quality data and agreeing to be interviewed to discuss water quality issues. Thank you to Carole Roberts and Dr Mary Seely of DRFN for sharing the information compiled for the Kuiseb Profile and for making available WADE reports and power point presentations. Dr Jill Kinahan and Dr Dieter Noli are thanked for their contributions on the archaeology of the Namib. Kevin Roberts kindly proof read the report several times and kept the home fires burning.

Finally, I would like to pay tribute to Keith Wearne of CETN, the Coastal Environmental Trust of Namibia and member of the KBMC and Piet Hamman, former Head of Water Quality at the Department of Water Affairs, who sadly both passed away this year, before either good share their expertise to improve this report. Keith will be remembered for his untiring efforts to instil an appreciation of wetlands and the birds they support and Piet as the person who knew more about the water quality of Namibian waters than anyone else.
5. REFERENCES


Department of Water Affairs, undated. Guidelines for the evaluation of drinking-water quality for human consumption with regard to the chemical, physical and bacteriological quality. *MAWF, Windhoek.*


NamWater, 2008. Guidelines for the evaluation of drinking-water for human consumption with regard to chemical, physical and bacteriological quality. Namibia Water Corporation, Windhoek


1. INTRODUCTION

1.1 Water supplied for human consumption must comply with the officially approved guidelines for drinking-water quality.

1.2 For practical reasons the approved guidelines have been divided into three basic groups of determinants, namely:

- Determinants with aesthetic or physical implications, see TABLE 1 attached.
- Inorganic determinants, see TABLE 2 attached.
- Bacteriological determinants, see TABLE 3 attached.

2. CLASSIFICATION OF WATER

2.1 The concentration of and limits for the aesthetic, physical and inorganic determinants define the group into which water will be classified. See TABLE 1 and TABLE 2 for these limits.

   - GROUP A: Water with an excellent quality
   - GROUP B: Water with good quality
   - GROUP C: Water with low health risk
   - GROUP D: Water with a higher health risk, or water unsuitable for human consumption

2.2 Water should ideally be of excellent quality (Group A) or good quality (Group B), however in practice many of the determinants may fall outside the limits for these groups.

2.3 If water is classified as having a low health risk (Group C), attention should be given to this problem, although the situation is not critical yet.

2.4 If water is classified as having a higher health risk (Group D), urgent and immediate attention should be given to this matter. Since the limits are defined on the basis of average lifelong consumption, short term exposure to determinants exceeding their limits is not necessarily critical, but in the case of extremely toxic substances such as cyanide, remedial procedures should immediately be taken.

2.5 The group in which the water is classified is determined by the determinant which complies the least with the guidelines for the quality of drinking-water.

2.6 The bacteriological quality of drinking-water is also divided into four groups, namely:

   - GROUP A: Water which is bacteriologically very safe
   - GROUP B: Water which is bacteriologically still suitable for human consumption
   - GROUP C: Water with a bacteriological risk for human consumption which requires immediate action for rectification
   - GROUP D: Water which is bacteriologically unsuitable for human consumption
3. FREQUENCY FOR BACTERIOLOGICAL ANALYSIS OF DRINKING-WATER SUPPLIES

The recommended frequency for bacteriological analysis of drinking-water supplies is given below in TABLE 4.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>More than 100 000</td>
<td>twice a week</td>
</tr>
<tr>
<td>50 000 - 100 000</td>
<td>once a week</td>
</tr>
<tr>
<td>10 000 - 50 000</td>
<td>once a month</td>
</tr>
<tr>
<td>Minimum analysis</td>
<td>once every three months</td>
</tr>
</tbody>
</table>

4. PROMULGATION

The Cabinet of the Transitional Government for National Unity has approved the guidelines for evaluating drinking-water for human consumption with respect to the chemical, physical and bacteriological qualities, by Cabinet’s Approval 461/85 and reporting on the evaluation of drinking-water according to the new guidelines took effect as from 1 April 1988.

GENERAL MANAGER : ENGINEERING & SCIENTIFIC SERVICES
June 1998
<table>
<thead>
<tr>
<th>DETERMINANTS</th>
<th>UNITS</th>
<th>LIMITS FOR GROUPS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Colour</td>
<td>mg/l Pt**</td>
<td>20</td>
</tr>
<tr>
<td>Conductivity</td>
<td>mS/m 25°C</td>
<td>150</td>
</tr>
<tr>
<td>Total hardness</td>
<td>mg/l CaCO₃</td>
<td>300</td>
</tr>
<tr>
<td>Turbidity</td>
<td>N.T.U.***</td>
<td>1</td>
</tr>
<tr>
<td>Chloride</td>
<td>mg/l Cl</td>
<td>250</td>
</tr>
<tr>
<td>Chlorine (free)</td>
<td>mg/l Cl</td>
<td>0.1-5.0</td>
</tr>
<tr>
<td>Fluoride</td>
<td>mg/l F</td>
<td>1.5</td>
</tr>
<tr>
<td>Sulphate</td>
<td>mg/l SO₄</td>
<td>200</td>
</tr>
<tr>
<td>Copper</td>
<td>µg/l Cu</td>
<td>500</td>
</tr>
<tr>
<td>Nitrate</td>
<td>mg/l N</td>
<td>10</td>
</tr>
<tr>
<td>Hydrogen Sulphide</td>
<td>µg/l H₂S</td>
<td>100</td>
</tr>
<tr>
<td>Iron</td>
<td>µg/l Fe</td>
<td>100</td>
</tr>
<tr>
<td>Manganese</td>
<td>µg/l Mn</td>
<td>50</td>
</tr>
<tr>
<td>Zinc</td>
<td>mg/l Zn</td>
<td>1</td>
</tr>
<tr>
<td>pH****</td>
<td>pH-unit</td>
<td>6.0-9.0</td>
</tr>
</tbody>
</table>

* All values greater than the figure indicated.
** Pt = Platinum Units.
*** Nephelometric Turbidity Units.
**** The pH limits of each group exclude the limits of the previous group.
### TABLE 2

**LIMITS FOR INORGANIC CONSTITUENTS IN DRINKING WATER**

<table>
<thead>
<tr>
<th>Determinants</th>
<th>Unit</th>
<th>Limit for Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Aluminium</td>
<td>µg/l Al</td>
<td>150</td>
</tr>
<tr>
<td>Ammonia</td>
<td>mg/l N</td>
<td>1</td>
</tr>
<tr>
<td>Antimony</td>
<td>µg/l Sb</td>
<td>50</td>
</tr>
<tr>
<td>Arsenic</td>
<td>µg/l As</td>
<td>100</td>
</tr>
<tr>
<td>Barium</td>
<td>µg/l Ba</td>
<td>500</td>
</tr>
<tr>
<td>Beryllium</td>
<td>µg/l Be</td>
<td>2</td>
</tr>
<tr>
<td>Bismuth</td>
<td>µg/l Bi</td>
<td>250</td>
</tr>
<tr>
<td>Boron</td>
<td>µg/l B</td>
<td>500</td>
</tr>
<tr>
<td>Bromine</td>
<td>µg/l Br</td>
<td>1000</td>
</tr>
<tr>
<td>Cadmium</td>
<td>µg/l Cd</td>
<td>10</td>
</tr>
<tr>
<td>Calcium</td>
<td>mg/l Ca</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>mg/l CaCO₃</td>
<td>375</td>
</tr>
<tr>
<td>Cerium</td>
<td>µg/l Ce</td>
<td>1000</td>
</tr>
<tr>
<td>Chromium</td>
<td>µg/l Cr</td>
<td>100</td>
</tr>
<tr>
<td>Cobalt</td>
<td>µg/l Co</td>
<td>250</td>
</tr>
<tr>
<td>Cyanide Free</td>
<td>µg/l CN</td>
<td>200</td>
</tr>
<tr>
<td>Gold</td>
<td>µg/l Au</td>
<td>2</td>
</tr>
<tr>
<td>Iodine</td>
<td>µg/l I</td>
<td>500</td>
</tr>
<tr>
<td>Lead</td>
<td>µg/l Pb</td>
<td>50</td>
</tr>
<tr>
<td>Lithium</td>
<td>µg/l Li</td>
<td>2500</td>
</tr>
<tr>
<td>Magnesium</td>
<td>mg/l Mg</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>mg/l CaCO₃</td>
<td>290</td>
</tr>
<tr>
<td>Mercury</td>
<td>µg/l Hg</td>
<td>5</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>µg/l Mo</td>
<td>50</td>
</tr>
<tr>
<td>Nickel</td>
<td>µg/l Ni</td>
<td>250</td>
</tr>
<tr>
<td>Potassium</td>
<td>mg/l K</td>
<td>200</td>
</tr>
<tr>
<td>Selenium</td>
<td>µg/l Se</td>
<td>20</td>
</tr>
<tr>
<td>Silver</td>
<td>µg/l Ag</td>
<td>20</td>
</tr>
<tr>
<td>Sodium</td>
<td>mg/l Na</td>
<td>100</td>
</tr>
<tr>
<td>Tellium</td>
<td>µg/l Te</td>
<td>2</td>
</tr>
<tr>
<td>Thallium</td>
<td>µg/l Tl</td>
<td>5</td>
</tr>
<tr>
<td>Tin</td>
<td>µg/l Sn</td>
<td>100</td>
</tr>
<tr>
<td>Titanium</td>
<td>µg/l Ti</td>
<td>100</td>
</tr>
<tr>
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<tr>
<td>Uranium</td>
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</tr>
<tr>
<td>Vanadium</td>
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* All values greater than the figure indicated.
TABLE 3

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<th>DETERMINANTS (COUNTS)</th>
<th>BACTERIOLOGICAL DETERMINANTS</th>
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<tr>
<td></td>
<td></td>
<td>A**</td>
</tr>
<tr>
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<tr>
<td>Total coliform counts per 100 ml</td>
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<tr>
<td>E. coli counts per 100 ml</td>
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<td></td>
<td>B**</td>
</tr>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>10</td>
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* All values greater than the figure indicated.
** In 95% of the samples.

NB If the guidelines in Group A are exceeded, a follow-up sample should be analysed as soon as possible.

TABLE 4:

<table>
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<tr>
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<td>F</td>
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<tr>
<td>Mg</td>
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Kuiseb Basin Water Resources Management Project

Development of a Water Resources Plan for the Kuiseb Basin

and a

Generic Water Resources Planning Procedure

WATER PLANNING AND UTILIZATION IN THE KUISEB BASIN

COMPILED BY:

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# TABLE OF CONTENTS

1. **INTRODUCTION**  

2. **WATER MASTER PLANNING IN NAMIBIA**  

3. **HYDROCLIMATE**  

4. **WATER RESOURCES OF THE KUISEB BASIN**  

5. **WATER DEMAND IN THE BASIN**  
   5.1 General  
   5.2 Upper Catchment  
   5.3 Lower Catchment  
   5.4 Historical Water Demand in the Central Namib Area  
   5.5 Unaccounted for Water  
   5.6 Water Demand Forecast for the Central Namib Area  
   5.7 Historic Water Demand for Walvis Bay  
   5.8 Small Water Consumers  
   5.9 Future Water Demand for Walvis Bay  

6. **EXISTING WATER SUPPLY INFRASTRUCTURE**  
   6.1 Background  
   6.2 Kuiseb Water Scheme  
      6.2.1 Kuiseb Water Scheme Water Sources  
      6.2.2 Swartbank – Swakopmund Component  
      6.2.3 Rooibank – Mile 7 Component  
      6.2.4 High Dune – Mile 7 Component  
   6.3 Power Supply  
   6.4 Capacity of the Kuiseb Water Scheme  

7. **STRATEGIC INFRASTRUCTURE DEVELOPMENT PLAN**  
   7.1 General Assessment  
   7.2 Sufficiency of the Kuiseb Water Scheme  
   7.3 Recent Developments  
   7.4 New Developments  

8. **CONCLUSIONS**  

9. **RECOMMENDATIONS**  

   REFERENCES  

   ACKNOWLEDGEMENTS  

   ABBREVIATIONS  

   ANNEXURES
WATER PLANNING AND UTILISATION IN THE KUISEB BASIN

1. INTRODUCTION

The Kuiseb River is a centrally located west flowing river in Namibia. See Figure 1. The water supplied from the ephemeral Kuiseb River supports a number of very important consumers in the Kuiseb Basin and the adjacent Swakop River basin to the north of the Kuiseb Basin. At the coast the main consumers are the port of Walvis Bay with its strategically and economically important deep sea harbour, the fishing industry and an economic processing zone (EPZ), as well as prime tourist and recreation destinations in the Namib-Naukluft Park, communal stock farming and the well known Namib Research Institute next to the Kuiseb River in the Namib Desert. It is also technically possible to supply water from the alluvial aquifers in the lower Kuiseb River across the watershed to Swakopmund, Arandis, the Rössing Uranium Mine, the Langer Heinrich Uranium Mine and other developments in the lower Swakop River basin. The consumers in the upper Kuiseb Basin are mostly commercial stock farmers and minor mining activities.

This report provides a brief description of the water resources of the Kuiseb River, the water demand, the water supply infrastructure and possible future developments.

Figure 1: Location of the Kuiseb Basin

2 WATER MASTER PLANNING IN NAMIBIA

In order to supply in the growing water demand in Namibia, the Government is actively engaged in the short term (5 to 10 years), medium term (10 to 15 years) and long term (10 to 30 years) planning of water projects in the interest of the nation as a whole. The timely establishment of water supply schemes for cities, towns, villages, settlements, mining and irrigation developments to cater for the
domestic, industrial and agricultural water needs in the country takes place according to national and regional water plans.

A water resources master plan is a broad, long term framework within which a strategy for future water supply infrastructure development is recommended to ensure that water supplies will always be available to support growing socio-economic development and national prosperity. When a master plan is prepared for a specific river basin care should be taken that it conforms to the national water master planning strategy in a country.

In the late sixties the Government of the Republic of South African started with a large development program in the then South West Africa and growth rates of up to 7 % per annum were experienced in the central area of Namibia. In order to meet the estimated future water demand with the available water resources, the situation was assessed and broad guidelines for water infrastructure development were proposed in the 1974 Water Master Plan for Namibia (DWA 1974). See Figure 2. According to those guidelines, the areas immediately adjacent to the perennial Kunene, Okavango, Orange and Zambezi rivers on the borders of Namibia must be supplied with water from those rivers, but it was also envisaged that water will have to be imported to the arid interior of Namibia from two of the northern border rivers, the Kunene and the Okavango. The demand forecasts at that time showed that the development of ephemeral surface water sources and groundwater sources would not be able to meet the estimated future water demand in the north, central and western areas. It was therefore recommended to develop a western water carrier from the Kunene to augment the water resources in the central Cuvelai Basin and the Central Namib Area (CNA). It was also recommended to construct an eastern water carrier from the Okavango to supply additional water to the highly industrialized central area. Furthermore, the master plan indicated that the central southern area of the country must be supplied with water from the Fish River. The rest of the country should as far as possible be supplied with water from groundwater sources, unless an unidentified future water need would necessitate the construction of a surface water source or the development of groundwater sources to supply water over long distances from a more reliable source to a major demand center, and it would be possible to develop such infrastructure in a sustainable way.

During the development of the Calueque Dam – Oshivel0 water carrier in the north and the Eastern National Water Carrier (ENWC) in the east, it was decided to rather utilize Kunene water for hydropower development and the supply of water to the north, than to divert water to the CNA. The development of the western water carrier was therefore abandoned and other measures to augment the coastal developments were investigated, such as desalination. In fact, the Department of Water Affairs conducted a research project at Swakopmund in the late seventies to investigate the available desalination technologies at that time.

After the independence of Namibia in 1990, large developments were expected all over the country and particular attention was given to the revision of the Water Master Plan. This led to the adoption of a number of regional water master plans, including a water Master Plan for the Central Area of Namibia in 1993 (MAWRD/DWA 1993) and the completion of a Feasibility Study for the Development of Water Supply to the Central Namib Area of Namibia in 1996 (MAWRD/DWA 1996). During the study to prepare the Central Area Water Master Plan the feasibility to link the ENWC with the coast was investigated and it became clear that it would not be economically viable. It was therefore recommended that the central coastal area will have to be supplied from groundwater, in conjunction with desalinated sea water.

The primary function of a water infrastructure development master plan is to provide information about the long term water demand and supply situation, the infrastructure development that would be required to meet the estimated future water demands and to recommend a short, medium and long term capital expenditure programme with respect to the investments necessary over time to implement the plan. This will not only ensure sufficient supply to meet reasonable and managed water demands, but provision should also be made to recover the capital investments for new water schemes and to
generate the income required for the operation and maintenance of the water supply infrastructure. Water schemes may also be developed in phases over time, or upgraded as the water demands increase.

---

**Figure 2: The 1974 Water Master Plan**

All water schemes have components that reach the end of their economic life over time and needs to be replaced with components of higher capacity, which means that capital extension and replacement issues form part of such a master plan. For each area-specific water master plan the following work is required:

- Evaluate the historical water demand and the realistic present water demand;
- Describe the existing water scheme, scheme components and condition;
- Estimate the realistic future water demand;
- Evaluate the present scheme capacity by component (Resources, pumping installations, pipelines, storage facilities, disinfection facilities, control and monitoring systems) and the remaining useful life of all components;
- Evaluate the current spare capacity or capacity shortfall and the date when additional capacity will be required;
- Define the available options to improve capacity where required;
- Estimate the costs for the creation of additional capacity, capital replacement and extension;
- Estimate the costs associated with improved efficiency, service level, operations, and equipment;
- State why and when new investments will be required;
The above approach is somewhat different when an integrated water resources master plan must be
developed in a basin management context. Policies and decisions regarding water resources
management are usually determined at the national level as has been illustrated above. This includes
legislation and the establishment of institutions, such as a basin management committee, within which
water resources management takes place. An integrated water resources plan must take into account
all activities and developments requiring water or influencing the water resources. Among these are
the availability and magnitude of the water resources, land use, water supply and sanitation,
agriculture, industry and mining, as well ecological requirements, to name a few. The plan should
include a prioritised series of programmes for the implementation of a development plan that ensures
a balanced approach.

The formulation of a national water resources plan may have four distinct phases:

2.1 Identify water resource issues, such as quantity, quality, demand, floods, droughts,
human impacts and natural effects, such as climate change.

2.2 Identify the management interventions which are required to deal with the issues
identified. These may include policy development, legislation, planning and
coordination, water allocation, effluent treatment, monitoring and information
dissemination.

2.3 Assess institutional capacities at all levels and determine the potentials and constraints
to attend to the issues at hand, including the efficiency of the institutional structures and
the adequacy of human and financial resources

2.4 Prepare a strategy to improve any deficiencies identified that would impair the
coordinated implementation of the plan.

A basin management plan is a tool that describes the framework for the management of the water and
related land resources in the basin and outlines how the concept of integrated water resources
management is going to be implemented. A basin management plan typically addresses such aspects as:

• A physical description of the basin and resource inventories
• To assess water availability and present water demands
• Estimate the water needs of aquatic and terrestrial ecosystems
• The allocation of water and water quality objectives
• Water treatment and pollution control
• The identification of stakeholders
• To determine priority issues and long term goals for the development of the basin
• To estimate the managed future demands
• To determine the water related developments required
• To assess water scheme vulnerability to climate extremes like floods, droughts and
climate change
• Develop a strategy to achieve the implementation goals, including capacity building,
financing and monitoring
3 HYDROCLIMATIC BACKGROUND

The Kuiseb River, one of the twelve western-flowing ephemeral rivers in Namibia, originates about 15 to 30 kilometres (km) west of Windhoek in the Khomas Hochland and flows 500 km on its way through the Namib Desert towards the Atlantic Ocean. The river drains a catchment area of 14 700 square kilometres (km²). The catchment receives summer rainfall, but the seasonal runoff in the Kuiseb very seldom reaches the sea. The floodwater normally dissipates some kilometres from the sea in a dry delta. See Figure 3.

![Figure 3: Kuiseb Catchment Hydrology](image)

The average precipitation over the catchment decreases from 350 millimetres per annum (mm/a) in the east to less than 50 mm/a at the coast in the west. The variability in the rainfall varies between 40% in the east and 100% at the coast. This means that there can be a large deviation from the mean annual rainfall. The same applies to the average evaporation that decreases from 2 400 mm/a in the east to 1 700 mm/a in the west. For the purposes of this report the catchment is divided into sections, namely the lower (most western), middle (the escarpment) and upper (highland) catchment.

It is estimated that only 9 000 km² of the catchment make a significant contribution to the mean annual runoff in the river but due to the variation in the rainfall there is also a large variation in the runoff measured at the hydrometric gauging stations along the river on its way to the sea. From records of the Department of Water Affairs (JACOBSON 1997) it is estimated that the mean annual runoff in the Kuiseb decreases from 16 million cubic metres per annum Mm³/a at the recording station at Schlesien.
(about 250 km from the delta) to 4.5 Mm$^3$/a at Gobabeb (85 km from the delta), and 0.6 Mm$^3$/a at Rooibank (18 km from the delta).

4 WATER RESOURCES OF THE KUISEB BASIN

The surface runoff in the entire catchment relies almost exclusively on rain falling in the upper catchment, but the source of water as an input from rainfall is very low and sometimes nonexistent in the middle and lower catchments. One major dam, the Friedenau Dam, with a storage capacity of 6.7 Mm$^3$ and a 95% assured safe yield of 0.5 Mm$^3$/a was constructed in the early seventies to supply water to the Matchless Mine.

There have been some studies done on the feasibility of constructing dams in the upper parts of the catchment. The water from the proposed Donkersan Dam would have been supplied to Windhoek or the proposed dams at Schlesien and downstream of the confluence of the Kuiseb and the Gaub rivers would have supplied water to possible mining developments in the Namib-Naukluft Park at the Hope and Gorob copper deposits. However, if any of the proposed dams are built, the total runoff into the lower parts of the Kuiseb will be reduced by 70%, causing major problems for farmers living downstream and reducing the recharge to the aquifers in the Kuiseb River bed.

It was estimated (DRFN 1994) that farm dams in the upper Kuiseb impounds about 20% of the runoff, but 76% is unaccounted for and only 13% enters the middle Kuiseb as runoff. This surface water, runoff, together with the little rain that falls, are the only sources of water available to recharge the aquifers in the middle and lower Kuiseb. The aquifers at Swartbank, Rooibank and Dorop in the lower Kuiseb are the major sources of water for the coastal towns and socio-economic activities. Water abstraction in the lower Kuiseb was generally greater than recharge over a long period of time. More information on the lower Kuiseb Aquifers is given in Paragraph 6.2.1

The quality of groundwater throughout the catchment appears to be acceptable for direct human consumption (upper and middle catchments) or with minimal treatment. The total dissolved solids (TDS) in the groundwater in the aquifers of the lower Kuiseb varies between 600 and 1 000 parts per million (mg/l). Surface water in the Kuiseb typically contains very low TDS except when the floodwater originates from tributaries in the Namib Desert in the lower reaches of the river. As a result, highly mineralised groundwater occurs in the tributaries of the Kuiseb coming from the northern bank.

5 WATER DEMAND IN THE BASIN

5.1 General

There are basically four major water user groups that obtain water from in the Kuiseb catchment. These are the Municipality of Walvis Bay, the Topnaar settlements and communal farmers and the Namib Research Institute at Gobabeb in the lower catchment and commercial farmers in the upper catchment. Other groups are the tourism industry in the Namib Naukluft Park and mining at Hope or Gorob, but the demand for water is at the moment relatively insignificant. Water can also be exported from the alluvial aquifers in the lower Kuiseb Basin into the Swakop River basin to supply Swakopmund, Arandis, the uranium mines at Rössing and Langer Heinrich, as well as numerous small developments along the pipeline routes.

When the developments in the lower Swakop River and lower Omaruru River are taken into account, the major bulk water users are Walvis Bay, Swakopmund, Henties Bay and the two uranium mines at Rössing and Langer Heinrich. These and other smaller consumers are supplied with water in bulk by the Namibia Water Corporation (Ltd) or generally known as NamWater and the whole area is referred
Water planning and utilisation

7
to as the Central Namib Water Supply Area. The CNA is located in the Erongo Region and is the most significant concentration of people on a coastline extending well over 1 000 km.

Swakopmund, the second largest coastal town, is a primary tourist destination. Founded in 1892, it has since become Namibia’s premier beach resort. The establishment of uranium mining in the CAN had a big impact on development in both Swakopmund and Walvis Bay. The Rössing Uranium Mine, situated 65 km inland from Swakopmund, has been in existence since 1976 and will probably remain in operation until at least 2016. When established, it was the largest opencast uranium mine in the world. The mine necessitated the expansion of infrastructure and housing in Swakopmund which has since become a major service provider to the uranium industry.

Arandis is mainly a dormitory town for employees of the Rössing Uranium Mine. The town was handed over to the Government (Ministry of Regional and Local Government, Housing and Rural Development for administration and in the past its growth and decline has mirrored the fortunes of the mine.

Henties Bay is named after the Major Hentie van der Merwe, who in 1929 settled at a fresh water fountain in the old Omaruru River at the coast. Henties Bay, has developed into a holiday resort since the late forties. During the last ten years Henties Bay has experienced rapid growth and developed into a town. The municipality was established in 1997.

Another uranium mine has been established during 2006 at the Langer Heinrich Mountain about 80 km to the east of Swakopmund. This mine is presently also supplied from the alluvial aquifers in the Omaruru River.

According to the 2001 census, the CNA had a total population of 88 785 inhabitants making up 13% of the total Namibian population. The majority of these people reside in the two coastal towns of Walvis Bay (40 849 persons) and Swakopmund (24 950 persons). In 2001 Arandis accommodated 3 820 persons and Henties Bay 3 608 persons. Between 1991 and 2001 the population of the Erongo Region grew by 52 159 persons. This amounts to an average compound growth rate over the 10-year period of 6.8% per annum. The national population growth rate for the same period was 2.6% and is an indication of heavy urbanisation in the major towns in the CNA. The much higher growth rate for the CNA can be attributed to migration of the rural population to the major urban areas in search of work. Many factors drive this movement from the rural areas, amongst which the high unemployment levels indicated to be in excess of 31% in 2001.

It is also estimated that the envisaged development of perhaps eight new uranium mines over the next five years would create an additional 6 000 new job opportunities. This may result in an influx of about 35 000 people into the CAN and would require additional facilities for education, health, recreation etc. The mining development would also stimulate the need for more service industries and other services, employing even more people.

5.2 Upper Catchment

According to a study that was done by the DRFN in 1994 there are about 109 commercial farms that consume about 0,6 Mm3/a. Most of the water is used for stock drinking (90%) and the balance for domestic purposes, including water for tourism at hunting and guest farms or lodges. The main water sources are groundwater and the use of surface runoff that is impounded in small farm dams to serve as stock drinking places and to augment the groundwater sources where practically possible.

The Matchless Mine, some 70 km from Windhoek, used to consume about 0,4 Mm3/a, supplied from the Friedenau Dam in the Kuiseb River. The mine closed due to low copper ore prices, but may be reopened if copper prices improve. Water is at present supplied to a school, a hotel school and a dairy
at Baumgartsbrunn, about 10 km from the dam. The dam is also used for recreational purposes, including fishing and boating.

5.3 Lower Catchment

The infrastructure linking the Central Namib Area to the Namibian interior and the rest of southern Africa is good in terms of tarred roads, railways, airports, communications and electricity supply. This, the potential for the development of new uranium mines in the central Namib and the fact that Walvis Bay with its EPZ is the only major harbour between Angola and South Africa, provide significant potential for growth, which would require the support of a reliable and sufficient water supply system.

Walvis Bay is the largest town in the CNA and is one of two ports on the Namibian coast which is the source of virtually all imports and exports by sea. It is the centre of the Namibian fishing industry, which contributes about 10% to the Namibian GDP and about 6% to total national formal employment. The town caters for the fishing industry and service industries forms the backbone of the economic activities, as well as tourism, salt mining and the oyster farms in the bay. The oyster farming activities suffered a severe setback due to the loss of oysters as a result of adverse conditions in the water.

International tourism is a growing industry in Namibia and has major potential for employment and income generation. The mining industry is a major employer in Namibia and contributes a large proportion of the GDP. The CNA is of great importance with regard to the mining industries, both as a direct contributor and as a conduit for export for the industry to the rest of the country.

5.4 Historical Water Demand in the CAN

The purpose of this section is to review the historical water demand trends of consumers within the CNA in order to form the basis upon which estimates of present and future demand can be founded. The historical records of water demand of the various major consumers in the CNA have been examined. The sources of information used in this work are described in the following section. Reports of NamWater, taking into account information from the municipalities, have been used as a primary source of data. NamWater supplies water in bulk to the major consumers in the CNA; and the largest of these are listed in Table 1 together with the relevant NamWater profit centres. They can be broken down mainly into towns, settlements, institutions, mines and industry.

The NamWater Board requested that vulnerable institutions in terms of water supply should be identified as part of their master planning and these were identified for the CNA to include the schools, hostels, hospitals and clinics for Arandis, Henties Bay, Swakopmund and Walvis Bay.

The historical annual water demand figures of the CNA, as determined from the NamWater records of direct sales volumes to consumers, are shown in Table 2 below. These demands are only for potable water supplied by NamWater and do not include demands for semi-purified water resulting from domestic sewage effluent and used in watering public or private gardens and sports fields. Demands by the fishing factories and NamPort for seawater are also excluded from the figures below because that consumption do not form part of the bulk water supply to the local Municipalities.
### Table 1: Bulk Consumers Supplied by NamWater

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<tr>
<th>Scheme</th>
<th>Consumers</th>
<th>Remarks</th>
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</thead>
<tbody>
<tr>
<td>Rooibank - Walvis Bay (ROB)</td>
<td>Walvis Bay Municipality&lt;br&gt;Industry (including NamPort)&lt;br&gt;Small consumers</td>
<td>Town</td>
</tr>
<tr>
<td>Swakopmund - Rössing Pipeline (SRA)</td>
<td>Stone Africa&lt;br&gt;Namibia Film&lt;br&gt;Stone Evolution &amp; Equipment Hire&lt;br&gt;Aztec Granite&lt;br&gt;Sea Fisheries&lt;br&gt;Arandis&lt;br&gt;Rössing Uranium Mine&lt;br&gt;Small consumers</td>
<td>Industry</td>
</tr>
<tr>
<td></td>
<td>Town</td>
<td>Industry</td>
</tr>
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<td></td>
<td>Stone Africa&lt;br&gt;Namibia Film&lt;br&gt;Stone Evolution &amp; Equipment Hire&lt;br&gt;Aztec Granite&lt;br&gt;Sea Fisheries&lt;br&gt;Arandis&lt;br&gt;Rössing Uranium Mine&lt;br&gt;Small consumers</td>
<td>Industry</td>
</tr>
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<td>Town</td>
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<td>Stone Africa&lt;br&gt;Namibia Film&lt;br&gt;Stone Evolution &amp; Equipment Hire&lt;br&gt;Aztec Granite&lt;br&gt;Sea Fisheries&lt;br&gt;Arandis&lt;br&gt;Rössing Uranium Mine&lt;br&gt;Small consumers</td>
<td>Institutions</td>
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<td>Town</td>
<td>Industry</td>
</tr>
<tr>
<td>Swakopmund Base (SKD)</td>
<td>Swakopmund Town&lt;br&gt;Small consumers</td>
<td>Town</td>
</tr>
<tr>
<td>Henties Bay (HEN)</td>
<td>Henties Bay Municipality</td>
<td>Various</td>
</tr>
<tr>
<td>Omdel – Swakopmund Pipeline (SOS)</td>
<td>Jakkalsputz&lt;br&gt;Wlotzkas Baken&lt;br&gt;Mile 14&lt;br&gt;Cape Cross Lodge&lt;br&gt;Salt Company&lt;br&gt;Small consumers</td>
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<td>Settlement</td>
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<td>Swartbank – Swakopmund (SSS)</td>
<td>Topnaars&lt;br&gt;Small consumers&lt;br&gt;Rooikop Airport&lt;br&gt;JP Brand Primary School&lt;br&gt;Farm Daizy&lt;br&gt;Rooikop Defence Force</td>
<td>Settlement</td>
</tr>
<tr>
<td></td>
<td>Settlement&lt;br&gt;Various&lt;br&gt;Commerce&lt;br&gt;Ministry&lt;br&gt;Industry&lt;br&gt;Ministry</td>
<td>Settlement</td>
</tr>
<tr>
<td>Swakopmund – Langer Heinrich Pipeline</td>
<td>Langer Heinrich Mine</td>
<td>Mine</td>
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</table>

### Table 2: Annual Potable Water Sales Volumes to CNA Bulk Consumers

<table>
<thead>
<tr>
<th>Year</th>
<th>Walvis Bay (m³)</th>
<th>Rössing Mine (m³)</th>
<th>Swakopmund (m³)</th>
<th>Arandis (m³)</th>
<th>Henties Bay (m³)</th>
<th>Langer Heinrich (m³)</th>
<th>Small Consumers (m³)</th>
<th>TOTAL (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY98</td>
<td>4 330 175</td>
<td>2 905 447</td>
<td>2 720 415</td>
<td>509 816</td>
<td>371 246</td>
<td>669 265</td>
<td></td>
<td>11 506 364</td>
</tr>
<tr>
<td>FY99</td>
<td>4 691 409</td>
<td>3 600 873</td>
<td>2 760 719</td>
<td>451 049</td>
<td>389 430</td>
<td>558 063</td>
<td></td>
<td>12 451 543</td>
</tr>
<tr>
<td>FY00</td>
<td>4 151 743</td>
<td>2 560 817</td>
<td>2 543 666</td>
<td>448 191</td>
<td>356 898</td>
<td>458 208</td>
<td></td>
<td>10 519 523</td>
</tr>
<tr>
<td>FY01</td>
<td>4 041 772</td>
<td>2 241 928</td>
<td>2 725 669</td>
<td>442 370</td>
<td>355 924</td>
<td>405 157</td>
<td></td>
<td>10 212 820</td>
</tr>
<tr>
<td>FY02</td>
<td>4 508 267</td>
<td>1 851 952</td>
<td>2 903 184</td>
<td>448 029</td>
<td>374 317</td>
<td>392 579</td>
<td></td>
<td>10 478 328</td>
</tr>
<tr>
<td>FY03</td>
<td>4 423 090</td>
<td>1 914 650</td>
<td>2 984 153</td>
<td>465 393</td>
<td>379 188</td>
<td>463 325</td>
<td></td>
<td>10 629 799</td>
</tr>
<tr>
<td>FY04</td>
<td>4 563 598</td>
<td>3 041 078</td>
<td>2 840 949</td>
<td>457 987</td>
<td>363 849</td>
<td>432 711</td>
<td></td>
<td>11 700 172</td>
</tr>
<tr>
<td>FY05</td>
<td>4 530 533</td>
<td>2 909 249</td>
<td>2 946 472</td>
<td>468 808</td>
<td>369 982</td>
<td>435 738</td>
<td></td>
<td>11 660 782</td>
</tr>
<tr>
<td>FY06</td>
<td>4 307 486</td>
<td>3 264 041</td>
<td>2 920 027</td>
<td>456 300</td>
<td>383 752</td>
<td>467 286</td>
<td></td>
<td>11 798 892</td>
</tr>
<tr>
<td>FY07</td>
<td>4 350 873</td>
<td>3 199 527</td>
<td>2 983 270</td>
<td>398 260</td>
<td>378 542</td>
<td>318 039</td>
<td>569 922</td>
<td>12 198 433</td>
</tr>
</tbody>
</table>
The annual compounded water demand growth rates achieved historically for in the CNA are reflected in **Table 3** below.

**Table 3: Annual Water Demand Growth Rates for the CNA**

<table>
<thead>
<tr>
<th>Period</th>
<th>Annual Compound Growth Rate Total CNA</th>
<th>Annual Compound Growth Rate excluding Rössing Mine</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY98-FY07</td>
<td>0.3%</td>
<td>-0.1%</td>
</tr>
<tr>
<td>FY00-FY07</td>
<td>1.7%</td>
<td>1.0%</td>
</tr>
<tr>
<td>FY03-FY07</td>
<td>2.6%</td>
<td>-0.5%</td>
</tr>
</tbody>
</table>

From **Figure 4** below it can be seen that the Rössing Mine has a large influence on the total water demands in the CNA with the decrease in total sales seen between FY1998 and FY1993 caused by a cutback in their production. Similarly, the rise during FY2004 was due to an increase in uranium production by the Rössing Mine.

![Historical Demand for Central Namib Study Area](image)

**Figure 4  Historical Water Demands in the Central Namib Area**

The distribution of water sales between the various bulk customers is depicted in **Figure 5** below. From the figure it can be seen that in FY2007, Swakopmund, Walvis Bay and Rössing together consumed 86% of the water supplied to the CNA by NamWater, with Walvis Bay being the largest single consumer.
5.5 Unaccounted for Water

The total bulk pipe network from the Kuiseb and Omdel is quite complex. Swakopmund Reservoir receives water from both the Kuiseb and Omdel aquifers and is distributed to Swakopmund Town, Rössing Mine, Langer Heinrich Mine and various small consumers along the Rössing pipeline.

It is difficult to calculate the precise production losses in the bulk system between the different scheme components. However, the total production between February 2004 and June 2007 for the total CNA was 5.8% higher than the total water sales for the same period. The actual losses may have been even higher, since the above figure does not make provision for broken or inaccurate water meters at boreholes. For the period September 2006 till March 2007, the total water production volumes were 3% less than the water sales volumes, which show that there is a problem with the production meters and thus difficult to say what the actual losses are.

5.6 Water Demand Forecast for the Central Namib Area

The purpose of this section is to use the information and results of the analyses of the historical water demand trends to develop future water demand projections. A scenario approach has been adopted for each of the major consumers in which a low, expected and high growth demand projections were made based upon various expectations.

The water demand of the CNA has previously been forecast in 1995 and 2002. For more information regarding these forecasts refer to the 1996 study by the Department of Water Affairs (MAWRD/DWA) as well as the study (NAMWATER 2001a) completed in 2002 by the Infrastructure Planning Unit of NamWater. In these documents, historical water demand figures were analyzed and the projections of future demand were mainly based on expected socio-economic developments. The actual historical demands of the CNA compared to the 1995 and 2002 projections are shown in Figure 6 below.
From the figure it can be seen that initially actual water demand followed the 1995 prediction fairly closely. In 1998/99 the water demand dropped considerably below what was expected. This was mainly due to a cutback in the production and hence lower water demand of the Rössing Mine. Similarly the rise in demand during 2003/04 was also mainly due to an increase in uranium production and associated higher water demand by the Rössing Mine. As can be seen, the actual water demand has been slightly higher than expected for the 2002 projection.

The information and results of analyses detailed above on the water demand trends as well as the information gathered from the municipalities and other major consumers were used to develop future water demand projections. Projections for three demand scenarios were developed, being a high or optimistic growth projection, an expected growth projection and a low growth projection. In most cases the low demand is based on the future water demand figures received from the Coastal Bulk Water Users Forum. The scenarios have been based upon a series of assumptions of those developments that can reasonably be foreseen at this time. They do not include those developments which are either pure speculation or conjecture nor do they take into account the unexpected such as a complete collapse of either the uranium price or fish stocks.

Due to the high uranium price there are presently several potential new mines in various stages of exploration, feasibility and development in the CNA. Since mining is a fairly water intensive process, if these mining developments materialise within the next five years, they will increase the water demand in the CNA substantially. Furthest advanced is the Trekkopje Uranium Project which lies some 70 km north-east of Swakopmund. The latest water demand estimate for this development is approximately 20 Mm³/a. Due to the urgency of the project however, the mine has decided to build its own dedicated water scheme to be supplied with desalinated seawater. The seawater abstraction point and desalination plant will be situated just north of Wlotzkasbaken. The demand by Trekkopje will thus not affect the demand on NamWater sources and is hence excluded. Apart from Trekkopje, the following locations in the CNA are currently being investigated for the purpose of uranium mining:
Water planning and utilisation

- Valencia with an estimated water demand of 3 Mm$^3$/a by September 2009 and situated about 80 km north-east of Swakopmund.
- Goanikontes with an estimated water demand of 4 Mm$^3$/a by 2010 and located 30 km east of Swakopmund.
- Marenica with an estimated water demand of 4 Mm$^3$/a by 2011 and located 95 km north-east of Swakopmund.
- Husab (Ida Dome) with an estimated water demand of 3 Mm$^3$/a by 2012, situated 60 km east of Swakopmund.
- Tubas/Tumas with an estimated water demand of 3 Mm$^3$/a by 2012 located 40 and 70 km respectively to the east of Walvis Bay.

Excluding Trekkopje, the expected water demand by 2012 of existing and future uranium mines is currently estimated as 28 Mm$^3$/a taking into account the additional demands of the Rössing and Langer Heinrich mines. A map indicating the approximate positions of these new mines together with those of existing mines is given in Figure 7 below.

![Figure 7: Location of Existing and Future Uranium Mines](image)

There are also other possible future developments in the CNA such as a pig farm, steel smelter and re-opening of the Namib Lead Mine, but these developments are presently sufficiently uncertain and their demand unknown, so that they have not been included in the estimate. Based on the expected demands of existing and future customers in the CNA, a summary of the expected annual demand estimates is given in Figure 8 below. Note that the figures shown below are sales volumes and do not include losses on the bulk side.
From the above figure, it can be seen that the existing and future uranium mines will have a very large impact on the future water demand of the CNA. Overall, water demand is expected to quadruple, if all uranium companies presently busy with exploration and feasibility studies go ahead establishing new mines. This projection of the future water demand in the CAN is depicted in Figure 9 below.
The projections of 1995 and 2002 are listed in Table 4 for comparison with the 2007 projection as indicated in Figure 8. Provision has been made for 5% production losses in the figures indicated.

### Table 4: Comparison between Previous and Latest Projections

<table>
<thead>
<tr>
<th>Year</th>
<th>Actual</th>
<th>1995 Projection</th>
<th>2002 Projection</th>
<th>2007 Projection</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY93</td>
<td>10 187 706</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FY94</td>
<td>10 557 541</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FY95</td>
<td>10 927 677</td>
<td>11 201 758</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FY96</td>
<td>10 963 099</td>
<td>11 786 025</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FY97</td>
<td>11 106 996</td>
<td>12 418 533</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FY98</td>
<td>11 571 134</td>
<td>12 465 020</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FY99</td>
<td>12 451 543</td>
<td>12 489 980</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FY00</td>
<td>10 519 923</td>
<td>13 100 994</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FY01</td>
<td>10 212 820</td>
<td>13 075 352</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FY02</td>
<td>10 478 328</td>
<td>13 287 504</td>
<td>10 404 237</td>
<td></td>
</tr>
<tr>
<td>FY03</td>
<td>10 620 799</td>
<td>13 507 444</td>
<td>10 549 051</td>
<td></td>
</tr>
<tr>
<td>FY04</td>
<td>11 700 172</td>
<td>13 735 275</td>
<td>10 807 375</td>
<td></td>
</tr>
<tr>
<td>FY05</td>
<td>12 614 753</td>
<td>13 971 123</td>
<td>10 994 903</td>
<td></td>
</tr>
<tr>
<td>FY06</td>
<td>12 873 277</td>
<td>14 815 396</td>
<td>11 095 146</td>
<td></td>
</tr>
<tr>
<td>FY07</td>
<td>12 787 101</td>
<td>15 061 423</td>
<td>11 243 807</td>
<td>12 787 101</td>
</tr>
<tr>
<td>FY08</td>
<td>15 315 683</td>
<td>11 400 341</td>
<td>13 885 709</td>
<td></td>
</tr>
<tr>
<td>FY09</td>
<td>15 570 076</td>
<td>11 565 014</td>
<td>18 452 690</td>
<td></td>
</tr>
<tr>
<td>FY10</td>
<td>15 832 680</td>
<td>11 738 100</td>
<td>23 950 018</td>
<td></td>
</tr>
<tr>
<td>FY11</td>
<td>16 093 985</td>
<td>11 966 062</td>
<td>30 314 864</td>
<td></td>
</tr>
<tr>
<td>FY12</td>
<td>16 352 988</td>
<td>12 198 861</td>
<td>38 786 403</td>
<td></td>
</tr>
</tbody>
</table>

An equivalent compound growth rate was calculated for 2007 to 2030 for each of the three projections and it was 1.7 % for the 1995 projection, 1.8 % for the 2002 projection and 5.7 % for the 2007 projection. The main difference between the current projection and the 2002 projection is caused by the higher demands of existing and additional demands of new the uranium mines. The average peak month factor over the past 10 years for the total CNA was 1.25; therefore this figure was used to calculate the peak month estimates. The calculated peak month projections can be seen in Figure 10 below.
5.7 Historic Water Demand of Walvis Bay

The historical annual demands of potable water by the Municipality of Walvis Bay, as determined from the NamWater records of direct sales volumes to consumers are shown in Table 5 below. This information is also depicted graphically in Figure 11 below.

In 2003 the Municipality of Walvis Bay introduced the sale of recycled semi-purified water from the sewerage plant for use in gardens. Currently only 0.6% of all water sold by the Municipality of Walvis Bay is semi-purified water. They foresee however that this figure will grow to 5.8% by 2015. The semi-purified water is much cheaper than potable water. Currently problems are experienced with the semi-purified water due to its high salt content.

Table 5: Annual Water Sales Volumes to Walvis Bay Municipality

<table>
<thead>
<tr>
<th>Year</th>
<th>Water Sales (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY98</td>
<td>4 330 175</td>
</tr>
<tr>
<td>FY99</td>
<td>4 691 409</td>
</tr>
<tr>
<td>FY00</td>
<td>4 151 743</td>
</tr>
<tr>
<td>FY01</td>
<td>4 041 772</td>
</tr>
<tr>
<td>FY02</td>
<td>4 508 267</td>
</tr>
<tr>
<td>FY03</td>
<td>4 423 090</td>
</tr>
<tr>
<td>FY04</td>
<td>4 563 598</td>
</tr>
<tr>
<td>FY05</td>
<td>4 530 533</td>
</tr>
<tr>
<td>FY06</td>
<td>4 307 486</td>
</tr>
<tr>
<td>FY07</td>
<td>4 350 873</td>
</tr>
</tbody>
</table>
The annual compounded water demand growth rates of the Walvis Bay Municipality are reflected in Table 6 below. According to the figures it can be seen that growth since financial year 1999 was -1.1%, thus a reduction in water sales. This is because in 1999, the Municipality introduced measures to reduce the consumption of potable water. These included increased and restructured water tariffs introduced to determine the water demand at tariff levels which would prevail after the establishment of the proposed desalination plant. During the same period also the potable water demand by the fishing industry decreased due to reduced quotas and some of the factories switching to seawater for some of their processes. It is clear from this that interpreting overall growth rates calls for a great deal of discretion as well as an understanding of the overall driving mechanisms and how these can fluctuate.

Table 6: Water Demand Growth Rates for Walvis Bay

<table>
<thead>
<tr>
<th>Description</th>
<th>Annual Compound Growth Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY98 - FY07</td>
<td>-0.01</td>
</tr>
<tr>
<td>FY99 - FY07</td>
<td>-1.1</td>
</tr>
<tr>
<td>FY00 - FY07</td>
<td>0.5</td>
</tr>
<tr>
<td>FY01 - FY07</td>
<td>1.1</td>
</tr>
<tr>
<td>FY02 - FY07</td>
<td>-0.9</td>
</tr>
<tr>
<td>FY03 - FY07</td>
<td>-0.7</td>
</tr>
</tbody>
</table>

The average peak month factor determined from the records available is 1.26 for the Walvis Bay Municipality. This was calculated using the maximum available monthly records of consumption. Ten years of monthly data have been used to derive the average figure given. It should be noted that the 2001 per capita consumption figures are based on the 2001 Population and Housing Census figures. According to these, the annual compounded population growth between 1991 and 2001 was 6.85%.
for the Erongo Region. This percentage was used to project a population figure for FY07 and the per capita consumption derived accordingly. The calculations are done on the total potable demand of the municipality and hence also include the industrial demand. The resulting consumption figures are shown in Table 7 below.

**Table 7: Per Capita Consumption for Walvis Bay Municipality**

<table>
<thead>
<tr>
<th>Year</th>
<th>Consumption (litres/capita/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY02</td>
<td>302</td>
</tr>
<tr>
<td>FY07</td>
<td>219</td>
</tr>
</tbody>
</table>

The 38% reduction in per capita consumption over the last 4 years can mainly be ascribed to an increase in water tariffs and increased water management by the Municipality of Walvis Bay. It could also result from an increase in population numbers in the low to very low income brackets. The total bulk water supply network from Kuiseb and Omdel to Swakopmund is quite complex. Swakopmund Reservoir receives water from both the Kuiseb and Omdel aquifers. Unfortunately the flow meter at the inlet of the Swakopmund Terminal Reservoir is not read and proper flow balancing is thus not possible between the Kuiseb and Omdel systems. Production losses for the the Kuiseb-fed side of the side hence cannot be calculated. It has been reported by the Municipality of Walvis Bay, which has been carrying out its own study of losses in its distribution system that these are currently in the order of 12% to 14%. These figures are derived from an overall flow balance calculation between the total of the sales to consumers and the bulk supply. No other flow balance has been undertaken.

![Figure 12 Unaccounted for Water in Walvis bay](image-url)
5.8 Small Water Consumers

NamWater supplies water to various small consumers, making up 5% of the total demand of the CAN. The largest of these supplied from the Kuiseb Aquifers are listed in Table 8 together with their relevant bulk infrastructure component. These can be broken down mainly into ministries, settlements, industry, private consumers and tourism. The demand of the small consumers will be discussed within the bulk infrastructure components.

Table 8: Main Small Consumers Supplied from the Kuiseb by NamWater

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Consumers</th>
<th>Remarks</th>
</tr>
</thead>
</table>
| Swartbank – Swakopmund/Walvis Bay | Topnaars  
C P de Wit  
Rooikop Airport  
JP Brand Primary School  
Farm Daizy  
Rooikop Defence Force | Rural Water Community  
Private Consumer  
Industry  
Ministry  
Private Consumer  
Ministry |
| Rooibank - Walvis Bay (ROB) | Industry (including NamPort)  
Various Private Consumers | Town                     |

The historical annual water demand figures of the small consumers as determined from the direct sales volumes are shown in Table 9 below.

Table 9: Annual Water Sales Volumes to Small Consumers

<table>
<thead>
<tr>
<th>Year</th>
<th>Annual Demand (m³)</th>
<th>Swartbank - Swakopmund</th>
<th>Rooibank - Walvis</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY98</td>
<td></td>
<td>464 912</td>
<td>111 889</td>
<td>576 801</td>
</tr>
<tr>
<td>FY99</td>
<td></td>
<td>493 160</td>
<td>124 505</td>
<td>617665</td>
</tr>
<tr>
<td>FY00</td>
<td></td>
<td>389 731</td>
<td>121 982</td>
<td>511 713</td>
</tr>
<tr>
<td>FY01</td>
<td></td>
<td>315 360</td>
<td>116 070</td>
<td>431 430</td>
</tr>
<tr>
<td>FY02</td>
<td></td>
<td>333 385</td>
<td>119 403</td>
<td>452 788</td>
</tr>
<tr>
<td>FY03</td>
<td></td>
<td>380 418</td>
<td>108 018</td>
<td>488 436</td>
</tr>
<tr>
<td>FY04</td>
<td></td>
<td>357 435</td>
<td>84 066</td>
<td>441 501</td>
</tr>
<tr>
<td>FY05</td>
<td></td>
<td>331 475</td>
<td>118 188</td>
<td>449 663</td>
</tr>
<tr>
<td>FY06</td>
<td></td>
<td>273 364</td>
<td>103 473</td>
<td>376 837</td>
</tr>
<tr>
<td>FY07</td>
<td></td>
<td>244 425</td>
<td>152 744</td>
<td>397 169</td>
</tr>
</tbody>
</table>

From the above figure it can be seen that the consumption declined between FY1998 and FY2007. It can be seen that over the past 10 years there was an overall decrease in the water demand of small consumers, the only increase in water demand being for the Rooibank – Walvis due to the port in Walvis Bay which is currently being upgraded and enlarged.
The water demand for Walvis Bay compares to that of Windhoek and is deemed realistic. A summary of Growth Rates and Peak Factors are given in Table 10 as well as the peak month factor in Table 11.

Table 10: Summary of Historic Water Demand Growth Rates

<table>
<thead>
<tr>
<th>Year</th>
<th>Walvis Bay (%</th>
<th>Small Consumers (%)</th>
<th>TOTAL (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY98 – FY07</td>
<td>0.1</td>
<td>-3.5</td>
<td>0.7</td>
</tr>
<tr>
<td>FY01 – FY07</td>
<td>1.2</td>
<td>1.8</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Table 11: Summary of Peak Month Factors

<table>
<thead>
<tr>
<th>Consumer Point</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walvis Bay</td>
<td>1.31</td>
</tr>
<tr>
<td>Rooikop</td>
<td>1.30</td>
</tr>
<tr>
<td>Total Kuiseb</td>
<td>1.26</td>
</tr>
</tbody>
</table>

The supply up to Mile 7 reservoir must be sufficient for the daily demands in peak month, at the average peak factor of 1.31 this demand is calculated to be 16 650 m³/day in FY2015 and 24100 m³/day in FY2030.

5.9 Future Water Demand for Walvis Bay

The projections for Walvis Bay are based on information according to officials from the Walvis Bay Municipality. The expected growth in the water demand of the town and fishing industry is estimated as 2.15% annually over the next 10 years. Included in this figure is the use of semi-purified water for domestic garden purposes, which is expected to increase by 30 000 m³ annually. According to the municipality there are currently no planned developments, which would have a major impact on the demand for potable water.

The Municipality of Walvis Bay has started to facilitate and promote the development of the informal trade and manufacturing industries. This includes providing training to start-up small and medium businesses (SMEs). The primary objective is to reduce the dependency of the local economy on the fishing sector, and to assist small traders to develop their businesses into fully fledged enterprises with the potential of exporting their products. The main manufacturing activities take place within the Export Processing Zone. The EPZ companies are involved in the manufacturing of plastic products, automotive parts, fishing accessories, bathroom fittings and diamond cutting and polishing.

Another emerging sector is tourism. To keep up with one of the fastest growing industries worldwide, Walvis Bay has upgraded its facilities and tourist attractions. The local accommodation and tour institutions now offer a high degree of quality services on par with international standards. This market contributes to the creation of more employment and the development of the city.

In the demand projections for the low demand scenario, only existing industrial consumers were taken into account. It is believed that the emerging uranium mines in the Central Namib will also have an effect on the growth of Walvis Bay, through SMEs and residential extensions. The expectation by the Municipality, excluding the effect of the mines are 2.15% growth, the expected scenario with the effect of the mines included yields an annual demand growth of 2.35% and for the high demand scenario a rate of 2.8% is used. The actual demand of FY 2007 is used as the basis for the projections. See Figure 13 for a graph of the three demand scenarios until FY2030.
6 EXISTING WATER SUPPLY INFRASTRUCTURE

6.1 Background

The limited water resources at the coast necessitated development of an integrated bulk water supply network. This is known as the Central Namib Water Supply System (CNWSS). Water is supplied to consumers along 100 km of coastline and as far as 65 km to east into the interior of the country. Present water supply is entirely from two alluvial aquifers near the coast, which receive recharge from ephemeral flow generated inland in the central highlands. The extent of the supply area leads to some vulnerability if supply from one of the two sources is restricted. Uncertainty also exists with respect to where demand within the area may develop in future.

Major components of the system, which has been in operation for thirty or more years, are coming to the end of their useful life and need replacement. Furthermore, the system efficiency can be significantly improved by remote monitoring and control and the efficient utilisation of the resources can be improved by the establishment of new abstraction points (boreholes).

Bulk water supply to the CNA is presently based on groundwater abstracted from the alluvium in the lower reaches of two ephemeral river systems. There are the Kuiseb River, some 20 km south of Walvis Bay and the Omaruru River, about 80 km north of Swakopmund as indicated in Figure 14.

Most of the bulk water supply infrastructure in the CNA was developed in the seventies and some of the pipelines are showing signs of having reached the end of their useful life. Most of the reservoirs are generally in good condition with capacities sufficient for many years to come. Exceptions are some problems with leaking reservoir joints (water stops) and some uncertainties about Quarry Reservoir, which is experiencing stability problems.

The CNAWSS is divided into four components as shown below, but only the Kuiseb Water Scheme will be discussed in detail:
The Omdel - Swakopmund Water Scheme;
The Kuiseb Water Scheme;
The Swakopmund - Rössing Water Scheme and
The Swakopmund - Langer Heinrich Water Scheme

6.2 The Kuiseb Water Scheme

The Kuiseb Water Scheme (KWS) consists of the Lower Kuiseb Aquifers and all bulk water infrastructure up to and including the Mile 7 reservoirs near Walvis Bay and the terminal reservoir at Swakopmund. A locality map of the scheme is given in Figure 15 below. For ease of description the scheme can be divided into 3 sub-components that feed Walvis Bay and/or Swakopmund, namely Swartbank – Swakopmund, Rooibank A – Mile 7 and High Dune – Mile 7. This is shown schematically in Figure 16.
Figure 15: Map of Kuiseb Water Scheme

Figure 16: Schematic Layout of Kuiseb Water Scheme
6.2.1 The Kuiseb Scheme Water Sources

The water sources as well as the different sub-components are detailed in the paragraphs that follow. The lower Kuiseb Aquifer currently comprises of the Swartbank, Rooibank A, Rooibank B and Dorop South aquifer compartments. These compartments have 57 production boreholes, scattered over a distance of approximately 30 km from the Kuiseb Delta at Dorop to Swartbank further south-east. Using a computer model, the sustainable yield of the Kuiseb Aquifer in 2001 was calculated as 7.0 Mm³/a by the Geohydrology sub-division of NamWater (NAMWATER 2001). A breakdown for each of the aquifer compartments is given in Table 12.

Table 12: Sustainable Yields of Lower Kuiseb Aquifer Compartments

<table>
<thead>
<tr>
<th>Compartment/ Aquifer</th>
<th>Sustainable Yield: Revised Estimates (Mm³/a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swartbank</td>
<td>4.9</td>
</tr>
<tr>
<td>Rooibank A</td>
<td></td>
</tr>
<tr>
<td>Rooibank B</td>
<td>2.25</td>
</tr>
<tr>
<td>Dorop South</td>
<td></td>
</tr>
<tr>
<td>Total: Existing Sources</td>
<td>7.15</td>
</tr>
<tr>
<td>Average: Existing Sources</td>
<td></td>
</tr>
<tr>
<td>Environmental Demand</td>
<td></td>
</tr>
<tr>
<td>Sustainable Yield</td>
<td></td>
</tr>
</tbody>
</table>

The 57 production boreholes in the lower Kuiseb aquifers are divided into five production areas namely Swartbank 1, Swartbank 2, Rooibank A, Rooibank B and Dorop South. A summary of the recommended abstraction rates as given by Geohydrology in each of these production areas appears in Table 13 below. The characteristics of each individual borehole are listed in Annexure A-1 and Annexure A-2 attached to this report.

Table 13: Recommended Abstraction Rates from Kuiseb Boreholes

<table>
<thead>
<tr>
<th>Production Area</th>
<th>Recommended Abstraction Rates (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hourly</td>
</tr>
<tr>
<td>Swartbank 1</td>
<td>457</td>
</tr>
<tr>
<td>Swartbank 2</td>
<td>140</td>
</tr>
<tr>
<td>Rooibank A</td>
<td>200</td>
</tr>
<tr>
<td>Rooibank B</td>
<td>273</td>
</tr>
<tr>
<td>Dorop South</td>
<td>168</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1 238</td>
</tr>
</tbody>
</table>
6.2.2 Swartbank – Swakopmund Component

It is pointed out that the combined recommended abstraction rate is higher than the present sustainable yield of the aquifer of 7.0 Mm\(^3\)/a. The higher installed capacity is however needed for supply during peak months. Some of the boreholes were replaced or rehabilitated during FY2006 due to deteriorating yields. A camera inspection of boreholes was done to determine the reason for the deterioration, which was found to be mainly due to scaling or corrosion of the borehole casing. This is based on the borehole capacities after rehabilitation/replacement. Some further work, which may include replacement due to unsuccessful rehabilitation, may be required on completion of the current contract.

A diagrammatic layout of the Swartbank – Swakopmund component is given in Figure 17. The different elements of this scheme component are detailed below.

![Diagram of Swartbank – Swakopmund Component](image)

**Figure 17:** Schematic Layout of the Swartbank – Swakopmund Component

The boreholes at Swartbank that supply water to Collector 2 Reservoir consists of 6 boreholes with a safe yield of 140 m\(^3\)/h. The borehole layout is given in Figure 18 below.
The capacities of pipeline sections SB 5 and SB 8 are in excess of 3 000 m³/h. The reservoir and pipelines are still in very good condition. According to NamWater, the hydraulic reservoir inlet control valve will be removed and the flow meter will be replaced by a 300 NB electronic flow meter during FY2008. The switchboards, flow meters and above-ground borehole pipework will be replaced during the same period. The reservoir will take 64 hours or 3.2 days to fill, if there is no outflow and the inflow is 140 m³/h (safe yield).

The Collector 1 to Collector 2 system consists of the connecting pipeline between Collector 2 and Collector 1 as well as the 17 boreholes, with a safe yield of 457 m³/h, feeding into Collector 1. See Figure 19 below, for a layout of this system.
The design capacity of the pipeline between the Collector 2 and Collector 1 reservoirs was calculated to be approximately 2 050 m³/h. This pipeline is in good condition. The valve upstream of the connection from the E-line boreholes is throttled to control the supply of water from Collector 2 Reservoir. During FY2008 this valve will be replaced with an actuated control valve to control the flow from Collector 2 Reservoir to Collector 1 Reservoir. The aboveground borehole pipework, flow meters and switchgear was replaced during FY2007 as well as the inlet flow meter at the Collector 1 Reservoir, which is a 250 NB electronic flow meter for water balancing purposes. Borehole E1, with a capacity of 110 m³/h, is in need of rehabilitation. A 45 m³/h standby borehole has been drilled near E1. Borehole E1 is scheduled for rehabilitation during FY2008. During the 2006 flood the power line running along pipeline section A-G was damaged due to poles that got washed away.

The Collector 1 Reservoir to Schwarzekuppe system consists of the connecting pipeline between Collector 1 Reservoir and Schwarzekuppe Reservoir. Included are the control valve at km 18 and the off-take to Rooibank 2 Reservoir. See Figure 20 below, for a layout of this system. The pipeline consists of a 900 NB lock joint class A section and a 800 NB lock joint class A section. The pipeline design capacity is calculated as 2 800 m³/h.

The valve installed at km 18 is controlled via telemetry. It opens when the level in the Schwarzekuppe Reservoir reaches the set low level and closes when the reservoir reaches the high level. Due to the condition of the lock joint pipeline, the inlet at the Schwarzekuppe Reservoir cannot be closed and therefore the valve at km18 is used. There is a 250 NB electronic flow meter installed at both the inlet and outlet of the Schwarzekuppe Reservoir. The accuracy of the meters is unknown. The 15 000 m³ Schwarzekuppe Reservoir has a full supply level of 159 m above mean sea level (amsl).

The capacity of the pipeline from the Collector 1 Reservoir to Rooibank 2 Reservoir is calculated as 220 m³/h. This reservoir is used to supply Rooibank with water. The pipeline pressure is sufficient to supply water to the houses at Rooibank.

From Schwarzekuppe Reservoir the water gravitates to Swakopmund via an AC and pre-stressed concrete pipeline with off-takes to Quarry Reservoir and Rooikop Reservoir. See Figure 21 for a layout of this section. The pipeline from Schwarzekuppe Reservoir to the off-take to Quarry Reservoir
is a 7,97 km long, 800 NB fibre cement class 18 pipeline. The pipeline from the off-take for Quarry Reservoir to the off-take for Rooikop Reservoir is 7,86 km long and consists of 800 NB fibre cement class 18, lock joint class A and lock joint class B pipes. The pipeline between the Rooikop Reservoir off-take and Swakopmund Reservoir is 38,84 km long and consists of 600 NB, 700 NB and 800 NB lock joint pipes.

The pipeline from the off-take on the Schwarzekuppe - Swakopmund pipeline to Quarry Reservoir is a 2,172 km long 400NB fibre cement pipeline with a calculated capacity of 970 m³/h. During FY2008 an electronic flow meter and actuated control valve will be installed at the inlet of the Quarry reservoir, to control the inflow from Schwarzekuppe Reservoir.

The pipeline from the off-take on the Schwarzekuppe - Swakopmund pipeline to the Rooikop Reservoir is a 150 NB fibre cement pipeline. The Rooikop Reservoir is a round concrete reservoir with a full supply level of 114 m amsl and a capacity of 1 000 m³. The calculated capacity of the pipeline to Rooikop is 57 m³/h.

![Schematic Layout of the Schwarzekuppe – Swakopmund System](image)

**Figure 21:** Schematic Layout of the Schwarzekuppe – Swakopmund System

Due to the condition of the pipeline downstream of the off-take to Rooikop Reservoir, valves together with orifice plates installed at kilometre 39,251, are used to throttle the flow rate to Swakopmund to below 300 m³/h. The 7,267 km part upstream of the valves is also suspect and the valve is kept slightly open (15 m³/h) to ensure that the upstream pressure is lowered.

The Swakopmund Reservoir is a 20 000 m³ square concrete reservoir (72 x 50 x 5.55) m with a full supply level of 61,9 m amsl.

### 6.2.3 Rooibank – Mile 7 Component

The Rooibank 1 Reservoir is a round concrete reservoir with a capacity of 2 000 m³ and a full supply level of 132,62 m amsl. Ten production boreholes with a safe yield of 200 m³/h supply water to the Rooibank 1 Reservoir. The boreholes only pump into Rooibank 2 Reservoir when Rooibank 1 Reservoir is out of operation. In this case, due to the higher inlet level, the supply capacity of the boreholes is reduced. The layout is given in **Figure 22** below.
From the Rooibank 1 Reservoir the water gravitates to Quarry Reservoir. The connecting pipeline consists of a 2,718 km long, 450 NB fibre cement section and a 10,509 km long, 375 NB fibre cement section. The pipeline capacity is estimated as 400 m³/h. A valve system to bypass Quarry Reservoir to Mile 7 exists, but is non-functional.

The Quarry Reservoir has a total capacity of 15,000 m³, but due to structural damage; it can only be used up to 60% of its total capacity. The full supply level of the reservoir is 89.7 m amsl. From Quarry Reservoir the water gravitates to the Mile 7 reservoirs. The 350 NB fibre cement pipeline is 5,537 km long. The pipeline capacity is approximately 680 m³/h.

There are two reservoirs at Mile 7 which are in use. The 10,000 m³ round concrete reservoir supplies Walvis Bay and Long Beach and the 4,500 m³ square concrete NamPort reservoir supplies water to the harbour. These reservoirs are currently supplied from the Quarry and High Dune reservoirs.

At the new 10,000 m³ reservoir, provision has been made for an additional future line from Swakopmund. Each reservoir has an inlet control valve, which closes and opens according to set water levels in the reservoir. Both reservoirs can be bypassed to supply directly into the Walvis Bay reticulation system, but then a pressure control valve is used, to prevent over-pressurising the reticulation system in Walvis Bay.

6.2.4 High Dune – Mile 7 Component

The High Dune – Mile 7 component of the Kuiseb Scheme includes the Rooibank B and Dorop South well fields, the High Dune Reservoir and the pipelines up to the Mile 7 reservoirs. See Figure23.
The Dorop South well field has 12 production boreholes with a capacity of 168 m³/h or 3360 m³/day which pump water to the High Dune Reservoir from where it gravitates to the Mile 7 reservoirs. Rooibank B Groups 1 and 2 have 6 production boreholes with a capacity of 150 m³/h or 3000 m³/day which also pump to High Dune Reservoir. Rooibank B Group 3 has 6 production boreholes with a capacity of 123 m³/h or 2460 m³/day which pump into the gravity pipeline connecting the High Dune and Mile 7 reservoirs.

The High Dune Reservoir is a 2000 m³ concrete reservoir of the same construction as that of Rooibank 1 Reservoir. The reservoir is not used for storage as its condition is suspect.

The pipeline between High Dune and Mile 7 is a 22.5 km long 350 NB fibre cement pipeline, with a static head of 5.2 m. The pipeline condition is suspect, therefore the inlet control valve at Mile 7 is not used and the boreholes are switched off according to the level of the Mile 7 reservoir. The operating capacity of the gravity pipeline is 322 m³/h.

### 6.3 Power Supply and Telemetry

The power line from the Ruby substation to Rooibank and from Mile 7 to High Dune, Dorop South and Area B is the property of NamWater. The power line from Ruby up to Rooibank includes the power supply to Schwarzkuppe Reservoir and the cathodic protection system on the Collector 1 – Schwarzkuppe pipeline. The bulk power supply infrastructure from Rooibank to Swartbank belongs to NamWater.

During 2005/06, 18.5 km of the power lines from Rooibank to Swartbank borehole DNA1, the nearest borehole to Rooibank, were replaced. The 30 km Swartbank power line also needs to be replaced. It is very old and frequently gives problems.

The underground power line between Mile 7 and High Dune reservoir also belongs to NamWater. This line has given trouble in the past. Due to shifting dunes in the area, the power line cannot be marked and fault finding on the 22.5 km long line is hence time consuming. Consequently this can leave the Dorop South and Rooibank B boreholes without power for an extended period of time.
The current telemetry control system of the Kuiseb Scheme is old and will be replaced under a capital maintenance project by 2008/09.

With the new system it will be possible to monitor and control all boreholes and control valves from Swakopmund base station. All reservoir levels and flow meter readings will also be available at Swakopmund. The telemetry signals will be sent to Swakopmund via the Schwarzekuppe and Rössing repeaters. Digital repeaters will be installed at the Swartbank and Rössing repeater sites.

6.4 Capacity of the Kuiseb Water Scheme

The capacities of the various components of the KWB water supply system are all summarized in Table 14 below.

Table 14: Summary of the Capacities of the Kuiseb Water Scheme

<table>
<thead>
<tr>
<th>Description</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aquifer Capacity: Kuiseb (Mm³/a)</strong></td>
<td>7.0</td>
</tr>
<tr>
<td><strong>Borehole Capacity: Kuiseb (Mm³/a)</strong></td>
<td>8.7</td>
</tr>
<tr>
<td><strong>Reservoir Capacities (m³)</strong></td>
<td></td>
</tr>
<tr>
<td>Collector 2 Reservoir</td>
<td>9 000</td>
</tr>
<tr>
<td>Collector 1 Reservoir</td>
<td>4 500</td>
</tr>
<tr>
<td>Schwarzekuppe Reservoir</td>
<td>15 000</td>
</tr>
<tr>
<td>Rooikop Reservoir</td>
<td>1 000</td>
</tr>
<tr>
<td>Rooibank 1 Reservoir</td>
<td>2 000</td>
</tr>
<tr>
<td>Rooibank 2 Reservoir</td>
<td>2 260</td>
</tr>
<tr>
<td>Quarry Reservoir (60% capacity)</td>
<td>9 000</td>
</tr>
<tr>
<td>High Dune Reservoir (not in use)</td>
<td>(2 000)</td>
</tr>
<tr>
<td>Mile 7 Reservoirs</td>
<td>14 500</td>
</tr>
<tr>
<td><strong>TOTAL Reservoirs</strong></td>
<td>57 260</td>
</tr>
<tr>
<td><strong>Pipeline Capacities (m³/h)</strong></td>
<td></td>
</tr>
<tr>
<td>Collector 2 - Collector 1</td>
<td>2 050</td>
</tr>
<tr>
<td>Collector 1 - Schwarzekuppe</td>
<td>2 800</td>
</tr>
<tr>
<td>•     Schwarzekuppe - Quarry</td>
<td>975</td>
</tr>
<tr>
<td>•     Rooibank - Quarry</td>
<td>400</td>
</tr>
<tr>
<td><strong>TOTAL to Quarry</strong></td>
<td>1 375</td>
</tr>
<tr>
<td>•     Quarry - Mile 7</td>
<td>680</td>
</tr>
<tr>
<td>•     High Dune - Mile 7</td>
<td>322</td>
</tr>
<tr>
<td><strong>TOTAL to Mile 7</strong></td>
<td>1 002</td>
</tr>
<tr>
<td>Schwarzekuppe - Rooikop</td>
<td>57</td>
</tr>
<tr>
<td>Schwarzekuppe - Swakopmund</td>
<td>300</td>
</tr>
</tbody>
</table>
7.1 General Assessment

Namwater is compiling a master plan to prepare a five year capital expenditure programme for the financial years 2011-2015. Therefore to determine the sufficiency of the various bulk water supply infrastructure components in the CNA, the scheme component capacities necessary to deliver the estimated demand in FY 2015 (2014/15) were compared to their present (2006/07) capacities. This means that any scheme component found to be incapable of delivering the estimated FY 2015 demands will show up a shortfall and will require an upgrade or extension. The sizing of such extension would consider a planning horizon of 15 years starting from FY 2015. The planning horizon thus ends in FY 2030 (2029/30). Based on the above principle the sufficiency of the various scheme components of the KWS was established. For the aquifers the sufficiency calculations were based on being able to supply the projected annual demand in 2014/15. Clear water reservoirs are required to meet a guideline of 48 hours storage of average monthly demand while all other components such as boreholes, pumps, pipelines and chlorination equipment must be able to meet the average daily demand in the peak month assuming a 20-hour day.

7.2 Sufficiency of the Kuiseb Water Scheme

Based on the above assumptions the sufficiency of each scheme component was determined. This information is a summary of the existing bulk water supply system as described above and the water demand projections as described in paragraph in order to get an overall picture of demand shortages. A summary of the results for the KWS is listed in Table 15.

<table>
<thead>
<tr>
<th>Description</th>
<th>Existing</th>
<th>Required by 2014/15</th>
<th>Surplus in 2014/15</th>
<th>Year of Supply Shortfall</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aquifer Capacity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Kuiseb (Domestic Demand)</td>
<td>7 Mm³/a</td>
<td>6 Mm³/a</td>
<td>1.0 Mm³/a</td>
<td>2019/20</td>
</tr>
<tr>
<td><strong>Borehole Capacity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kuiseb Boreholes (Domestic Demand)</td>
<td>1 238 m³/h</td>
<td>1 076 m³/h</td>
<td>162 m³/h</td>
<td>2016/17</td>
</tr>
<tr>
<td><strong>Reservoir Capacity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL Kuiseb</td>
<td>57 260 m³</td>
<td>32 928 m³</td>
<td>24 332 m³</td>
<td>&gt;2029/30</td>
</tr>
<tr>
<td><strong>Pipeline Capacity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collector 2 - Collector 1</td>
<td>2050 m³/h</td>
<td>1 076 m³/h</td>
<td>974 m³/h</td>
<td>&gt;2029/30</td>
</tr>
<tr>
<td>Collector 1 - Schwarzekuppe</td>
<td>2800 m³/h</td>
<td>1 076 m³/h</td>
<td>1 724 m³/h</td>
<td>&gt;2029/30</td>
</tr>
<tr>
<td>Schwarzekuppe - Quarry</td>
<td>975 m³</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roobilank - Quarry</td>
<td>400 m³</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL to Quarry</td>
<td>1375 m³</td>
<td>720 m³</td>
<td>655 m³</td>
<td>&gt;2029/30</td>
</tr>
<tr>
<td><strong>Quarry - Mile 7</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>High Dune - Mile 7</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quarry - Mile 7</td>
<td>680 m³</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL to Mile 7</td>
<td>1002 m³</td>
<td>940 m³</td>
<td>62 m³</td>
<td>2009/10</td>
</tr>
<tr>
<td>Schwarzekuppe - Rooikop</td>
<td>57 m³</td>
<td>43 m³</td>
<td>14 m³</td>
<td>&gt;2029/30</td>
</tr>
<tr>
<td>Swartbank - Swakopmund Terminal Res.</td>
<td>300 m³</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The borehole pump capacity was taken as 10% less than the borehole capacity to make provision for standby. Each of the components determined above which are insufficient to meet the 2014/15 demand will be discussed in more detail. The capacity shortfall is calculated for 2029/30 using a 15 year planning period. In calculating the sufficiency of this scheme it was assumed that the water demand of existing and future uranium mines will be supplied from the Omdel Scheme and/or a completely new source such as a desalination plant. The sufficiency of the various components of the Kuiseb Scheme is indicated in Table 16 below.

**Table 16: Sufficiency of Kuiseb Scheme**

<table>
<thead>
<tr>
<th>Scheme Component</th>
<th>Capacity 2014/15 m³/h</th>
<th>Required Capacity 2029/30 m³/h</th>
<th>Surplus 2029/30 m³/h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Boreholes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boreholes Swartbank 1</td>
<td>457</td>
<td>1 076</td>
<td>1527</td>
</tr>
<tr>
<td>Boreholes Swartbank 2</td>
<td>140</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boreholes Rooibank A</td>
<td>200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boreholes Rooibank B</td>
<td>273</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boreholes Dorop</td>
<td>168</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Boreholes Total</strong></td>
<td><strong>1 238</strong></td>
<td><strong>1 076</strong></td>
<td><strong>1 527</strong></td>
</tr>
<tr>
<td><strong>Borehole Pumps</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Borehole Pumps Swartbank 1</td>
<td>411</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Borehole Pumps Swartbank 2</td>
<td>126</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Borehole Pumps Rooibank A</td>
<td>180</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Borehole Pumps Rooibank B</td>
<td>246</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Borehole Pumps Dorop</td>
<td>151</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Borehole Pumps Total</strong></td>
<td><strong>1 114</strong></td>
<td><strong>1 076</strong></td>
<td><strong>1 527</strong></td>
</tr>
<tr>
<td><strong>Pipelines</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipeline Collector 2 to Collector 1</td>
<td>2 050</td>
<td>1 076</td>
<td>1 527</td>
</tr>
<tr>
<td>Pipeline Collector 1 to Schwarzekuppe Res.</td>
<td>2 800</td>
<td>1 076</td>
<td>1 527</td>
</tr>
<tr>
<td>Pipeline Offtake Col1-SK to Rooibank 2 Res.</td>
<td>220</td>
<td>33</td>
<td>49</td>
</tr>
<tr>
<td>Pipeline Schwarzekuppe-Rooikop Off-take</td>
<td>970</td>
<td>720</td>
<td>1 156</td>
</tr>
<tr>
<td>Pipeline Rooikop Off-take to Swakopmund</td>
<td>300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipeline Offtake SK-SW to Quarry</td>
<td>970</td>
<td>940</td>
<td>1 399</td>
</tr>
<tr>
<td>Pipeline to Rooikop</td>
<td>57</td>
<td>43</td>
<td>59</td>
</tr>
<tr>
<td>Pipeline Rooibank 1 to Quarry Res.</td>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipeline Quarry to Mile 7 Res.</td>
<td>680</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipeline High Dune to Mile 7 Res.</td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total to Mile 7 Res.</strong></td>
<td><strong>1 002</strong></td>
<td><strong>940</strong></td>
<td><strong>1 339</strong></td>
</tr>
<tr>
<td><strong>Clearwater Reservoirs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collector 1 Reservoir</td>
<td>4 500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collector 2 Reservoir</td>
<td>9 000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rooibank 1 Reservoir</td>
<td>2 000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rooibank 2 Reservoir</td>
<td>2 260</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schwarzekuppe Reservoir</td>
<td>15 000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quarry Reservoir</td>
<td>9 000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Dune Reservoir</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mile 7 Reservoir (for Walvis Bay)</td>
<td>10 000</td>
<td>29 421</td>
<td>41 684</td>
</tr>
<tr>
<td>Mile 7 Reservoir (for harbour)</td>
<td>4 500</td>
<td>723</td>
<td>1 025</td>
</tr>
<tr>
<td>Rooikop Reservoir</td>
<td>1 000</td>
<td>1 095</td>
<td>1 586</td>
</tr>
<tr>
<td><strong>Clearwater Reservoirs Total</strong></td>
<td><strong>57 260</strong></td>
<td><strong>32 928</strong></td>
<td><strong>46 742</strong></td>
</tr>
</tbody>
</table>

**Figure 22** below illustrates the sufficiency of the boreholes, pumps and pipelines according to the requirements for 2014/15.
From Figure 22 it can be seen that the flow rate available at Mile 7 reservoir is less than the total Kuiseb borehole pump capacity. This is due to the limiting effect of the High Dune – Mile 7 pipeline which cannot convey all water produced at Rooibank B and Dorop South. Because of this, the capacity of the Kuiseb scheme will become insufficient in 2015/16.

The components from Table 16 with shortfalls by 2014/15 are discussed in more detail in the paragraphs that follow.

Mile 7 reservoir has insufficient storage capacity on its own to supply water for two days (48 hours) to Walvis Bay, so is the combined capacity of Mile 7 and Quarry reservoir for the security of supply to Walvis Bay. The 2014/15 shortfall for the two reservoirs is 10 400 m$^3$. If Schwarzekuppe Reservoir is added, there is sufficient storage for Walvis Bay. Both Quarry and Schwarzekuppe reservoirs are however further away from Walvis Bay and are of little use if pipe breaks are experienced between them and Mile 7.

The Rooikop reservoir will have a shortfall of approximately 95 m$^3$ by 2014/15. This is less than 0.1% of the capacity and is not seen as a serious constraint. As shown in Table 16 the borehole pumps are sufficient to supply the 2014/15 domestic demand including standby capacity, but not the total demand (mines included) of 2014/15.

All those KWS components which have been identified in previous paragraphs as being inadequate to meet the estimated 2014/15 water demand are summarised in Table 17 below.
### Table 17: Scheme Components Insufficient by 2014/15

<table>
<thead>
<tr>
<th>Scheme Component</th>
<th>Capacity</th>
<th>Present</th>
<th>Required in 2014/15</th>
<th>Required in 2029/30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear Water Storage</td>
<td>m(^3)</td>
<td></td>
<td>10 000</td>
<td>29 421</td>
</tr>
<tr>
<td>Mile 7 Reservoir</td>
<td></td>
<td></td>
<td>1 000</td>
<td>41 684</td>
</tr>
<tr>
<td>Rooikop Reservoir</td>
<td></td>
<td></td>
<td>1 095</td>
<td>1 586</td>
</tr>
</tbody>
</table>

#### 7.3 Recent Developments

The following recent developments have taken place on the KKS:

During major floods in the Kuiseb, power lines and pipelines in the river are prone to damage resulting in serious water supply disruptions in Walvis Bay. The flood intensity and path are very unpredictable and vary greatly from year to year. As a result the extent of the damage can also vary, making it difficult to protect the infrastructure. The risk of flood damage to bulk water supply and associated infrastructure in the Kuiseb causes great concern and the Municipality of Walvis Bay has requested that the problem be addressed urgently.

Several options to ensure continued, albeit reduced, supply during flood events have been investigated. Of these, supply from Swakopmund to Mile 7 using a portion of the existing Schwarzekuppe - Swakopmund pipeline in reverse is considered the most feasible solution and will be implemented in the following two phases:

- **Phase 1** - Replacement of a 1,9 km long, 500 mm diameter pipe section of the Schwarzekuppe – Swakopmund pipeline downstream of the Rooikop off-take planned for FY2008 and FY2009.
- **Phase 2** – Laying of a new 6,4 km long, 400 mm diameter pipeline from the Schwarzekuppe - Swakopmund pipeline to Mile 7 Reservoir (emergency link). This link will only be established once adequate funding is procured.

During FY2006 eleven boreholes were rehabilitated and fourteen boreholes replaced, due to deteriorating yields and pump water levels. Power lines were replaced over a distance of 8,5 km, including a new ring feed power line. Power failures occur up to five times a month. Most borehole pumps must be started by hand and this causes a loss of production as it takes the operator at least two hours to go through all the boreholes once the power has been restored.

The automation and control of the Swartbank – Swakopmund system will be completed during FY2008. The automation and control of the Rooibank – Mile 7 system is planned to be completed during FY2009. Due to the distances and difficult terrain of the Kuiseb area and the age of the infrastructure, the system should be automated. After completion of this project, it will be possible to monitor the operating condition of the various components of the scheme from the Swakopmund Base Station. This project will include the replacement of borehole pipework to the specified standard, replacement of switchboards and the installation of telemetry systems for all boreholes and reservoirs. The pipeline link for the supply of water from Swakopmund to Mile 7 reservoir with the new pipeline from the Schwarzekuppe pipeline directly to Mile 7 reservoir will solve the need for pipeline capacity increase to Walvis Bay.

The Dorop South and Rooibank B area supplies 27% of the total supply from the Kuiseb. The underground power line to High Dune has given trouble in the past. Due to the area the power line cannot be marked and fault finding on the 22,5 km power line between Mile 7 and High Dune Reservoir is very difficult. Any errors can leave the Dorop South and Rooibank B boreholes without power for an extended period. Possible solutions must be investigated in depth.
The Swartbank boreholes supplies approximately 48% of water from the Kuiseb. The 15 km power line supplying power to the Swartbank boreholes is old and in a bad condition. It needs to be replaced. The replaced section of the Rooibank system was successful.

The additional capacity that the boreholes can yield over the pipeline capacity to Dorop South is approximately 140 m³/h. The borehole capacity of Dorop South is 3.2 Mm³/a and the aquifer capacity is 2.5 Mm³/a. The pipeline capacity is 2.35 Mm³/a. The cost of a 200 NB DCI pipeline will be approximately N$15,284 million which would only be financially viable should 0.43 Mm³/a be used, which is only half the source capacity available, but nearly 3 times the available aquifer capacity. Therefore this option is not viable.

Currently the difference between the water production and sales figures is approximately 7.5 % for Kuiseb and Omdel combined. The main cause of the water losses cannot currently be established as this could be due to faulty water meters and or hour meters or due to pipe leaks. To establish the reason for the difference, the flow meter readings must be sufficient and trustworthy. If the flow meters are spaced too far apart and differs, it is difficult to find the source of water losses or flow differences. The currently installed flow meters are suspect. Two of the four flow meters (installed during 1994) that were checked during a site visit, proved to be inaccurate. It is therefore assumed that at least 50 % of the six electronic flow meters installed during that period are inaccurate. These inaccuracies must be investigated and corrected.

### 7.4 New Developments

In order to manage future flood damage to the water supply infrastructure in the Kuiseb River, it is proposed to construct the link to Swakopmund to supply water from Swakopmund. The capital cost for the Swakopmund – Mile 7 link has been estimated by NamWater and the cost is indicated in Table 18.

#### Table 18: Cost of the Swakopmund – Mile 7 Link

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost and cash flow (N$ million)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FY2008</td>
</tr>
<tr>
<td><strong>Phase 1: Replacement of Schwarzekuppe – Swakopmund pipeline sections</strong></td>
<td></td>
</tr>
<tr>
<td>Project Management</td>
<td>30 000</td>
</tr>
<tr>
<td>EMP Monitoring</td>
<td>10 000</td>
</tr>
<tr>
<td>Design of pipeline</td>
<td>20 000</td>
</tr>
<tr>
<td>Preliminary and General</td>
<td>300 000</td>
</tr>
<tr>
<td>Replacement of pipeline</td>
<td>5 348 000</td>
</tr>
<tr>
<td>Minor civil works</td>
<td>70 000</td>
</tr>
<tr>
<td>Contingencies (5%)</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>5 778 000</td>
</tr>
<tr>
<td><strong>Phase 2: Pipeline link to Walvis Bay and bypass at Swakopmund Base</strong></td>
<td></td>
</tr>
<tr>
<td>Mechanical and Electrical</td>
<td>254 000</td>
</tr>
<tr>
<td>Civil</td>
<td>5 590 000</td>
</tr>
<tr>
<td>Preliminary and General</td>
<td>230 000</td>
</tr>
<tr>
<td>Contingencies (5%)</td>
<td>306 000</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>6 380 000</td>
</tr>
</tbody>
</table>
The automation and control of the Swartbank – Swakopmund borehole system will include the replacement of borehole pipework, switchgear, control valves and upgrading the telemetry system, to include all the boreholes. The cost is indicated in Table 19 below:

### Table 19  Cost of the Swartbank – Swakopmund Automation

<table>
<thead>
<tr>
<th>Swartbank – Swakopmund Automation</th>
<th>Total (N$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector 2 and associated boreholes</td>
<td>635 500</td>
</tr>
<tr>
<td>Collector 2 and associated boreholes</td>
<td>1 700 500</td>
</tr>
<tr>
<td>Km18 Control Valve and Schwartzekuppe Reservoir</td>
<td>28 000</td>
</tr>
<tr>
<td>Quarry Reservoir</td>
<td>316 000</td>
</tr>
<tr>
<td>Telemetry System</td>
<td>243 000</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>2 923 000</strong></td>
</tr>
</tbody>
</table>

The automation and control of the Rooibank – Mile 7 borehole system will include the replacement of borehole pipework, switchgear, control valves and upgrading the telemetry system, to include all the boreholes. The cost is indicated in Table 20 below.

### Table 20  Rooibank – Mile 7 Automation

<table>
<thead>
<tr>
<th>Rooibank – Mile 7 Automation</th>
<th>Cost (N$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rooibank A – Mile 7</td>
<td>1 000 500</td>
</tr>
<tr>
<td>High Dune – Mile 7</td>
<td>742 500</td>
</tr>
<tr>
<td>Rooibank B</td>
<td>683 000</td>
</tr>
<tr>
<td>High Dune Reservoir</td>
<td>78 000</td>
</tr>
<tr>
<td><strong>Sub Total</strong></td>
<td><strong>2 504 000</strong></td>
</tr>
<tr>
<td>Escalation (10%)</td>
<td>250 400</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>2 754 400</strong></td>
</tr>
</tbody>
</table>

A summary of the cost for projects up to FY2010 can be viewed in Table 21 below.

Due to the uncertainty of the capacity of J-Line, exploration is needed for future planning purposes. Exploration is therefore scheduled for FY2008. The production boreholes should be drilled by end FY2009. The pipelines, power lines and borehole installation must be completed by the middle of FY2010, to be available by November 2010. This is indicated in the costs. The costs make provision for the 2 Mm$^3$/a option. See Table 22.
Water planning and utilisation

### Flood Management
- Replacement of pipeline sections: N$5,778,000
- 6.4 km emergency link to Mile 7 reservoir: N$2,134,000

### Developments Planned for Kuiseb
- Automation and control of the Swartbank - Swakopmund and Rooibank – Mile 7 systems: N$5,677,000

<table>
<thead>
<tr>
<th>Description</th>
<th>FY2008</th>
<th>FY2009</th>
<th>FY2010</th>
<th>FY2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flood Management</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Replacement of pipeline sections</td>
<td>5,778,000</td>
<td>2,134,000</td>
<td>6,380,000</td>
<td>1,320,000</td>
</tr>
<tr>
<td>6.4 km emergency link to Mile 7 reservoir</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Developments Planned for Kuiseb</td>
<td>5,677,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>11,455,000</td>
<td>2,134,000</td>
<td>6,380,000</td>
<td>6,320,000</td>
</tr>
</tbody>
</table>

**Table 22: Estimated Cost to Develop the J-Line**

<table>
<thead>
<tr>
<th>Scheme Component</th>
<th>Amount (N$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boreholes</td>
<td>6,405,000</td>
</tr>
<tr>
<td>M&amp;E work, borehole installations, booster pump stations</td>
<td>4,990,000</td>
</tr>
<tr>
<td>Pipeline, 18.5 km, 250 mm DCI</td>
<td>10,015,000</td>
</tr>
<tr>
<td>Civil work, road crossings, manholes</td>
<td>0</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>21,410,000</td>
</tr>
<tr>
<td>Preliminary and General</td>
<td>3,028,000</td>
</tr>
<tr>
<td>Project Management</td>
<td>1,009,000</td>
</tr>
<tr>
<td>Contingencies</td>
<td>302,800</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>28,475,000</td>
</tr>
</tbody>
</table>

The Dorop South power supply problem must be investigated and a solution found. A new power line may not be the most cost effective option; however this option has been included in the costs. See Table 23.

**Table 23: Estimated Cost for the Dorop South Power Line**

<table>
<thead>
<tr>
<th>Dorop South Power Line</th>
<th>Total (N$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scheme Investigation - M&amp;E</td>
<td>100,000</td>
</tr>
<tr>
<td>22.5 km Bulk Power Lines, 11 kV</td>
<td>1,125,000</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>1,225,000</td>
</tr>
<tr>
<td>Total scheme Preliminary and General</td>
<td>183,750</td>
</tr>
<tr>
<td>Project management and supervision</td>
<td>61,250</td>
</tr>
<tr>
<td>Contingencies</td>
<td>183,750</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>1,653,750</td>
</tr>
</tbody>
</table>
The approximately 15 km power line supplying power to the Swartbank boreholes is old and in a bad condition, it needs to be replaced. The replaced section of the Rooibank system was successful. The Swartbank boreholes supplies approximately 48% of water from the Kuiseb.

Power failures occur up to five times a month. Most boreholes must be started by hand, thus this causes loss of production as it takes the operator at least two hours to go through all the boreholes once the power has been restored. The automation of the Swartbank – Swakopmund scheme will be completed by the end of FY2007. See Table 24. This would reduce the effect of power failures slightly.

**Table 24: Estimated Cost for the Kuiseb Power Line Replacement**

<table>
<thead>
<tr>
<th>Description</th>
<th>Total (N$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminary scheme design - M&amp;E</td>
<td>100 000</td>
</tr>
<tr>
<td>Bulk Power Lines, 11 kV</td>
<td>900 000</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td><strong>1 000 000</strong></td>
</tr>
<tr>
<td>Total scheme Preliminary and General</td>
<td>150 000</td>
</tr>
<tr>
<td>Project management and supervision</td>
<td>50 000</td>
</tr>
<tr>
<td>Contingencies</td>
<td>150 000</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1 350 000</strong></td>
</tr>
</tbody>
</table>

The pipeline to Dorop South causes concern. During windstorms the fibre cement pipeline is blown open by the wind, and the sand removed from under the pipe, which can cause the pipe to break. Therefore an additional DCI pipeline was investigated.

During flood situations, the combined capacity of the Dorop South and Rooibank B boreholes is higher than the pipeline capacity. The Rooibank B boreholes are not affected by floods as these are in the dune area with no pipelines crossing the river. In case of a flood where none of the Dorop South boreholes is affected, an additional pipeline could be used to supply the additional 140 m³/h to Mile 7.

The source capacity of Dorop South is 3.2 Mm³/a and the aquifer capacity is 2.5 Mm³/a. The pipeline capacity is 2.35 Mm³/a. The cost of a 200 NB DCI pipeline will be approximately N$15,284 million. This option is not financially viable and the financial analyses summary can be seen in Table 25 below.

**Table 25: Financial Analysis of the Dorop South Pipeline Capacity Increase**

<table>
<thead>
<tr>
<th>Net Present Value</th>
<th>Profitability Index</th>
<th>1</th>
<th>1.46</th>
</tr>
</thead>
<tbody>
<tr>
<td>N$ -9.625 million</td>
<td>0.46</td>
<td>1</td>
<td>1.46</td>
</tr>
<tr>
<td>Net Present Value</td>
<td>Profitability Index</td>
<td>N$ 0</td>
<td>N$ 14.949 million</td>
</tr>
<tr>
<td>N$ -9.625 million</td>
<td>0.46</td>
<td>1</td>
<td>1.46</td>
</tr>
<tr>
<td>Internal Rate of Return (excl. inflation)</td>
<td>3.05%</td>
<td>12%</td>
<td>26.13%</td>
</tr>
<tr>
<td>Internal Rate of Return (incl. inflation)</td>
<td>-4.59%</td>
<td>3.7%</td>
<td>16.79%</td>
</tr>
<tr>
<td>Water Tariff</td>
<td>N$ 4.86 /m³</td>
<td>N$ 4.86 /m³</td>
<td>N$ 4.86 /m³</td>
</tr>
<tr>
<td>Discounted Breakeven Period</td>
<td>&gt;17 years</td>
<td>17 years</td>
<td>7 years</td>
</tr>
</tbody>
</table>
No economical study or flood management evaluation was done to estimate the value of this pipeline in case of a flood. N$100 000 was allowed for this study.

Currently the difference between the water production and sales figures is approximately 7.5 % for Kuiseb and Omdel combined. The main cause of water losses cannot currently be established as this could be due to faulty water meters and or hour meters or due to pipe leaks. To establish the reason for the difference, the flow meter readings must be sufficient and trustworthy. If the flow meters are spaced too far apart and differs, it is difficult to find the source of water losses or flow differences. The currently installed flow meters are suspect. Of the 2 of the 4 flow meters (installed during 1994) that were checked during a site visit for the master plan proved to be inaccurate. It is therefore assumed that at least 50% of the six electronic flow meters installed during that period are inaccurate. These inaccuracies must be investigated and corrected. Provision has been made in the cost for the replacement of 6 flow meters at a cost of N$35 000 each including labour.

Provision must be made for the replacement of the lock joint pipe sections because it was found that all of the lock joint pipes installed at the coast have a potential risk to fail. The currently installed pipes, are summarised in Table 26 below.

Table 26: Lock Joint Pipes installed for the CAN

<table>
<thead>
<tr>
<th>Description</th>
<th>Size</th>
<th>Length (Km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schwarzekuppe - Swakopmund</td>
<td>800 NB</td>
<td>45,412</td>
</tr>
<tr>
<td>Collector 1 - Schwarzekuppe</td>
<td>800 NB</td>
<td>5,7</td>
</tr>
</tbody>
</table>

If these pipes are replaced at 5 km per year it would take approximately 24 years to replace all the lock joint pipelines. The diameter must be optimised for the replacement of the Schwarzekuppe – Swakopmund and Collector 1 – Schwarzekuppe pipelines. The proposed pipeline section to be replaced each year is approximately 5 km long. The cost included is based on a replacement of 5 km of pipeline with 700 NB DCI pipes at approximately N$3.04 million per kilometre. A summary of the future capital replacement projects are given in Table 26 below.

Table 26 Summary of the Capital Replacement Projects Plan

<table>
<thead>
<tr>
<th>New Projects</th>
<th>Cost in N$ x Thousands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Supply to Swartbank</td>
<td>100 1 250</td>
</tr>
<tr>
<td>Pipeline to Dorop South</td>
<td>100</td>
</tr>
<tr>
<td>Water Balancing Flowmeters</td>
<td>210</td>
</tr>
<tr>
<td>Replace lock joint sections 5km/a</td>
<td>15 200 15 200 15 200 15 200</td>
</tr>
<tr>
<td>TOTAL</td>
<td>410 1 250 15 200 15 200 15 200 15 200</td>
</tr>
</tbody>
</table>

The summary of the total financial plan of Namwater for the KWS, including FY2008 till FY2015 is given in Table 27 below.
### Table 27: Summary of Financial Plan

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost in N$ x 1000 per Financial Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Projects</td>
<td></td>
</tr>
<tr>
<td>Flood Management</td>
<td>5 778</td>
</tr>
<tr>
<td>Developments Planned for Kuiseb</td>
<td>5 677</td>
</tr>
<tr>
<td>Sub-Total Current Projects</td>
<td>11 455</td>
</tr>
<tr>
<td>Development Projects</td>
<td></td>
</tr>
<tr>
<td>J-Line</td>
<td>1 650</td>
</tr>
<tr>
<td>Sub-Total Development Projects</td>
<td>1 650</td>
</tr>
<tr>
<td>Capital replacement Projects</td>
<td></td>
</tr>
<tr>
<td>Power Supply to Swartbank</td>
<td>100</td>
</tr>
<tr>
<td>Power Supply to Dorop South</td>
<td>100</td>
</tr>
<tr>
<td>Water Balancing Flowmeters</td>
<td>210</td>
</tr>
<tr>
<td>Replacement of lock joint sections 5km/a</td>
<td></td>
</tr>
<tr>
<td>Sub-Total Capital replacement Projects</td>
<td>410</td>
</tr>
<tr>
<td>TOTAL</td>
<td>13 605</td>
</tr>
</tbody>
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### 8 CONCLUSIONS

The following can be concluded:

- The combined aquifer capacity for the Kuiseb Aquifers is 7,0 Mm³/a.
- The development of the J-Line is more financially viable than desalination, but the capacity will not be sufficient. Therefore a desalination plant will also be needed for Walvis Bay. Other options were either not financially viable or unreliable and were therefore not recommended.
- N$28,907 million will be needed for the future development of the J-Line in the lower Kuiseb. This projects will need to be implemented by FY2012.
- The total water sales for the central Namib Area was 11.6 Mm³ for FY2005, the production figure was 12.6 Mm³ for FY2005, thus a 9.2% losses, which is very high. Water demand management to reduce losses should generally be improved by all water supply entities at the coast
- In the future demand estimation the growth rate for the Uranium Mines was taken as 0% and the average growth rate for the rest as 2.4%, then the expected water production required by FY2015 will be 15.3 Mm³/a. Should the aquifer yield be reduced, the supply capacity from other water resources, such as desalination, will have to be increased. It is foreseen that all uranium mines will be supplied with desalinated water from FY2010
• N$64 Million will be needed up to the end of FY2015 for future Maintenance Projects, which include the replacement of lock-joint pipe sections upgrading the power supply of the Kuiseb and the replacement of electronic flow meters.

9 RECOMMENDATIONS

9.1 The need for continuing with the following projects must be noted:

• Flood management
• Rooibank – Mile 7 Automation
• Water demand management

9.2 It is recommended that consideration be given to further planning work for the following projects:

• Investigation and development of the J-Line
• Power supply to Dorop South
• Power supply to Swartbank
• Water balancing flow meters
• Lock Joint pipeline replacement
• The Swakopmund - Schwarzekuppe link

WINDHOEK,
SEPTEMBER 2008
REFERENCES

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ACKNOWLEDGEMENTS

I would like to express my appreciation to all staff members at NamWater, the Municipality of Walvis Bay and the Department of Water Affairs and Forestry that assisted me to obtain the necessary information required for this project
ABBREVIATIONS

a  = annum
AC  = Asbestos Cement
CAN = Central Namib Area
CNWSS = Central Namib Water Supply System
DCI  = Ductile Cast Iron
DWA  = Department of Water Affairs
ENWC = Eastern National Water Carrier
EPZ  = Economic Processing Zone
h   = hour
k   = kilometre
km² = square kilometres
kV  = kilovolt
ℓ   = litre
LJ  = Lock Joint
M   = million
m   = metre
amsl = above mean sea level
MAWF = Ministry of Agriculture Water and Forestry
MAWRD = Ministry of Agriculture, Water and Rural development
M&E  = mechanical and electrical
mg  = milligramme
mg/ℓ = milligramme/litre
mm  = millimetres
mm/a = millimetres per annum
Mm³ = million cubic metres
Mm³/a = million cubic metres per annum
NamWater = The Namibia Water Corporation Ltd
NB  = nominal bore (inside diameter)
N$  = Namibian Dollar
FY  = Financial Year
SME = Small and Medium Enterprise
V   = volt
## ANNEXURES

### Annexe A-1: Swartbank and Rooibank A borehole information

#### Swartbank

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**TOTAL ANNUAL:** 1.46

### Total Production Rate for Swartbank - Rooibank A Aquifer

- **Production (m³/h):** 752
- **Production (m³/mnth):** 451200
- **Production (Mm³/a):** 5.49

*This is the best information available on 21/9/2006 from Borehole Installation Reports, Asset Inventories etc.*
Annexe A-2: Rooibank B and Dorop South Borehole Information

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*This is the best information available on 21/9/2006 from Borehole Installation Reports, Asset Inventories etc.
REPUBLIC OF NAMIBIA
MINISTRY OF AGRICULTURE, WATER AND FORESTRY
DEPARTMENT OF WATER AFFAIRS AND FORESTRY

Kuiseb Basin Water Resources Management Project

- Development of a Water Resources Plan for the Kuiseb Basin and Development of a Planning Procedure for use by Other Basins -

Part

GEOHYDROLOGY

GEOHYDROLOGY DIVISION
DEPARTMENT OF WATER AFFAIRS
PRIVATE BAG 13193
WINDHOEK

COMPiled BY:
Dr. Martin Falke
CIM-Consultant

July 2008
# Table of Contents

1  **BASELINE INFORMATION AND GAPS ANALYSIS CONCERNING GEOLOGY AND GEOHYDROLOGY OF THE BASIN**  
1.1 Inventory of relevant geological and geo-hydrological records and reports  
1.2 Overviews of Main Hydrological & Geological Features  
   1.2.1 Hydrology  
   1.2.2 Geology  
   1.2.3 Main Aquifer Types  
1.3 Groundwater-Dependant Ecosystems (see also B 7 & B 8)  
1.4 Gaps and shortcomings in information, knowledge and measures  

2  **WATER RESOURCES**  
2.1 Inventory of relevant records and reports of presently used groundwater sources and unutilised groundwater resources  
2.2 Concise description of these features/resources, including undeveloped water resource potential  
2.3 Recharge dynamics and rates, discharge, abstractions and the possible over-exploitation of groundwater  
2.4 Future water requirements for mining activities in the Kuiseb Basin  
2.5 Concise description concerning health of groundwater resources and the threats thereto, including quality and pollution of these waters, in order to devise control, protection and remedial measures  
   2.5.1 Groundwater Quality and Pollution  
2.6 Significant interdependencies between specific groundwater and surface water sources  
2.7 Inputs for the ecologist in the team to estimate ecological water requirements  
2.8 Gaps and shortcomings in information, knowledge and measures  
2.9 Scope-level vulnerability assessment  

3  **FIRST CYCLE AND FUTURE ACTION PLANS**  
3.1 Preparation of the action plans by providing the necessary expert inputs for these plans to the Team Coordinator  
3.2 Identification of medium and long-term basin management and improvement plans
Annex

Annex 1  Localities, River-Subdivisions and Hardrock Barriers in the Kuiseb River
Annex 2  Boreholes in the Kuiseb Basin
Annex 3  Abstraction Areas in the Lower Kuiseb River
Annex 4  Actual and Simulated Results in Monitoring Borehole Hydrographs representing the Kuiseb Aquifers
Annex 5  Palaeo channels in the J-line as delineated by the 1994 BGR study, overlain over the contoured EM34 results from 2003
Annex 6  Sustainable Yields Calculated for the Active Kuiseb Aquifer between Swartbank and Rooibank and the Delta Aquifer
Annex 7  Operating Mines in the Kuiseb Basin Area
Annex 8  Current Mineral Exploration along the Kuiseb River
Baseline information and gaps analysis concerning Geology and Geohydrology of the Basin

1.1 Inventory of relevant geological and geo-hydrological records and reports

1. AIN (1999): Assessment Interconsult Namibia (PTY) LTD: Preliminary Environmental Assessment of proposed development at the Gobabeb Training and Research Centre.


12. BGR (1998): German-Namibian Groundwater Exploration Project – Technical Cooperation Project No.: 89.2034.0 – Reports on Hydrogeological and Isotope Investigations Vol. D-II – Isotope Hydrological Study on the Kuiseb Dune Area, Koichab Area (Lüderitz) and Omaruru Delta (OMDEL) (Central and Southern Namib Desert) (by D. PLOETHNER)


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19. CAWMP/ DWA (1993): Central Area Water Master Plan: Phase 1/ Republic of Namibia, Ministry of Agriculture, Water and Rural Development (DWA), German Technical Cooperation (GTZ), Consulting Engineers Salzgitter (CES), Lund Consulting Engineers (LCE), Windhoek Consulting Engineers (WCE). Windhoek, Namibia.
Geo-hydrology

1.2 Overviews of Main Hydrological & Geological Features

1.2.1 Hydrology

The Kuiseb, an ephemeral river with a length of 560 km, drains a catchment of approx. 14 700 km$^2$ in west-central Namibia. Only the upper 9 000 km$^2$ of this area are considered to be producing significant runoff, while the remaining part of the catchment area forms an arid to hyper-arid desert plain yielding runoff only in exceptionally wet years (HATTLE 1985).

The Kuiseb river is bound to a clearly defined river bed until it reaches the lowlands in the delta area (Annex 1). The Upper Kuiseb River reaches from the Khomas Highland through the escarpment in a generally well incised river bed in SW direction over 220 km until Hudaob. The Middle Kuiseb River, between Hudaob and Natab, flows for 40 km in WNW direction within a narrow, canyon-like river bed. From Natab downstream, the Lower Kuiseb River changes to a general NW direction and flows over 75 km within a broad, sandy river bed towards the delta region W of Rooibank.

Hydraulically the Kuiseb is the most thoroughly monitored river of western Namibia, with 8 rainfall and 14 flow gauging stations distributed within the catchment. Records at Gobabeb indicate the river flows between 0-105 days per year. In the early 80’s the river did not flow for more than 4 years (SHANYENGANA 1997). The WNNR REPORT (1984) states that between 1837 and 1984 the Kuiseb flow only reached the Atlantic 15 times.

While BLOM (1978) estimated a long term average annual runoff of 35.5 x 10$^{-6}$ m$^3$, JACOBSON (1997) calculated a mean annual runoff from 1979 – 1993 of 4.65 x 10$^{-6}$ m$^3$. The annual range however is between 0 – 220 x 10$^{-6}$ m$^3$ according to AIN (1999) & HUNTLEY (1985). The latter one gives a mean of 40 x 10$^{-6}$ m$^3$ at the base of the escarpment.

BLOM (1978) estimates an average flood loss downstream of the Gaub confluence up to Rooibank due to evaporation and infiltration into the alluvial bed at 20.9 x 10$^{-6}$ m$^3$.

The rainfall in the catchment declines from a mean annual rainfall of approx. 360 mm in the headwaters to almost zero at the coast (JACOBSON 1997/ BGR 1998).

According to HUNTLEY (1985) the Kuiseb catchment receives on average only 159 mm rainfall per annum.

DRFN (1994) states that 660 M. m$^3$ of water fall as rain in the upper catchment and 21 M. m$^3$ pass the Kuiseb-Gaub confluence, 2 M. m$^3$ run off are measured at Swartbank and 0.6 M. m$^3$ at Rooibank. According to that report the highly variable upper catchment runoff shows a high of 105.9 M. m$^3$/a and a low of 0.0065 M. m$^3$/a recorded at Schlesien Wei.$^r$. 
1.2.2 Geology

The Namib desert is underlain by Precambrian bedrock consisting of granites, gneisses and schists. These are separated from younger Tertiary & Quarternary deposits by the Namib unconformity surface formed during the Late Cretaceous erosional phase. Outcrops of Precambrian rocks can be found all over the Central Namib Region. The oldest Tertiary deposits (50 – 20 Ma) pertain to the cross-bedded, aeolian Tsondab Sandstone Formation, which underlies most of the Central Namib Desert south of the Kuiseb River and was deposited under arid conditions. The Tsondab Sandstone Formation, a precursor of the present Namib Sand Sea, is generally 45 to 90 m thick, but reaches a thickness of over 200 m in the eastern part of the Namib Sand Sea (BESLER & MARKER 1979).

In the area of the Kuiseb Valley the Tsondab Sandstone Formation is overlain unconformably by the well rounded quartzite and vein quartz gravels of the tertiary Karpfenkliff Conglomerate Formation (WARD 1984). This Conglomerate and its equivalents in the Tsondab and Tsachub valleys represent the earliest evidence of a well integrated drainage in the central Namib. These tertiary fluvial deposits are extensively calcified, as the Tsondab Sandstone shows with an up to 5 m thick pedogenic calcrete horizon on adjacent interfluves, representing a long period of landform stability in a semiarid climate.

The geological sequence of the Namib Desert north of the Kuiseb river is over lain by alluvial sediments of the Namib Group (Early Miocene) indicating a wetter, more humid climate with sporadic high energy flow events. Extensive Calcrete formation occurred at the end of the Miocene. The Late Tertiary deposits of the Sossus Sand Formation indicate a return to arid conditions. The Pleistocene sediments show a mostly arid climate, which alternates sporadically with short slightly wetter periods. Evidence of lacustrine and moister conditions can be seen in the Oswater Conglomerate, Hudaob Tufa deposits, the Khommabes Carbonates, the Homeb Silts, the Awa Gamteb muds and the pebble to cobble sized Gobabeb Gravel formation (which all make up Kuiseb Palaeochannel Fills). Ephemeral rivers within the Kuiseb Delta have deposited the most recent sediments in the form of sand deposits and silty river alluvium during floods. The modern coastline with its headlands, lagoons, bays and sabkhas is a result of the interaction of eolian, coastal and fluvial processes.

The Kuiseb rises on the interior plateau of central Namibia, the Khomas Hochland, at an elevation of approx. 2000 m. Westwards from the headwaters the river has eroded a shallow, sinuous valley into Late Precambrian metasediments, largely composed of schists and quarzites which provide a large proportion of sandy bed loads transported within the river’s lower reaches (WARD 1987).

West of the escarpment separating the inland plateau from the coastal plains, the river has incised a deep canyon (>200 m) in similar rocks. The river is highly confined herein, often flowing over bedrock with no alluvial cover due to the comparatively steep gradient (0.003 – 0.004 m/m) and narrow channel (<100 m). The channel broadens 65 km from the coast (approx. 45 km above Gobabeb), freeing the river channel to expand onto an increasingly wide (ephemeral or dry) delta and floodplain, the Kuiseb Delta. Approx. 42 km below Gobabeb station the floodplain width increases to over 1 km.

Within 20 km from the coast low crescentic dunes cross the river, resulting in poorly defined channels terminating on coastal flats in the vicinity of Walvis Bay. Gradients below the canyon average 0.001-0.002 m/m, increasing again to 0.004 m/m within 60 km from the coast, resulting in a slightly convex longitudinal profile in the lower river. When in flood, the river’s lower reaches transport a sandy bed load and a suspended load high in silts. The sandy channel sediments within the lower 150 km are largely devoid of cobble or bedrock, excluding occasional bedrock dikes which cross the channel and form local knick points in the longitudinal profile (WARD 1987).

The Kuiseb delineates the gravel plains of the Namib, underlain by massive granites and covered by thin soils in the north, from the dune fields of the Namib Sand Sea in the south.

1.2.3 Main Aquifer Types

According to KUELLS & HEIDBUECHEL (2006) the main aquifer types are the following:
- **Alluvium**: Hydraulic Conductivity $2.0 \times 10^{-3}$ m/s / Porosity 30% / Layer Thickness 30 m / Storativity S=0.133 (at Rooibank) or S=0.06 to 0.08 (at Swartbank)

- **Palaeochannels**: Hydraulic Conductivity $1.0 \times 10^8$ m/s [BGR 1998/Vol 7:]
  $3.1 \times 10^6$ m/s] / Porosity 25% / Layer Thickness 105 m / Storativity S=0.046 or 4.6%

- **Sandstone**: Hydraulic Conductivity $3.0 \times 10^{-6}$ m/s / Porosity 7% / Layer Thickness 100 m

- **Basement**: Hydraulic Conductivity $1.55 \times 10^{-8}$ m/s / Porosity 0.1% / Layer Thickness down to sea level

BGR (1998/Vol 7) give the following transmissivities, saturated thicknesses & hydraulic conductivities (including a mean overall porosity of $n=0.15$):

- **Kuiseb River Sediments**: $150 - 1600$ m$^2$/d / Saturated thickness 15 m / Hydraulic Conductivity $10^{-4} - 10^{-3}$ m/s

- **Palaeochannel Sediments**: $6$ m$^2$/d

- **Tsondab Sandstone**: $4$ m$^2$/d

- **Basement**: $0.03$ m$^2$/d

Values from other studies for **Kuiseb River Sediments**:

- **BLOM (1978)**:
  - Hydraulic Conductivity $3 \times 10^{-4}$ to $2 \times 10^{-3}$ m/s (Mean value $K= 9 \times 10^{-4}$ m/s or $K= 79$ m/d)/ Storage Coefficients between 0.09 and 0.25 (Mean value 0.17)

- **VAN RENSBURG (1992) for the period 1988 - 1990**:
  - Hydraulic Conductivity $K= 2 \times 10^{-3}$ m/s or $K= 134$ m/d/ Storage Coefficient $S= 0.13$

According to AIN (1999) there are **2 alluvial aquifers** (on top of each other) with differing water qualities in the **Kuiseb at Gobabeb**:

- **A freshwater aquifer** underlain by a denser & more saline aquifer. In places the interface between the upper and lower groundwater is sharp but in other places a zone of mixing is present. The thickness of the fresh-water layer varies between 3 and 15 m, the water quality is also not constant.

The **Kuiseb Alluvial Aquifer** is not continuous. At several locations basement rocks crop out on either side of the river channel restricting the lateral extent of the alluvium. Upstream of **Gobabeb** and approx. 5 km downstream, near **Soetrivier**, such outcrops exist. In the vicinity of the latter, geophysical surveying suggested that the depth to fresh bedrock is very limited. Such lateral and vertical restrictions to the alluvial channel constitute possible barriers to GW-flow.

The average alluvial width is 150 m, the porosity 35% and the saturated thickness 10 m according to AIN (1999) while BATE & WALKER (1991) give an average alluvial width of 307 m and a thickness of 10 m.

According to BGR (1995/Vol E-I) the above values reveal that the palaeochannels’ fill is an unconfined, low permeable aquifer which will not maintain a viable well field. Comparatively the Kuiseb River deposits have more favourable aquifer parameters according to VAN RENSBURG (1992) & CAVMP (1993).

On the other hand, although the information on the Tsondab Sandstone aquifer parameters is still poor, it is assumed by BGR (1998/Vol D-II) that **the palaeochannel fill is the major aquifer of the Kuiseb Dune Area** due to its lower grade of consolidation. This was also confirmed in subsequent pumping tests by DWAF in the late 1990’s, where the paleo-channels had good hydraulic properties closer to the sea – just north of Sandwich Harbour - whith good yields and very little drawdown.
According to BGR (1998/Vol D-II) the stored GW-reserves in the palaeochannels is assessed to a volume of 75 Mm$^3$ brackish and 280 Mm$^3$ fresh GW using a storativity of 4.6 %.

According to BGR (1995/Vol D-I) the amount of water available in the palaeochannel aquifer is estimated to be about 340 Mm$^3$ (in contrast to a former estimate of 1500 Mio. m$^3$ [VAN ZIJL & HUYSEN 1967]), of which about 100 Mm$^3$ are brackish. A further 160 Mm$^3$ is in the Tsondab Sandstone. This estimate of a total of 500 Mm$^3$ is based on assumed and measured thicknesses of saturated sediments of 15 – 30 m and an effective pore volume of 0.04 – 0.05 (BGR 1995/Vol D-I).

1.3 Groundwater-Dependant Ecosystems (see also B 7 & B 8)

The Kuiseb plain is considered a linear oasis or a green belt in the desert. While in the desert itself there is nearly no vegetation, the river plain maintains a woodland vegetation, normally composed of Anaboom, Camel thorn, Wild tamarisk, Ebony tree, Mustard tree and Sycamore fig. Famous is the Nara melon, which is covering small sand dunes within the river bed and also its southern flank (BGR 1995/Vol D-I).

BLOM (1978) mentions that downstream of Rooibank the tree vegetation with a few exceptions disappears altogether from the river plain.

The vegetation cover depends for their survival on the infrequent floods and on the subsurface water flow. The reduction of the vegetation cover reported on the last decades, may be caused by different effects:

A very important one has been certainly the lowering of the GW-table due to the intensive GW-abstractions in the lower Kuiseb valley (BGR 1995/Vol D-I).

But also the domestic stocks of the native Topnaar communities may have contributed so far, because their goats feed especially on new sprouts and young trees, hampering these new tree generations to grow up.

According to HUNTLEY (1985) the consequences of the increased use of the water resources of the Kuiseb basin were believed to cause a lowering of the water table which would result in:

- the death of the dense acacia woodland which forms a linear oasis across the desert
- the unhindered northward advance of dunes from the Namib Sand Sea
- the termination of subsurface flow of freshwater from the Kuiseb to Sandwich Lagoon
- the depletion of drought reserves for plains game and Topnaar domestic stock through the loss of the acacia woodland and associated vegetation
- and ultimately the siltation of Walvis Bay Lagoon.

1.4 Gaps and shortcomings in information, knowledge and measures

Information gaps exist regarding the entire Kuiseb Basin. There are much more GW-research-data available in MAWF/DWAF for the downstream area than for the upstream area.

2 Water resources

2.1 Inventory of relevant records and reports of presently used groundwater sources and unutilised groundwater resources


4. **CAWMP/ DWA (1993):** Central Area Water Master Plan: Phase 1/ Republic of Namibia, Ministry of Agriculture, Water and Rural Development (DWA), German Technical Cooperation (GTZ), Consulting Engineers Salzgitter (CES), Lund Consulting Engineers (LCE), Windhoek Consulting Engineers (WCE). Windhoek, Namibia


### 2.2 Concise description of these features/resources, including undeveloped water resource potential

The Kuiseb River in central & western Namibia is one of the most heavily used rivers in the country, well known for providing all the water used in Walvis Bay and part of that used in Swakopmund and Rössing Mine and Arandis. In addition it supports the farming activities and production of the Topnaars (400 communal farmers in 10 villages) along the lower water course, the activities of researchers and educators working with the Namib Research Institute at Gobabeb (the *Gobabeb Desert Research Station of DRFN* is supplied with a borehole on the northern bank of the Kuiseb river) and animals living in the Namib-Naukluft Park. It also supports the production from 109 commercial farms in the upper reaches of its catchment area (DRFN 1994).

According to DRFN (1994) the consumption was the following in detail:
- 0.6 Mm³/a on 109 farms (ground dams & boreholes, for livestock (90 %) and domestic purposes (10 %)
- 0.006 Mm³/a by 400 Topnaar communal farmers in 10 villages for livestock (58 %) and domestic purposes (42 %)
- 0.007 Mm³/a by the Namib Research Institute at Gobabeb (for domestic purposes, 86 % for gardening)
- 4.3 Mm³/a for water supply of Walvis Bay (from Rooibank Aquifer/ 72 % for domestic purposes, industrial use 28 %; 36 % of the town’s entire water consumption were used for gardening)
- 2.9 Mm³/a for water supply of Swakopmund (from Swartbank Aquifer/ 96 % for domestic purposes, light industrial use 4 %)
- 3.0 Mm³/a for Rössing Uranium Mine and the town of Arandis (from a reservoir in Swakopmund, supplied by Kuiseb & Omaruru aquifers)
- Evaporation & gardening were identified as major sources for water use & losses

The amount of water available in the palaeochannel aquifer (the only existing prospective aquifer) is estimated to be about 340 Mm³ (in contrast to a former estimate of 1500 Mm³ [VAN ZIJL & HUYSSEN 1967]), of which about 100 Mm³ are brackish. A further 160 Mm³ is in the Tsondab Sandstone. This estimate of a total of 500 Mm³ is based on assumed and measured thicknesses of saturated sediments of 15 – 30 m and an effective pore volume of 0.04 – 0.05 (BGR 1995/Vol D-I).

BGR 1998/Vol D-II describe the palaeochannels as following:
The palaeochannels (Annex 5) are 20 to 65 km in length and <0.5 to 5 km in width which are covered by 15 to 70 m (average 35 m) dune sand below the inter-dune valleys. They predominantly contain a 40 to 90 m (average 55 m) thick calcareous silty fine sand, locally medium to coarse-grained sand. In the southernmost palaeochannel the sediments attain a max. thickness of 120 m of which 60 % is marl. The palaeochannel has a saturated thickness of between 20 – 40 m which is maintained by indirect recharge from the Kuiseb river, which totals 0.42 Mm³/a.

Calculations to predict the amount of lowering of the GW-table show that pumping will mainly take GW from the sediments of the palaeochannels. With an annual extraction of 5 Mm³ for 20 years only about 3 % of the water will be taken from the Tsondab Sandstone.
The water supply at the central West Coast is based on GW-abstraction from the lower reaches of two ephemeral river systems, the Kuiseb River some 20 km south of Walvis bay and further southeast, and the Omaruru River some 80 km north of Swakopmund.
There are major schemes for water supply located in the lower part of the Kuiseb. The water supply of Walvis Bay and of the Uranium Mine Rössing are supplied from a GW-abstraction scheme located in the lower Kuiseb river delta, operated by Nam Water (see down). Other areas to be supplied are major tourist centres like Swakopmund and Henties Bay.
Since 1923 Groundwater has been continuously abstracted from the lower Kuiseb River, near the village of Rooibank. From 1960 onwards the Groundwater-abstraction in the Kuiseb area increased considerably due to new production fields going into operation in:

- B-area in 1966
- Swartbank in 1976
- Dorop South in 1992.

NamWater is operating the abstraction areas Rooibank A & B, Dorop North & South and Swartbank for the water supply of Walvis Bay (Annex 3, 4 & 6). According to BGR (1995/Vol D-I/ table p.4) and NamWater (2000/Annex) 58 production wells are located in the lower Kuiseb abstraction areas. The pump rate development over the years can be studied in detail in NamWater (2000 & 2001). Over the period between 1986 and 2000, abstraction from the Lower Kuiseb Aquifers averaged 7.7 Mm³/a. Just after the development of the Swartbank Aquifer abstraction peaked between 13 and 16 Mm³/annum.

In 1977/78 annual Groundwater-production reached its total peak with 16.53 Mm³/a (BGR 1995/Vol D-I). After completion of the Omaruru Delta GW-Abstraction Scheme in 1978 the production of the
Kuiseb aquifers has been cut back. According to BGR (1995/Vol D-I) and NamWater (2001) the annual abstraction was surpassing the mean annual recharge and the reserves continue being depleted until present. As an effect pumping rates of the production wells had to be reduced and some wells fell even dry. The abstraction had reached about 8 Mm³/day and is now being reduced to 3-4 Mm³/day due to studies on Groundwater-recharge (NamWater 2001; KUELLS & HEIDBUECHEL 2006). According to the CAWMP (Phase 1/ DWA 1993) the water demand for 2005 was 18 Mm³/a and will be 29 Mm³ by 2020.

The growing demand for the time ahead requires additional water supply by groundwater, and in the longer run, by surface-water dams or desalination plants (BGR 1995/Vol D-I). The latter one is now (2008) under construction at Wlotzkasbaken (north of Swakopmund) with financial support from the mining industry and will go into operation by end of 2009.

The Central Namib Area consists of the Kuiseb and Omdel water abstraction schemes, which 2 aquifer systems at the coast at the end of 2007 had a calculated total abstractable reserve of 204 Mm³ (which has to be confirmed by more research in the future). The running average abstraction at the coast at the end of 2007 was ~ 1.15 Mm³/month, which included the potable water supply to Rössing and Langer Heinrich. The current available natural water resources of the Kuiseb & Omdel scheme, excluding the recent upgrades at Omdel to accommodate Langer Heinrich, are 12.9 Mm³/a. This can be increased to a max. of 15.9 Mm³/a by developing other natural resources within both catchments. Such 15.9 Mm³/a sustainable yield of all the available natural resources will not be sufficient to supply in the demand of the proposed new uranium mines in the Erongo region and the construction of a desalination plant (see above) is seen as the most viable solution to meet the water demand of these new uranium mines. NamWater and any bulk user/ private utility taking water from natural resources must have valid abstraction licenses from DWAF, while NamWater must prepare & present a Water Master Plan for the Central Namib to DWAF (see also Chapter D. First cycle and future action plans) to ensure the sustainable use of the resources. As well all bulk water users should develop a Water Conservation & Demand Management Plan, ensuring the optimum use of water (WATER & WASTE MANAGEMENT TECHNICAL ADVISORY COMMITTEE/WWM TAC of THE CHAMBER OF MINES OF NAMIBIA / unpublished meeting minutes 02/ 2008).

The aquifer below the lower Kuiseb provides a considerable proportion of the water supply. Annual production between 1986 and 1997 in the area studied between Swartbank and Rooibank averaged 4 Mm³/a. A further 1 Mm³/a have been taken from additional wells since 1995. The wells are not usually pumped throughout the day. How long a well is pumped depends on how full the storage tanks/reservoirs are. Alternating well groups are pumped (BGR 1998/Vol 7). During the BGR-investigations the Groundwater-table was regularly monitored by hand measurements, at 4 wells the levels were recorded automatically. The density of the observation wells was suitable for describing the Groundwater-Level over relatively large areas. Since 1982 the Groundwater-table has dropped 2 – 6 m (BGR 1998/Vol 7). During the 1997 floods the Groundwater-table rose up to 6 m in wells near the river.

Prior to MUINJO’s findings in 1998 the sustainable yield for all the aquifers was assessed to be in total 3.2 Mm³/a, with a further 1.2 Mm³/a, which represents a mining yield of the Dorob South abstraction area. The Swartbank waterworks comprising 22 production wells abstracted a max. of 5.4 Mm³/a for 1988 after which production rates were reduced, averaging 3.75 Mm³/a for the years 1989 to 1991. The Rooibank A-scheme, comprising 14 production wells, increased its abstraction from 2.3 Mm³/a in 1985 to 4.2 Mm³/a in 1991.

Due to this over-exploitation the average saturated thickness diminished by 6 to 10 m between Klipneus, Swartbank and Rooibank A from 1972/75 to 1993/94 resulting in a reduction of the abstractable GW reserves from 40 to 19 Mm³ (at Rooibank A) and 38 to 21 Mm³ (at Swartbank).
According to NamWater (1998) the Lower Kuiseb Aquifers, comprising the Delta Aquifer (Dorop South & Rooibank B well fields) and the Swartbank/ Rooibank A Aquifer were being overutilized to supply the demand of consumers in the Central Namib Area. This situation would probably prevail until the planned desalination plant is in operation. The average abstraction from both areas were 3.62 Mm³/a and 4.72 Mm³/a respectively.

Further possible areas of GW-development in the Kuiseb area not influencing the current utilised resources were also included into the sustainable yield calculations by NamWater (2001): The most promising area regarding both accessibility and yield potential is the J-line area (south of the Swartbank Area/ Annex 5), which could yield up to an estimated 1.5 Mm³/a without any negative impact on the current areas utilised and the environment.

By the development of other areas in the Kuiseb Aquifer the sustainability of the Kuiseb Aquifers might be increased to an average of 11 Mm³/a if it is feasible or practical to develop and utilise the other resources mentioned in NamWater (2001/Table C).

2.3 Recharge dynamics and rates, discharge, abstractions and the possible over-exploitation of groundwater

Recharge to the alluvial aquifers occurs mainly via vertical infiltration of runoff down the present day Kuiseb river and from through-flow within the alluvial aquifers, mainly during ephemeral flash floods. During those the duration of the floods is the most important factor concerning recharge and not their intensity.

Owing to the high evaporation rates, rain in the desert areas does not contribute significantly to groundwater recharge. Depending on the intensity and location of rainfall in the catchment area, flash floods occur in the main streams. The amount of water and the duration varies. Every several decades a flash flood in the Kuiseb reaches the Atlantic, the last time in the 1962/63 rain season. Flash floods since then have gone no further than Rooibank (to Dorop in 1996/97).

Most of the flash floods occur in the eastern half of the catchment area and can recharge the groundwater below the dry bed of the lower Kuiseb. At some places along the river bed relatively small amounts of water from the flash floods reach the aquifer in the dunes area via the palaeochannels of the Kuiseb. Such conditions exist between Gobabeb and Rooibank. This area was mapped as part of hydrogeological studies based on data from an aerial geophysical survey (BGR 1995/Vol B-III, SENGPIEL & SIEMON 1997). Correlation of borehole data with the maps of apparent resistivity prepared from the electromagnetic data show that the palaeochannels of the Kuiseb cut through the Tsondab Sandstone into the basement.

The amount of water available in the palaeochannel aquifer (the only existing prospective aquifer) is estimated to be about 340 Mm³ (in contrast to a former estimate of 1500 Mm³ [VAN ZIJL & HUYSEN 1967]), of which about 100 Mm³ are brackish. A further 160 Mm³ is available in the Tsondab Sandstone. This estimate of a total of 500 Mm³ is based on assumed and measured thicknesses of saturated sediments of 15 – 30 m and an effective pore volume of 0.04 – 0.05 (BGR 1995/Vol D-I).

Calculations to predict the amount of lowering of the Groundwater-table show that pumping will mainly take groundwater from the sediments of the palaeochannels. With an annual extraction of 5 Mm³ for 20 years only about 3 % of the water will be taken from the Tsondab Sandstone.

However, salinity changes indicate an inflow from saline source to the alluvium as well from the granites or from the basin as subsurface discharge.

The DWAF has installed gauging stations at various points along the Kuiseb. Records, including length of the flood, are available for the period since 1961 at the Gobabeb and Rooibank stations. Between 1961 and 1982 the floods lasted an average of a month. Discharge averaged 17.6 Mm³ at
**Geo-hydrology**

Gobabeb and 9.5 Mm$^3$ at Rooibank. Since 1982 the floods at Gobabeb have lasted only half as long (about 14 days) with an average of 9.1 Mm$^3$. Since 1982 significant amounts were measured at Rooibank only in 1993 and 1997.

The measurements at the Swartbank gauging station are incomplete for the period since 1989, because the river bed has moved in some places (BGR 1998/Vol 7).

The recharge estimates assume that only heavy flooding contributes to local GW-recharge. Hence the water must reach at least Rooibank.

BGR (1998/Vol 7) carried out model calculations [MUINJO 1998] to simulate the effects of flash floods on the Groundwater-system in order to determine the magnitude of potential Groundwater-recharge. According to these investigations inflow at Swartbank is held at a constant annual 4 Mm$^3$, estimated from the gradient and transmissivity. Small amounts of water flow into palaeochannels (0.12 and 0.07 Mm$^3$) in the dunes area.

The effects of flash floods in 1985, 1988 and 1997 were simulated using the actual Groundwater-production since 1986 and assumed values for the rates of infiltration. These calculations indicate infiltration of 0.1 Mm$^3$ per year from the relatively small amounts of water in the floods of 1985 and 1988. Simulation of the large floods of 1997 (43 days) indicate infiltration of only 0.84 Mm$^3$, which is in agreement with the calculated Groundwater-recharge of about 1 Mm$^3$ (BGR 1998/Vol 7).

The grain size distribution near Gobabeb site (Kuiseb active channel & floodplain) is heterogeneous. The surface channel is often covered by a silt layer, which varies from 1 mm to a couple of cm thickness. This silt is known to negatively affect recharge from floods (CRERAR et al. 1988). While infiltration rates in the alluvium can reach more than 1 cm/hour in the absence of silt layers, silt may reduce infiltration dramatically.

According to chemical & isotope research indirect recharge is indicated from the 9000 km$^2$ in the upper Kuiseb area (KUELLS & HEIDBUECHEL 2006) and the water at Gobabeb, Homeb and Swartbank represents a mixture of a) recharge from (extremely large) floods and b) the inflow from sections that carry the fingerprint of (isotopically) “heavier” water recharged further upstream.

The groundwater at the settlements Homeb, Soetriver, Klipneus and Swartbank does not show strong temporal changes as a direct result of flood events.

While recharge from transmission losses is estimated with 1.5 Mm$^3$ (KUELLS & HEIDBUECHEL 2006), direct recharge rates have been estimated to reach at least 0.1 to 1 mm/year (DE VRIES & SIMMERS 2002). The size of the basin creates a Groundwater-recharge of $2.5 \times 10^6$ m$^3$ / a (for the upper Kuiseb).

In the Lower Kuiseb Dune Area (Kuiseb-down stream area) –model, according to findings of transmission loss measurements by KUELLS & HEIDBUECHEL (2006), low water tables appear in the upper part and very high water tables in the lower part of the area. The assumption that a high water table reduces transmission losses even in arid regions can be supported by this.

$^{14}$C ages in Kuiseb Delta indicate that most of the Groundwater is recent (KUELLS & HEIDBUECHEL 2006).

BGR (1998/Vol 7) underlined, that the Groundwater-table-measurements in some parts of the palaeochannels and near the present Kuiseb River had to be viewed as a momentary picture of a continual natural drainage of the aquifer, which owing to its low permeability may be assumed to occur very slowly. $^{14}$C ages indicated that GW in some palaeochannels was recharged about 4000 years ago by infiltration of river water. Distinctly younger ages in other palaeochannels (1000 to 2000 a) lead to the conclusion that water can infiltrate into the Groundwater-system from the active Kuiseb River. The places where the palaeochannels intersect the Kuiseb River are potential areas for infiltration, especially in the area west of Swartbank.
There are springs at numerous places along the coast and at the lagoon at Sandwich Harbour. According to BGR (1998/Vol 7) their amounts of discharge had not yet been estimated. Area-wide groundwater-recharge now or earlier is excluded by BGR (1998/Vol 7). Groundwater-flow in the palaeochannels can be estimated from the hydraulic gradients and permeabilities. The value of 0.42 Mm\(^3\)/a for inflow along the model boundaries is relatively low.

According to the BGR (1998/Vol 7)-model for the Lower Kuiseb area the groundwater-balance is governed by the inflow and outflow at the boundaries of the system. Inflow across the eastern model boundary amounts to 0.42 Mm\(^3\)/a via the Kuiseb River and different palaeochannels, determined by the local gradients and hydraulic conductivity. Outflow into the Atlantic at the western model boundary amounts to 0.42 Mm\(^3\)/a.

According to that study, there is little effect of an assumed well field on groundwater-flow in the system over a simulated period of 30 years. The outflow of 0.42 Mm\(^3\)/a is reduced by a groundwater-abstraction of 5.1 Mm\(^3\)/a by approx. 5 % to approx. 0.40 Mm\(^3\)/a after a simulated period of 30 years. Owing to the unfavourable hydraulic conditions indicated by the low permeability values, the daily abstraction rates per well were limited to about 140 m\(^3\). After about 25 years the water table in the middle of the modelled area and at the southern edge of the well field has been lowered down to the base of the aquifer. To maintain production, the abstraction rate would have to be reduced after 20 years to 4.5 Mm\(^3\)/a and after 25 years to 3.8 Mm\(^3\)/a. Assuming a minimum lowering of 5 m, the cone of depression progressively expands to about 100 km\(^2\) of the Kuiseb Dune area.

According to a NamWater-Report (1997) recharge to the Lower Kuiseb Aquifers is dependent on runoff events and subsurface base flow. After the 1997 floods recharge to all the aquifers was recorded. Water levels in the Swartbank and Rooibank A areas increased by an average of 2.23 m and in the Dorop South and Rooibank B areas by 0.41 m and 0.5 m respectively. From recharge calculations approx. 15 Mm\(^3\) of water infiltrated into the Swartbank and Rooibank A areas during runoff. The safe yield of the Swartbank/ Rooibank A Aquifer is 3.3 Mm\(^3\)/a.

An estimated 5.6 Mm\(^3\) recharged into the Dorop South and Rooibank B areas. The safe yield of the Dorop South/ Rooibank B Aquifer in a time of minimum or no recharge from surface flow is 0.99 Mm\(^3\)/a as opposed to 2.0 Mm\(^3\)/a for the long-term sustainable yield which includes periodic recharge events.

According to NamWater (2001) based on abstraction and change in water level calculations for the Rooibank B and Dorop South areas between 1993 and 2000, the combined recharge for the Delta Aquifer is estimated in the order of 2.03 Mm\(^3\)/a.

Due to extensive silt layers found in the aquifers infiltration over the Swartbank and Rooibank A areas have a definite delayed time of approx. 6 months. A delayed time in infiltration is also inferred for the Rooibank B area.

The most recent available figures concerning the total sustainable yield of the Kuiseb according to a numerical groundwater flow model in NamWater (2001/Annex 6): the sustainable yield of the active Kuiseb is 4.9 Mm\(^3\)/a plus 2.5 Mm\(^3\)/a of the Kuiseb Delta (Rooibank & Dorop South) brings the total sustainable yield of the Kuiseb to 7.4 Mm\(^3\)/a. Including the environmental demand of 0.8 Mm\(^3\)/a into the equation, it can be concluded that the sustainable yield for the active Kuiseb between Swartbank and the Delta is in the order of 7 Mm\(^3\)/a.

### 2.4 Future water requirements for mining activities in the Kuiseb Basin

Possible mineral deposits that may become attractive for mining development in the future (apart from the currently operating mines/ Annex 7), which would have an impact on water requirements to be satisfied in the Kuiseb Basin, are the following:
1. Starting from 2012 Reptile Uranium (Deep Yellow-Company) want to abstract 5 Mm$^{3}$/a for Uranium-Calcrete mining in the Lower Kuiseb/ Gobabeb region (oral information from Dr. R. Ellmies BGR/ GSN)

2. The Map in Annex 8, received from GSN (Mrs. Filadelphia Mbingeneeko) shows the current state of mineral exploration (mainly Uranium and Copper Mining) along the Kuiseb River, which will require large quantities of water once exploitation takes place. According to the EPL Nos, these mining exploration areas are overlapping and there could be several reasons for that, e.g. that the companies applied for different commodities and that could be a case whereby one company is exploring for base metals whereas the other company might be exploring for uranium.

2.5 Concise description concerning health of groundwater resources and the threats thereto, including quality and pollution of these waters, in order to devise control, protection and remedial measures

2.5.1 Groundwater Quality and Pollution

The Groundwater-quality in the Kuiseb Basin depends on the recharge and on the geologic conditions. There is a strong contrast in lithology between the area north and south of the Upper Kuiseb. In the northern part schist is the dominant rock, a fractured aquifer with small storage volumes and low transmissivity. These characteristics are also reflected in the hydrogeology and hydrochemistry: The northern part has low yields and a lower Groundwater-quality due to high salinity. This water is mixed into the Groundwater of the alluvium most probably at Gobabeb (KUELLS & HEIDBUECHEL 2006), where the fresh Groundwater is underlain by brackish Groundwater, which may stem from this diffuse recharge.

The Groundwater-Resources in the Upper part are of lower quality in the northern part and of higher quality in the southern part. Also the yield is higher as quartzite represents a better fractured aquifer. The Groundwater-quality and yield decreases towards the west/downstream due to the reduction of rainfall & recharge.

The alluvium represents an exception: In the alluvial bodies the Groundwater-quality is generally better ~600 uS/cm compared to 1500-2500 (and more) uS/cm in the rock. The sustainability downstream increases related to 2 factors:

a) the basin area and the runoff production potential is getting higher until transmission losses revert this trend

b) there is also a constant seepage of Groundwater-recharge in higher sections of the alluvium.

Both processes, crucial for the estimation of Groundwater-recharge in arid environments, can be observed and estimated based on stable isotope data. A third component has been described that is produced by diffuse recharge. In the Kuiseb basin this component rather deteriorates the Groundwater quality due to its salinity.

The most intensive study on Groundwater-quality in the Lower Kuiseb area has been done by BGR (1995/Vol D-I):

The overall mineralization of the Groundwater varies to a large extent. Low mineralized waters of less than 250 mg/l are found. Highly mineralized Groundwater occurs near the coast.

The mineralization of the Groundwater in the active Kuiseb and Kuiseb south subareas is mainly caused by three factors:

- mineralization of the Kuiseb floodwaters
- mineralization of the floodwaters of the northern tributaries to the lower Kuiseb river
- evapotranspiration and solution during infiltration into the active Kuiseb aquifers.
The ephemeral floods reaching the lower Kuiseb river from the Khomas Highlands carry beside their sediment load of up to 4500 mg/l also a dissolved mineralization load (TDS) of up to > 500 mg/l, on average around 200 mg/l.

In 1993/94 the average TDS was at 1450, 600 and 950 mg/l at Klipneus, Swartbank and Rooibank A (BGR 1995/Vol D-I & BGR 1998/Vol D-II).

Very rarely floods from the northern tributaries (as Soutrivier and Aussinanis River) join the lower Kuiseb River as sheet flows cover the sodium chloride and calcium sulphate (gypsum) crusts of the Stone Namib, these waters are becoming highly mineralized. A floodwater at the Aussinanis confluence with the Kuiseb River was determined with a TDS-value of 5375 mg/l (1976), with 1700 mg/l of sulphate and 1670 mg/l of chloride ions (BLOM 1978).

The waters at the lower end of the mineralization scale belong to the Ca-Mg-HCO$_3$ Type, with up to 20 meq% Na-K-SO$_4$-Cl. With higher mineralization, the Na and K portion increases up to 70 meq% and the Cl/ SO$_4$ portion up to more than 90 meq%.

The evapotranspiration of Groundwater from the active Kuiseb River aquifers is also supposed to be a considerable factor of increasing the salinity. While BGR (1995/Vol D-I) assumes, that due to the remarkable lowering of the Groundwater-table in the last 30 years this factor should have diminished to a large extent, MUINJO (1998) states that salinity has increased due to evapotranspiration of groundwater from the Kuiseb river.

In the Kuiseb South Subarea, with a mean Groundwater-table in the dune valleys in excess of 40 m below surface and under the dunes some 100 m below surface, and without vegetation, the evapotranspiration effects should be minimal. On the other hand the very slow Groundwater-movement in that area facilitates the enrichment through solution of salts from the aquifer (BGR 1995/Vol D-I).

In the Coastal Subarea, especially at the lowlands near sea level, the Groundwater-table is over larger areas relatively shallow, with 1 to 3 m below the surface. Here, additional to sea water intrusion, also the evaporation effect is also supposed to be relevant on increasing the overall salinity.

The overall salinity as well as chemical composition of Groundwater respectively has been compiled in Annexes A 6 and B 3 & B 4 of the Borehole Data Bank (BGR 1995/Vol D-I).

The considerable variations in the Groundwater-quality within the individual compartments of the Active Kuiseb subarea let one suppose, that they do not constitute homogenous aquifers. On the contrary it is a question of separate Groundwater compounds with differentiated Groundwater-bodies. Such hydro-chemical differentiations, including a classification for human consumption and health threats, are given for the different palaeochannels of the Kuiseb South subarea in BGR (1995/Vol D-I/p.91-102).

### 2.6 Significant interdependencies between specific groundwater and surface water sources

Interdependencies between groundwater and surface water sources are given in terms of recharge, since recharge to the alluvial aquifers occurs mainly via vertical infiltration of runoff down the present day Kuiseb river and from through-flow within the alluvial aquifers, mainly during ephemeral flash floods (see Chapter “Recharge dynamics and rates” on page 11).

KUELLS & HEIDBUECHEL (2006) implemented an interaction of surface water and groundwater within a DAFLOW / MODFLOW-model for the Kuiseb area [using a coupled model from JOBSON &
HARBAUGH (1999)] by a seepage term which consists of the hydraulic conductivity of the streambed, the difference between the aquifer head and the river stage and the width of the stream bed at a certain discharge. Streamflow routing (with & without seepage to groundwater), return flow (out of the aquifer) and transmission losses (into the aquifer) were simulated, including pumping wells to adjust the model to the real situation.

B 7. Impacts on Groundwater resources of land use such as urbanisation and (alien) vegetation

Owing to the high evaporation rates, rain in the desert areas does not contribute to groundwater recharge. The coastal fog and rare rainfall however are sufficient for a flora and fauna that have adapted to these hyper-arid conditions. Vegetation is sparse within the dune field of the Namib Sand Sea (south of the Kuiseb) but a few fog-dependent, endemic plant species, such as Stipagrostis sabulicola & Trianthema hereroensis are found (SHANYENGANA 1997).

North of the Kuiseb within the Namib plains (a deflation surface with a thin layer of coarse sand & gravel, broken in places by granitic inselbergs and low kopies) calcrete, gypcrete & shallow suboutcrops of metamorphic & granitic basement lithologies underlie the gravel plains. In general these plains are devoid of vegetation supporting lichen, a few dwarf shrubs and acacias. Welwitschia mirabilis are found in a limited number of localities. Grasses, particularly Stipagrostis species are common, proliferating after rare rainfall events (SHANYENGANA 1997).

Riverine vegetation is mainly consisting of 4 species: Anatrees (Faidherbia albida), Camel Thorn (Acacia arioloba), False Ebony (Euclea pseudobenus), Tamarix (Tamarix usneoides) (BATE & WALKER 1993).

A high degree of uncertainty exists regarding the evapotranspiration by trees and vegetation that is found in the Lower Kuiseb River. BLOM (1978) calculated an evapotranspiration loss of 0.24 m/a over the whole active Kuiseb River plain. Incorporating this value over an area 23 km X 1 km with an average storativity of 15 %, an evapotranspiration volume of 0.83 Mm³/a is calculated.

Experiments carried out at Gobabeb in 1980 by BATE & WALKER concluded that vegetation in the river at Gobabeb uses probably between 15 - 20 % of the water in the aquifer per year. Due to the fact that these values are influenced by the storage capacity of the aquifer, over-estimations of evapotranspiration will be calculated for aquifers with high storage capacities. The stored reserves in the Lower Kuiseb, that is in the order of 150 Mm³ between Swartbank to Rooibank, will for instance yield an estimated loss to evapotranspiration for this area of approximately 24 Mm³/a, which is far higher than the sustainable yield of the aquifer.

After SONNTAG (1985/ cited in NamWater 2001), the evapotranspiration loss in this sandy aquifer with its water table in place between 8 and 16 m below ground must be much less. He published a graph, according to which in arid regions, evaporation from a 10 m deep water table in a sandy aquifer amounts to around 0.3 mm/annum. Calculating over an area of 23 km X 1 km, this value indicates an evapotranspiration loss from the water table of only 70 000 m³/a, which seems to be rather low.

Although the vegetation is certainly influenced by prevailing climatic conditions, the availability of groundwater probably has the most pronounced effect on the habitat of the different species along the ephemeral rivers. THERON et al. (1980) investigated the vegetation of the lower Kuiseb River valley upstream of Rooibank. They compiled a map and distinguished 14 different communities with the Acacia albida and Acacia erioloba communities as the most important. A total of 40 variations were distinguished. Four additional units, consisting mainly of dead herbaceous species were mapped between Gobabeb and Rooibank.
The maintenance of this vegetation is not only essential to the Kuiseb River ecosystem as a whole, but the vegetation along this linear oasis acts as a barrier checking the northwards movement of the Namib Sand Sea. The dune & inter-dune valleys are very sparsely vegetated. Along the Koichab and Omaruru river valleys, the vegetation is less dense compared with the Kuiseb river, apart from the area which is now being impounded by the OMDEL Dam.

Another comprehensive study on vegetation & ecology has been done by HUNTLEY (1985), where interdependencies of groundwater & vegetation can be studied (see also chapter B 2 & B 7).

2.7 Inputs for the ecologist in the team to estimate ecological water requirements

The Kuiseb plain is considered a linear oasis or a green belt in the desert. While in the desert itself there is nearly no vegetation, the river plain maintains a woodland vegetation, normally composed of Anaboom, Camel thorn, Wild tamarisk, Ebony tree, Mustard tree and Sycamore fig. Famous is the Nara melon, that is covering small sand dunes within the river bed and also its southern flank (BGR 1995/Vol D-I).

BLOM (1978) mentions that downstream of Rooibank the tree vegetation with a few exceptions disappears altogether from the river plain. The vegetation cover depends for their survival on the infrequent floods and on the subsurface water flow. The reduction of the vegetation cover reported on the last decades, may be caused by different effects:
A very important one has been certainly the lowering of the Groundwater-table due to the intensive Groundwater-abstractions in the lower Kuiseb valley (BGR 1995/Vol D-I). But also the domestic stocks of the native Topnaar communities may have contributed so far, because their goats feed especially on new sprouts and young trees, hampering by these new tree generations to grow up.

One of the most comprehensive studies on vegetation & ecology for the Kuiseb environment has been conducted by HUNTLEY (1985). During that investigation the Kuiseb Basin was divided into hydrological/ ecological compartments within and between each of which the rates and directions of water transfers and the factors influencing or influenced by these flows could be studied.

According to such studies the consequences of the increased use of the water resources of the Kuiseb basin were believed to cause a lowering of the water table which would result in:

- the death of the dense acacia woodland which forms a linear oasis across the desert
- the unhindered northward advance of dunes from the Namib Sand Sea
- the termination of subsurface flow of freshwater from the Kuiseb to Sandwich Lagoon
- the depletion of drought reserves for plains game and Topnaar domestic stock through the loss of the acacia woodland and associated vegetation
- and ultimately the siltation of Walvis Bay Lagoon.

The overriding conclusion that could be drawn from those studies conducted within this Kuiseb Environmental Project was that the entire ecosystem is extremely dynamic, undergoing unusually large fluctuations in all climatic, geomorphological, hydrological and ecological processes. Water is unquestionably the principal driving force in the Kuiseb environment and changes to the volume, rate and directions of flows within the system would have major consequences. At that time man-induced changes to the hydrology of the Kuiseb basin had not been demonstrated to have influenced geomorphological or ecological processes within the area.
Water supplied from the nearby Omaruru River caused a considerable reduction in the rate of water abstraction from the Lower Kuiseb, following an initial threefold-increase from 1974 to 1977. This undoubtedly averted major changes being recorded during HUNTLEY’s study (1985). The detailed baselines established during that project provide a benchmark against which changes can be measured in the long term, particularly during the establishment of a basin water management plan. According to limited unofficial experiments carried out by the Laboratory and Research Division within NamWater (NamWater 2001), a water demand for a big tree could be as high as 180 m$^3$/a, depending on the availability of water and climate. To apply this value, the number of big trees in the Kuiseb River must be known and an investigation on the demand of each species in the Kuiseb River must be investigated. In NAMWATER (2001) it was assumed, that water is always available in the alluvium and a density of between 5 and 8 trees per hectare exists. The total area that could be covered by trees in the Kuiseb River between Swartbank and Rooibank was digitised to obtain the area and estimated at 450 hectare. This means that between 2 250 and 3 600 trees are located in the river between Swartbank and Rooibank. This means that the water demand from the trees in this part of the aquifer based on the above assumptions is estimated to be between 0.4 Mm$^3$/a and 0.65 Mm$^3$/a.

2.8 Gaps and shortcomings in information, knowledge and measures

Information gaps exist regarding the entire Kuiseb Basin. There are much more Groundwater-research-data available in MAWF/ DWAF for the downstream area than for the upstream area.

2.9 Scope-level vulnerability assessment

List of previous work and geohydrological inputs for scope-level assessment of vulnerability of groundwater to contamination from spillage of harmful substances.


According to HYMNAM (Hydrogeological Map of Namibia 2001) the following differentiations for the vulnerability of groundwater-resources and risk of pollution, assessed on the basis of aquifer type, GW-flow, depth to GW and annual recharge are being made:

High: Along the Kuiseb river valley, from approx. 50 km east of Gobabeb to the coast

Moderate: Area A: upper catchment area from the Kuiseb start west of Windhoek to approx. Rostockberg/ Sandsteenberg area
Area B: Kuiseb Delta: Gobabeb area to the coast

Rather low: From approx. Rostockberg/ Sandsteenberg area to the coast (north & south of “Moderate Area B”)

3 First cycle and future action plans
3.1 Preparation of the action plans by providing the necessary expert inputs for these plans to the Team Coordinator

Owing to the favourable amount of data for the river area the results for the approximation of Groundwater-recharge from flash floods in the Kuiseb river may be viewed as reliable and thus the results of the (BGR 1998/Vol 7)-model may also be viewed as relatively good. According to that model & report as well as NamWater (2001) Groundwater-production between Swartbank and Rooibank (and further west) must be restricted in the future to avoid completely draining the system by Groundwater-mining.

Improvement in the reliability of recharge rates from the flash floods determined by modelling can be attained only by more closely monitoring the outflow and Groundwater-table data and inclusion of studies of the unsaturated soil zone. These measures will require considerable effort, but will provide a finely tuned Groundwater-balance. They will not provide predictions that can be used for water management, however, because future rainfall rates are not known.

According to the (BGR 1998/Vol 7)-model the calculations for the assumed well field in the dunes area indicate a lowering of the water table that would occur with a horizontal drainage system. The operations lifetime would be 20-30 years in the most favourable case. In the case of conventional abstraction rates from individual wells a large number of wells each with a low pumping rate would be necessary in order to avoid lowering the water table too much. Taking the results obtained for the palaeochannels into consideration, the simulated well field is in the last possible, relatively large area. This location has disadvantages, however, because this well field would be

- below the level of the flow of brackish water in a palaeochannel (01)
- the furthest distance within the region from the available electricity supply and roads
- in an area with a relatively low degree of hydrogeological exploration with the attendant uncertainties in the data on Groundwater-levels and depth to the base of the aquifer.

Groundwater exploration in the Kuiseb Dune area has provided information with which the description of the Groundwater-system as a whole could be improved and made it possible to model the southern part of the study for the first time (BGR 1998/Vol 7). The data base is sufficient to estimate the amount of groundwater in the system and the possibilities for Groundwater management. It must be expected that considerable effort would be required to further improve the already available information and that these efforts would not be justified by usefulness of the results. A cost-benefit analysis indicates that the only alternative for securing a long-term water supply for the coastal region would be a desalination plant (GKW, PARKMAN, BICON 1996/ BGR 2000/ Vol.3), that is currently under construction (2008).

3.2 Identification of medium and long-term basin management and improvement plans

An assessment of recharge from runoff to the Lower Kuiseb Aquifer is greatly dependent on the availability of accurately interpreted hydrological data. All efforts should be made according to NamWater (1998) to maintain existing gauging stations at Gobabeb and Rooibank (at least) and to record and evaluate runoff data on a regular basis.

NamWater (1998) suggests concerning the assessment of recharge & sustainable yield

- the collation of existing data from previous investigations to determine more accurately aquifer boundaries, boundary conditions, dynamics of natural recharge and discharge
- proper conceptualization of the aquifer system for the further application in numerical
Groundwater-flow models, which can be applied for management purposes, if realistically
conceptualized and constructed.

Concerning medium and long-term basin management and improvement plans the following is
recommended for the Erongo Region by WATER & WASTE MANAGEMENT TECHNICAL ADVISORY
COMMITTEE/ WWM TAC of THE CHAMBER OF MINES OF NAMIBIA (unpublished meeting minutes
02/2008 & 03/2008):

Because of its value and importance to sustain life, water usage needs to be managed, especially
when used for non-domestic purposes in such large volumes as proposed by the uranium mines. It is
thus important to have an overall governing Water Strategy Framework which should address and
regulate all aspects of water usage of the uranium mines. Before preparing any Strategy on water
usage and the management thereof, there are water-related objectives which must be addressed as
these have a significant influence on any action proposed by the WWM TAC. These strategic issues
are the following:

1. **Clarify the roles and responsibility** of the different role players so that it is clearly
understood who will take responsibility for enforcing what legislation, who will do the
permitting, who and what will be monitored, etc.

   - What are the roles (e.g. management, permitting, monitoring) of the various government
     ministries (DWAF, MET and MME), the Erongo Regional Council and the Water Utility
     companies such as NamWater?
   - How do the different organisations interact (National, regional, local government, Parastatals
     and private water utilities)?
   - How can the CoM influence / improve the performance of some Ministries / Utilities?
   - Is it possible for private Water Utilities to be formed and to compete with NamWater?
   - If water is to be supplied to the mines by a private water utility and not NamWater, what is the
     role of this private utility and how will its operations and performance be monitored?
   - Understand the NamWater organisation structure so that relationships can be built and actions
     put in place to ensure that NamWater is able to provide a reliable and quality service to bulk
     water users. This includes adequate and trained staff, as well as financial backing, to affect
     immediate repairs and improve on maintenance.

2. **Establish the current status and sustainability** of all groundwater resources at the coast,
and not only the Kuiseb and Omdel, so as to establish a broader understanding of the
groundwater resources available and of the opportunities and constraints associated with
this resource.

   - The current status of all the available groundwater resources in the Central Namib should be
determined. We need to understand if these underground aquifers are linked to each other
as cross-flow may influence decisions around extraction? We also need to understand the
rates at which other aquifers are recharged and how much is being extracted from them.
The end product should be data that can be made available to bulk users and water
management agencies and includes water volumes (total abstractable reserves, abstraction
and recharge), sustainability of aquifers, water quality, background radiation, etc.
   - Identify alternative options for potable water (e.g. desalination, improved recycling and
treatment of industrial water).
   - Ensure that NamWater has a clear Policy that outlines how the groundwater resource will be
utilised, describes their commitment towards desalination and explain how desalination will
be incorporated into their water management plan.
Once the status of the ground water aquifers are understood, we need to understand how water users are managing their water. Ideally, any utility (NamWater, private utility or bulk user) that is granted permission, by DWAF, to take water from a ground water resource must prepare and present a Water Master Plan to DWAF who in turn must have a Water Master Plan for the Central Namib. This will facilitate monitoring and management of the sustainable use of water.

We also need to ensure that water users in the Central Namib have valid abstraction licenses from DWAF and we need to understand what the conditions of those licenses are (e.g. how much can be extracted and for what length of time).

3. **The socio-economic environment** and the water needs of all users in the region must be understood.

- The role of local communities in the construction, management, operation and / or maintenance of water supplies, as well as any potential social responsibility or assistance of the uranium mines in general or of a specific mine (e.g. Rössing Foundation) towards the local community in their mining area, should be clearly spelled out.
- Conduct a socio-economic study that profiles current water-users, their needs and expected future needs and identifies potential future users (e.g. eco-tourism, heavy industry in Walvis Bay etc) and their needs.
- Develop a stakeholder database (including their expectations, roles, etc) to ensure that Interested and Affected Parties (I&APs) are included in the development of a regional water strategy. This will include national, regional and local stakeholders other than government departments and bulk users.
- Identify existing and potential water fora and committees and understand their mandates and goals (e.g. the Kuiseb Basin Management Committee-KBMC and Omaruru BMC) as well as in the other basins, are the ideal platform to address water related issues with the community and this avenue should be utilised by other water users (e.g. mines and utilities).

4. **Strengthen the legal framework** pertaining to the use, conservation and management of surface and ground water.

- DWAF to complete the Water Quality (potable and effluent) Regulations being developed in terms of the Water Resources Management Act 2004 and ensure that the regulations are passed so that the Water Resources Management Act 2004 can be enacted.
- Understand the status of the Integrated Pollution Control and Waste Management Bill and work through the issues that are preventing it from being promulgated.
- MET and DWAF to develop regulations for the Integrated Pollution Control and Waste Management Bill and submit these to Cabinet with the Bill. The Regulations should address the “polluter pays principle” to discourage indiscriminate dumping.
- MET and DWAF to finalise the Regulations / Minimum Requirements on the handling, classification, transporting and safe disposal of hazardous waste.

**Issues that need to be addressed by all bulk water users:**

If water in the Erongo Region is to be used and disposed of in a sustainable manner, an integrated Water and Waste Management Strategy will be required for the region. All bulk water users will need to align themselves with this strategy. The issues that will need to be considered in such a strategy are listed below and discussed in more detail in Table 1.

1. Develop a **Water Conservation & Demand Management Plan**, to ensure the optimum use of water.
• **Water conservation** is inter-alia defined at “the minimisation of loss or waste, the preservation, care and protection of water resources and the efficient and effective use of water”.

• **Demand management** is inter-alia defined as “the adaptation and implementation of a strategy (policy and initiatives) by an institution to influence the water demand and usage of water to meet any of the following objectives: economic efficiency, social development, social equity, environmental protection, sustainability of water supply and services, and political acceptability”.

2. **Contribute to the protection of the environment, ecology and natural water resources of the Erongo region by preventing pollution arising from the discharge of liquid effluent and solid waste.**

3. **Establish an information management and monitoring system to improve communication between bulk users and stakeholders and to regulate the use of data.**

4. **Implement a Liquid Waste Management Plan to promote the re-use of treated effluent and reduce the risk of groundwater pollution.**

5. **Implement a Solid Waste Management Plan to coordinate waste collection, transportation and disposal activities.**

6. **Establish a Disaster Management Plan to minimise the risk of groundwater pollution during unforeseen situations.**

Table 1: Table of actions that will need to be put in place if water management issues are to be addressed

<table>
<thead>
<tr>
<th>Responsibility</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Develop a Water Conservation &amp; Demand Management Plan, ensuring the optimum use of water</strong></td>
<td></td>
</tr>
<tr>
<td>DWAF &amp; Water Utility</td>
<td>Ensure that all Water Utilities (e.g. NamWater) have a valid water abstraction and effluent discharge permits for the supply of water from each water resource at the coast and for the discharge of the treated effluent back into the environment (land, fresh water or marine). Audit compliance annually. Ensure that bulk users (e.g. mine) abstracting water directly from a groundwater source and not via a Water Utility have a valid water abstraction and effluent discharge permits.</td>
</tr>
<tr>
<td>DWAF &amp; Bulk users</td>
<td></td>
</tr>
<tr>
<td>Water Utilities / DWAF</td>
<td>Any Water Utility supplying water to the mines directly to have the necessary water abstraction and effluent discharge permits from DWAF.</td>
</tr>
<tr>
<td>MET / DWAF</td>
<td>Develop strategies to ensure that the use and management of the water resources at the coast does not destroy or damage the local ecosystems and biodiversity. These strategies to be shared with all bulk water users and be updated every 5 years.</td>
</tr>
<tr>
<td>NamWater (&amp; other water utilities)</td>
<td>Re-evaluate and annually update its Water Master Plan for the Region, including the sustainable yield calculations of all natural water resources at the coast. Water utilities to communicate this plan to their users.</td>
</tr>
<tr>
<td>Responsibility</td>
<td>Actions</td>
</tr>
<tr>
<td>----------------</td>
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</tr>
<tr>
<td><strong>Bulk users</strong></td>
<td>Bulk water users to draft a site specific Water Conservation and Demand Management (WC&amp;DM) Plan, which must be submitted to DWAF. Specific water conservation objectives should be set and be reviewed at least every 5 years to ensure targets are being achieved and are driving continuous improvement. DWAF to monitor the mines against their consumption targets to ensure efficient and effective use of water. This to include the development and monitoring of a water efficiency rating / benchmark system, to be monitored by the CoM.</td>
</tr>
<tr>
<td><strong>DWAF / CoM</strong></td>
<td>Investigate the development of incentives and rewards for mines achieving the water efficiency rating and for WC &amp; DM initiatives.</td>
</tr>
<tr>
<td><strong>NamWater / DWAF</strong></td>
<td>Bulk water users as part of their WC&amp;DM Plan to in writing via the CBWUF submit a 10-year water demand projection to NamWater, highlighting the expected timeline for consumption. Projections to be updated annually.</td>
</tr>
<tr>
<td><strong>NamWater / Bulk users (CBWUF)</strong></td>
<td>Bulk water users and mines receiving water from NamWater to conclude and sign a Water Supply Agreement with NamWater, highlighting the term and conditions under which such service are provided by NamWater.</td>
</tr>
<tr>
<td><strong>NamWater / Bulk Users / Mines</strong></td>
<td>NamWater to draft a clear Policy on how it will manage water distribution to all of its bulk users in the event of reduced water availability at the coast (as a result of damage / failure of infrastructure, natural disasters or if the sustainable yield is exceeded).</td>
</tr>
<tr>
<td><strong>NamWater</strong></td>
<td>Ensure the long-term sustainability of groundwater resources by supporting the establishment of a seawater desalination plant in the Central Namib area.</td>
</tr>
<tr>
<td><strong>Mines</strong></td>
<td>Educate and create awareness on WC &amp; DM issues within the mine by introducing an internal training programme on WC &amp; DM aspects for employees and contractors.</td>
</tr>
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</table>

**2. Protection of the environment from pollution**

<table>
<thead>
<tr>
<th>Responsibility</th>
<th>Actions</th>
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<tbody>
<tr>
<td><strong>Mines / DWAF</strong></td>
<td>All mines to develop a ground water monitoring programme to prove that they are not polluting the ground water. DWAF to review and endorse the ground water monitoring programmes and monitor results regularly.</td>
</tr>
<tr>
<td><strong>Mines / DWAF</strong></td>
<td>Develop site specific effluent quality discharge standards against which compliance can be measured.</td>
</tr>
<tr>
<td><strong>Mines</strong></td>
<td>Regular (minimum of monthly) effluent discharge monitoring to be done to ensure that effluent discharge standards are being met. Ensure zero discharge of effluent to the environment unless in possession of a valid permit and unless discharge standards are being met.</td>
</tr>
<tr>
<td><strong>Mines or Water utilities</strong></td>
<td>A valid discharge permit should also be obtained in the case of desalination where brine is discharged back into the sea.</td>
</tr>
<tr>
<td><strong>Mines</strong></td>
<td>Each mine to prepare and submit a site specific Mine closure plan (including decommissioning and rehabilitation) to the relevant Ministries for approval (MET, MME, DWAF, MOHSS). The plan shall be updated at least every 3 years.</td>
</tr>
<tr>
<td><strong>CoM</strong></td>
<td>CoM to keep copies of all Mine closure Plans. Someone needs to monitor Mine closure Plans meet the required standard and that mines are complying. If regulators are not performing this task we need to discuss what the best way forward is to ensure industry compliance.</td>
</tr>
<tr>
<td>Responsibility</td>
<td>Actions</td>
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<tr>
<td><strong>3. Establish an information management and monitoring system to improve communication between stakeholders and to regulate the use of data</strong></td>
<td></td>
</tr>
<tr>
<td>Mines / BMC</td>
<td>Bulk users and mines to elect a representative from amongst themselves to attend Basin Management Committee (BMC) meetings and share data with all BMC members.</td>
</tr>
<tr>
<td>Mines / CBWUF</td>
<td>Bulk water users (including the mines) to attend the Coastal Bulk Water Users Forum (CBWUF) meetings and share data with all CBWUF members. Share non-confidential data and expertise gained via the various water programmes within the respective mine / utility / town with external groups / Govt. / to increase awareness of water issues amongst all at the coast on the value and conservation of water.</td>
</tr>
<tr>
<td>Mines / Bulk users</td>
<td></td>
</tr>
<tr>
<td>CoM</td>
<td>Develop a database and / or library of knowledge, information and case studies and ensure easy access to all interested parties.</td>
</tr>
<tr>
<td><strong>4. All bulk water users to implement a Liquid Waste Management Plan to promote the re-use of treated effluent and reduce the risk of groundwater pollution</strong></td>
<td></td>
</tr>
<tr>
<td>DWAF / Bulk water users</td>
<td>Domestic effluent - Ensure that all bulk users have a properly designed and functional Sewage Treatment Plant and a valid Sewage Discharge Permit. This will also apply for the sewage disposal from ablations and related facilities at mines. Industrial effluent - All bulk water users producing industrial effluent to ensure zero discharge of effluent to the environment (water or land) unless in possession of a valid discharge permit and unless discharge standards are being met.</td>
</tr>
<tr>
<td>Mines / industrial bulk users (Namport)</td>
<td>All bulk water users producing industrial effluent to have properly designed and functional facilities to ensure that industrial effluent is not released into the environment. This includes but is not limited to: Effluent treatment plants, Pollution control dams, Evaporation ponds, Tailings storage facilities, Storm water control facilities, Recycling facilities.</td>
</tr>
<tr>
<td>DWAF</td>
<td>DWAF to control and monitor the discharge permits of all Mines and bulk users to ensure compliance and timely renewal thereof.</td>
</tr>
<tr>
<td><strong>5. All mines and towns to implement a Solid Waste Management Plan to coordinate waste collection, transportation and disposal activities and reduce the risk of environmental pollution</strong></td>
<td></td>
</tr>
<tr>
<td>Mines / Municipalities / Industries</td>
<td>Mines, Municipalities and Namport (Bulk users) to draw up an individual site specific Solid Waste Management Plan, addressing the handling, storage and safe disposal of all types of waste. The plans should also address waste minimisation (reduction, recycling and reusing).</td>
</tr>
<tr>
<td>Mines</td>
<td>Investigate the possible establishment of a centralised hazardous waste disposal facility to minimise the risks associated with the transport and disposal of hazardous waste (non radioactive).</td>
</tr>
<tr>
<td>Responsibility</td>
<td>Actions</td>
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<tr>
<td>Mines</td>
<td>Supply various ministries (MOHSS, MME, Met and DWAF) with outline of how radioactive waste will be managed.</td>
</tr>
<tr>
<td>Mines</td>
<td>Investigate the possible re-use of waste oil in burners to minimise on the dumping of waste oil and / or purchase of new oil / diesel for burner / power generation applications.</td>
</tr>
<tr>
<td>Mines / Municipalities / Industries</td>
<td>All domestic and hazardous solid waste to be removed from the mines, Municipalities and Namport on a regular basis and be disposed of at approved landfill sites or hazardous waste disposal facilities only.</td>
</tr>
<tr>
<td>CoM</td>
<td>A system of auditing the Mines for compliance, to be developed and implemented.</td>
</tr>
<tr>
<td>Line Ministry</td>
<td>In the absence of national legislation, towns to be audited by the relevant line Ministry</td>
</tr>
<tr>
<td>6. Each mine to establish a Disaster Management Plan to minimise the risk of groundwater pollution during unforeseen situations</td>
<td></td>
</tr>
<tr>
<td>Bulk Users</td>
<td>All bulk users are to draft a Disaster Management Plan, which clearly outlines how spillages (potable water or effluent) will be contained during a disaster, early warning systems, crises reaction and intervention, public awareness, international assistance, etc.</td>
</tr>
<tr>
<td>Mines / CoM</td>
<td>All mines to submit their Spillage Disaster Management Plans to the CoM.</td>
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<tr>
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<tr>
<td>BMC</td>
<td>Basin Management Committee</td>
</tr>
<tr>
<td>CBWUF</td>
<td>Coastal Bulk Water Users Forum</td>
</tr>
<tr>
<td>CoM</td>
<td>Chamber of Mines</td>
</tr>
<tr>
<td>DWAF</td>
<td>Department of Water Affairs and Forestry</td>
</tr>
<tr>
<td>IAEA</td>
<td>International Atomic Energy Agency</td>
</tr>
<tr>
<td>HERS</td>
<td>CoM Health, Environment, Radiation and Safety Committee</td>
</tr>
<tr>
<td>MET</td>
<td>Ministry of Environment and Tourism</td>
</tr>
<tr>
<td>MME</td>
<td>Ministry of Mines and Energy</td>
</tr>
<tr>
<td>MLRGH</td>
<td>Ministry of local and regional government and housing</td>
</tr>
<tr>
<td>SEMP</td>
<td>Strategic Environmental Management Plan</td>
</tr>
<tr>
<td>WC &amp; DM</td>
<td>Water Conservation and Demand Management</td>
</tr>
<tr>
<td>WRM Act</td>
<td>Water Resources Management Act</td>
</tr>
<tr>
<td>WWM TAC</td>
<td>Water and Waste Management Technical Advisory Committee</td>
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Socio-Economic Assessment in the Context of Vision 2030 and Millennium Development Goals

Information assessment, Gap analysis and Action Plan

IMLT

October 2008
List of Abbreviations

<table>
<thead>
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<tbody>
<tr>
<td>BMC</td>
<td>Basin Management Committee</td>
</tr>
<tr>
<td>DWAF</td>
<td>Department of Water Affairs</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>HDI</td>
<td>Human Development Index</td>
</tr>
<tr>
<td>HPI</td>
<td>Human Poverty Index</td>
</tr>
<tr>
<td>IRBM</td>
<td>Integrated Results Based Management</td>
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<tr>
<td>IWRMP</td>
<td>Integrated Water Resource Management Plan</td>
</tr>
<tr>
<td>KBMC</td>
<td>Kuiseb Basin Management Committee</td>
</tr>
<tr>
<td>MDG</td>
<td>Millennium Development Goal</td>
</tr>
<tr>
<td>MAWF</td>
<td>Ministry of Agriculture, Water and Forestry</td>
</tr>
<tr>
<td>NDP</td>
<td>National Development Plan</td>
</tr>
<tr>
<td>WRMA</td>
<td>Water Resource Management Agency</td>
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<tr>
<td>WRP</td>
<td>Water Resource Plan</td>
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</tbody>
</table>
Table of contents

1 Background .................................................. 1
2 Overview of the Kuiseb Basin ............................. 2
3 Scope of Work .................................................. 2
4 The Context of Socio-Economic Assessment ......... 3
   4.1 IWRM and Vision 2030 .................................. 4
      4.1.1 Theme 1 – Inequalities & Social Welfare ....... 4
      4.1.2 Theme 2 - Peace and Political Stability ....... 5
      4.1.3 Theme 3 - Human Resources, Institutional & Capacity Building .... 5
      4.1.4 Theme 4 – Macro Economic Issues .............. 5
      4.1.5 Theme 5 – Population, Health and Development .... .... 6
      4.1.6 Theme 6 – Natural Resources & Environment .... 6
      4.1.7 Theme 7 – Knowledge, Information and Technology .... 6
      4.1.8 Theme 8 – External Environment ................. 6
      4.1.9 Implications for KBMC .............................. 7
   4.2 IWRM and NDP3 .......................................... 7
      4.2.1 Sustainable Use of Natural Resources .... ...... 9
      4.2.2 Quality of Life ...................................... 10
   4.3 IWRM and Agenda 21 .................................... 10
   4.4 IWRM and the MDGs ...................................... 11
      4.4.1 Goal 1 - Eradicate extreme poverty and hunger .... 12
      4.4.2 Goal 2 - Achieve universal primary education .... 13
      4.4.3 Goal 3 - Promote gender equality and empower women .... 13
      4.4.4 Goal 4 - Reduce child mortality .................. 13
      4.4.5 Goal 5 - Improve maternal health ............... 13
      4.4.6 Goal 6 - Combat HIV/AIDS, malaria and other diseases .... 13
      4.4.7 Goal 7 - Ensure environmental sustainability .... 14
      4.4.8 Goal 8 - Develop a global partnership for development .... 14
   4.5 Managing water within the Vision 2030, NDP3 and MDGs context .... 14
5 Socio-economic assessment of Kuiseb Basin ......... 16
   5.1 Social Aspects - Demographics ..................... 16
   5.2 Human Development Index/Human Poverty Index .... 17
   5.3 Economic Active Population ......................... 18
   5.4 Access to Water ......................................... 19
   5.5 Economic Aspects ....................................... 19
      5.5.1 Mining ............................................. 19
      5.5.2 Tourism .......................................... 22
      5.5.3 Fishing .......................................... 23
      5.5.4 Shipping and the Walvis Bay Harbour .......... 24
      5.5.5 Agriculture ...................................... 25
6 Gap Analysis .................................................. 29
7 Bibliography .................................................. 30
1 Background

A new water law for Namibia, the Water Resources Management Act, Act No. 24 of 2004 (hereinafter referred to as the Water Act), is in the process of promulgation in Namibia. In terms of this Act, Namibia is being divided into new water basins that will be managed by Basin Management Committees (BMC), which will be established in due course. The Basin Management Committees will resort under a Minister whose ministry will be responsible for water resource management in Namibia.

A Water Resources Management Agency (WRMA) will be also be established by the Minister. The primary purpose of this agency will be to assist the Minister in the execution of his/her oversight responsibilities conferred upon him/her in terms of the Act. However, until such time that the WRMA is established and empowered, the Minister will be expected to perform these functions via the existing Ministry of Agriculture, Water and Forestry.

In due cognisance of this pending structure the assignment covered by this document will focus on basin-level developments, particularly the Kuiseb basin, as well as the relationship between and links to the overarching national structures.

Basin Management Committees must co-ordinate with the regional planning component in the regional councils concerned to ensure that water resources within the basin and the region are effectively managed in accordance with the Water Act. In terms of the Act a BMC will be required:

(a) to protect, develop, conserve, manage and control water resources within its water management area;
(b) to promote community participation in the protection, use, development, conservation, management and control of water resources in its water management area through education and other appropriate activities;
(c) to prepare a water resources plan for the basin which must be submitted to the Minister for consideration when developing the National Water Master Plan;
(d) to make recommendations regarding the issuance or cancellation of licences and permits under the Water Act;
(e) to promote community self-reliance, including the recovery of costs for the operation and maintenance of waterworks;
(f) to facilitate the establishment of an operational system and maintenance system of waterworks and the accessing of technical support for water management institutions within its water management area;
(g) to monitor and report on the effectiveness of policies and action in achieving sustainable management of water resources in its water management area;
(h) to collect, manage and share such data as is necessary to properly manage the basin in co-ordination with the Water Resources Management Agency when established, and/or with the Ministry of Agriculture Water and Forestry in the interim;
(i) to develop a water research agenda, together with the Water Resources Management Agency, appropriate to the needs of water management institutions and water users within its water management area;
(j) to help resolve conflicts relating to water resources in its water management area; and
(k) to perform additional functions as the Minister may direct in terms of the Water Act.

As basic principles for water resources management in Namibia the 2000 Namibian Water Policy white paper (MAWRD, 2000) emphasises equitable access, sustainable utilisation and contribution to best socio-economic development, with due consideration for the natural environment. Integrated management of water, land and natural resources within the geographical context of water management basins is fundamental and the input by all involved persons and organisations in this
regard is essential.

2 Overview of the Kuiseb Basin

More than 80 000 people live in the water-poor basin, of which about 70 000 live in Walvis Bay. Others live on commercial and traditional farms, and at mines, tourism enterprises and conservation areas. The present growth centre is Walvis Bay.

Entities that use water from the river are mainly:

(a) The natural environment from pools in the river and alluvial ground water;
(b) Commercial farmers, from small farm dams and boreholes;
(c) The Topnaar community, tourism enterprises and research units in the desert, from hand dug wells and boreholes in and along the river; and
(d) Namibia Water Corporation (NamWater) for supply of water to towns and mines in the Kuiseb basin and other nearby basins. Water for this NamWater scheme is partly sourced from a network of boreholes in and along the Kuiseb River, and otherwise from nearby basins. The towns of Walvis Bay, Swakopmund, Henties Bay, Arandis, the uranium mines Rössing and Langer Heinrich, and several smaller settlements are served from this water supply scheme.

The following are the focal areas for the first cycle WRP of the BMC that the project team must address:

(a) Database;
(b) Baseline information: Making of a consolidated description of existing information and knowledge on:

(b.1) Natural features of the basin with emphasis on geography, climate, water resources;
(b.2) Human settlement, demographics, present land use and socio-economic activities in the basin, and existing knowledge on impact thereof on natural resources (including water), hydrological cycle, ecosystem and other components of the environment;
(b.3) State of environment;
(b.4) Relevant stakeholders;

(c) Identification of gaps and shortcomings in the above information, knowledge and measures;
(d) Demographic changes and development: Summarising of the socio-economic development objectives forthcoming from Vision 2030, Millennium Development Goals 2015, NDPs: for the purpose of identifying the implications on land use, use of natural resources (including water), impact on hydrological cycle and ecosystem impact;

3 Scope of Work

The Terms of Reference required the team members responsible for completing the socio-economic assessment component to familiarise themselves with the relevant legislation, policies and guidelines in Namibia and take full account of all relevant previous studies undertaken under the auspices of the MAWF/DWAF, NamWater, Walvis Bay Municipality, the DRFN and others.

The ToR was very specific that the best available data is to be used to complete the tasks and no fieldwork was required, other than short duration site visits for the purpose of verifying and assessing the reliability of information and data and to carry out consultative processes.

As a final output, Action Plans should be developed by the consultant team, containing short, medium term, or long term actions to be considered for implementation.

It is expected that this report should provide an overview of economic activity and possible future developments and highlight potential economic stimulants and growth areas. It should also consider
requirements forthcoming from objectives set in Vision 2030, NDPs and MDGs. The implications on land use, use of natural resources (including water), impact on hydrological cycle and ecosystem impact expected from these developments should be estimated. Key issues pertaining to integrated development and management of these issues must be identified and prioritised.

4 The Context of Socio-Economic Assessment

“... water is not only the most basic of needs but is also at the centre of sustainable development and is essential for poverty eradication. Water is immediately linked to health, agriculture, energy and biodiversity. Without progress on water, reaching the other Millennium development Goals will be difficult, if not impossible.”

Namibia as an arid country is a good example of the various impacts that water has on society and the economy of a country. In a country where still more than an estimated 60% of the population lives in rural areas, water becomes a key factor in contributing towards rural poverty reduction, food production, promoting industrial development and sector growth and lately also the production of energy. In addition to these, the integrity and quality of our very fragile environment needs to be ensured.

1 Not only does water play a key role in unlocking the economic potential of the country in an attempt to improve the quality of life for all Namibians, but water poses its own development challenges or risks through floods, droughts and water related diseases that can, and do have, huge and serious impacts on communities and ultimately the national economy. A case in point is the floods experienced in 2006 in Mariental and the 2008 floods in the northern-central communal areas of Namibia.

2 How a country chooses to approach the challenge of finding the balance in optimising economic returns from water as a scare resource while conserving the resource and its associated environmental dependencies to ensure sustainable development for future generations while at the same time protecting its communities against the devastation that too much or too little water can cause it will need to consider: The numerous and complex interdependent links between activities that influence and that are influenced by how water is used, and

3 Improved efficiencies of water usage as a limited resource.

The importance of and role that socio-economic assessments will play in developing an appropriate IWRM approach will largely be guided by regional, national and international policies, protocols, agreements and targets that Namibia has ascended to. For the purpose of this analysis, two of the most important documents will be analyses, namely, Vision 2030 as the overall development guideline for national, regional, and local development planning in Namibia up to 2030, the National Development Plan 3 (NDP3), Agenda 21, and the Millennium Development Goals (MDGs) to be achieved by 2015.

While access to safe water is a specific target of Millennium Goal 7 (to which sanitation was added, during the 2002 World Summit on Sustainable Development) the starting point for this review is to consider how water and its management contributes to all the major objectives of Vision 2030, NDP3 and the MDGs for it is in this context that the contribution of the IWRM approach becomes clear.

IWRM provides a framework within which to consider tradeoffs between different development objectives and, where possible, to identify win-win water investments. By aligning and integrating interests and activities that are traditionally seen as unrelated or that, despite obvious interrelationships, are simply not coordinated, IWRM can foster more efficient and sustainable use of water resources to achieve the development goals. It must be emphasised however that an IWRM approach will support not just achievement of these development goals but also long-term economic development, poverty reduction and environmental sustainability that will be needed to sustain that achievement.
This process provides an opportunity to re-examine and modify the current development paradigm such that national development and poverty reduction strategies consider more explicitly (1) the multi-faceted role that water resources management plays in poverty alleviation, environmental protection, and economic development; and (2) the tradeoffs between, and potential synergies among, a multitude of objectives (e.g., equity, economic efficiency, and environmental protection). IWRM is not simply a process designed to carry us to a set of long-range targets, but a way of thinking that enhances our capacity to tackle multi-objective, multi-sectoral development planning—such as is embodied by the Vision 2030 and MDG goals and related implementation strategies.

4.1 IWRM and Vision 2030

The overall goal of Vision 2030 is to develop Namibia into a “… prosperous and industrialised Namibia, developed by her human resources, enjoying peace, harmony and political stability”. This broader vision has been broken down into 8 dimensions, which once achieved, should lead to having achieved the vision. The following diagram provides a graphical illustration of the eight central themes addressed by Vision 2030:

In an attempt to redress the problems associated with these themes eight major objectives were set for Namibia’s Vision 2030. Each of these objectives is thus examined in the context of the key attributes of sound water resource management.

4.1.1 Theme 1 – Inequalities & Social Welfare

The Project Group working on this theme has defined inequality as the “…absence of equality in any respect. It is the state of being unequal, uneven, variable or different. In contrast, equality is the state of being equal, uniform and balanced.”

One aspect in which inequality persists in Namibia has been identified as access to land and natural resources by residents, specifically in communal areas. This is likely to be addressed through land
reform. The aim of land reform it to expand access to land in the southern and central areas of the country, but may not occur at the speed necessary to meet the pressing needs of many rural households. Land reform may lead to changes in land use patterns, which in turn may have an impact on water use and demand. The basin area, as will be seen in sections to follow, has seen relatively few cases of land reform related actions.

4.1.2 Theme 2 - Peace and Political Stability

Peace cannot exist outside political stability. To achieve this there is a need for an enabling environment to attain sustainable development. With regard to principles of development, the following requirements should be in place:

- a good constitution
- high level of legitimacy
- good infrastructure
- availability of resources, and
- an enabling environment

The last three requirements are directly related to water as the basic requirement for progress and development that would be the platform for promoting peace and stability.

4.1.3 Theme 3 - Human Resources, Institutional & Capacity Building

Eleven core issues were identified that would be crucial of the objectives of this theme are to be achieved by 2030. Seven of these will be directly related to the activities of the KBMC. They are:

- Labour force dynamics
- Labour productivity
- Capacity building for economic management
- Full employment
- Efficiency in public and private institutions
- Building and restructuring national institutions for posterity
- Private and public sector interrelations

The extent to which the KBMC will be successful in managing the availability of water in sufficient and sustainable quantities will have a huge impact on the industrial development in the basin area. This will have an impact on labour force dynamics, productivity, and achieving full employment. Capacity building, efficiency, restructuring and creating an environment in which private and public sector can interact all relates to the way in which the KBMC will plan and conduct its work.

4.1.4 Theme 4 – Macro Economic Issues

The key question to be addressed under this theme is the level of economic growth Namibia should aim for in order to ensure a better quality of life for all Namibians.

GDP growth rate, as a proxy for economic development, need to be in the order of 7% per year if the goals of Vision 2030 are to be achieved. Sectoral review shows that growth in the post independence decade emanated mainly from the primary sectors such as fisheries and agriculture. The contribution of the manufacturing sector to growth remained more or less unchanged when compared with the independence periods.

The Namibian economy will however remain reliant on exports of primary commodities, especially minerals, fish, and tourism as the main drivers for economic development. All three of these are the main sectors found in the Kuiseb basin area. It is therefore clear that whatever happens in the basin area will have direct consequences on national economic growth targets.
4.1.5 Theme 5 – Population, Health and Development

The demographic composition of Namibian society will be the determining factor in shaping a Vision for the year 2030. This is because it is the people of Namibia, with their diverse characteristics, talents and needs who will formulate and implement national policy, interact with the natural environment, determine economic growth and who will, ultimately, be responsible for their own destinies.

Demographic patterns have been strongly influenced by the resource endowments of the country, and as will be seen from this report, this is specifically true for the Kuiseb basin area.

Not only will demographic patterns and profiles be influenced by changes in indicators such as Life Expectancy, Infant Mortality Rates and Population Growth, it will also be affected by factors such as internal migration, urbanisation and the impact of HIV/AIDS. Internal migration will be an important issue when investigating the impact of development in the basin area.

One important aspect under this theme is the provision of water and sanitation. The basin area can boast with one of the highest coverage rates in Namibia in terms of this outcome. Maintaining this aspect will however come under pressure as increased numbers of Namibians will migrate to the Erongo region and specifically the basin area as a result of the overall attractiveness of the area in terms of economic opportunities.

4.1.6 Theme 6 – Natural Resources & Environment

Commercial fishing, mining, agriculture and nature centred tourism currently sustain Namibia’s national economy and the majority of rural Namibians rely heavily on natural resources for their livelihoods. This couldn’t be more true about the situation in the basin area. In addition, Namibia’s natural environment provides essential services, natural capital and genetic resources that buffer the Nation against economic uncertainty, disease and environmental change. Namibia’s renewable natural resource base is further characterised by low productivity and/or high variability.

The overriding message from analysing the consequences of the above on the management of natural resources is that:

“… by capitalising on Namibia’s comparative advantages and providing appropriate incentives to use our natural resources in the most efficient way possible, decision-makers today will be in a better position to create a safer, healthier and more prosperous future for all Namibians, to 2030 and beyond’’

This sets the stage for the future operations of the KBMC.

4.1.7 Theme 7 – Knowledge, Information and Technology

This theme will require the KBMC to ensure that all their strategies, planning, and activities will be driven by either utilising or promoting the use of the latest knowledge, information and technologies. This will among other include that the KBMC must ensure that the latest, most accurate and reliable planning information will be utilised for planning purposes. This also implies that as a managing authority, the KBMC will need to ensure that water users in the basin area utilises the latest knowledge, information and technology in their area of business.

4.1.8 Theme 8 – External Environment

The phrase “Think global, act local” is very fitting in terms of the theme. In terms of achieving the ideals set out in Vision 2030, Namibia and more specifically the KBMC, can not operate in isolation. Considerations under this theme will work both ways, the KBMC will need to be aware of changes globally and how these will impact on the local environment(s) and from a local perspective, how can the work of the KBMC be enhanced by forming global partnerships.
From the foregoing analysis, it becomes quite clear that the work of the KBMC will interface with all eight the strategic themes outlined in Vision 2030. It would therefore be very important for the KBMC for internal monitoring to develop an own set of performance indicators that would measure and track its contribution towards national goals and objectives as contained in Vision 2030.

4.1.9 Implications for KBMC
The implications of aims and objectives set out in Vision 2030 for the KBMC are that, although planning of resource utilisation and the management of it will happen within the local context, demand against the resource will most likely be defined from within a national context. Specific expectations are harboured in terms of industry or sectoral performance and these will need to be met within the limitations set by the level of sustainable use of water in the Kuiseb basin.

One weakness in the existing planning setup in Namibia, is that very little strategic analyses have gone into the various dimensions of Vision 2030 with the result that many of the expectations on the national or macro level are in most cases unrealistic. Another challenge for managers of strategic resources is that, like in the case of the Kuiseb basin, no clear expectations have been framed for what should be contributed by the geographical area of the Kuiseb basin. However, it can be expected that significant demands will be made against the development capacity of the basin area, especially in terms of industrial development, the expansion of the Walvis Bay port, mining development as well as the associated human settlement.

It will thus be absolutely necessary for the KBMC to develop a thorough understanding of the dynamics of these industries or sectors in the local as well as national context and to develop a management plan that will continuously monitor changes in these sectors in order to ensure that the resource is managed in a strategic manner and that resource allocation happens in the most effective way possible.

4.2 IWRM and NDP3
The following schematic illustration provides an graphical overview of how medium and long-term planning processes in Namibia are interacting and should aim at achieving the goals and objectives set out in Vision 2030.
Vision 2030 was crafted during the NDP 2 period and NDP 3 is therefore the first post Vision 2030 medium term 5-year development plan. NDP 3 was formulated using the Integrated Results Based Management (IRBM) approach. The main theme of NDP3 is “Accelerated Economic Growth and Deepening Rural Development”.

Specific sectoral targets have been stated for the NDP 3 cycle of which the following are important for consideration in terms of integrated resources planning within the Kuseb River basin:

<table>
<thead>
<tr>
<th>Sector</th>
<th>NDP 2 Growth %</th>
<th>NDP 3 Growth Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual</td>
<td>Baseline Growth Scenario</td>
</tr>
<tr>
<td>Agriculture</td>
<td>2.2</td>
<td>3.7</td>
</tr>
<tr>
<td>Fishing and Fish Processing on Board</td>
<td>-0.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Mining &amp; Quarrying</td>
<td>9.3</td>
<td>0.8</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>2.9</td>
<td>4.9</td>
</tr>
<tr>
<td>Electricity &amp; Water</td>
<td>0.9</td>
<td>3.4</td>
</tr>
<tr>
<td>Hotels &amp; Restaurants</td>
<td>3.6</td>
<td>8.2</td>
</tr>
<tr>
<td>Transport &amp; Communications</td>
<td>11.6</td>
<td>11.4</td>
</tr>
</tbody>
</table>

The baseline growth expectations are based on existing sectoral/industry performances with known expansion or investment programmes while the higher growth scenarios are based on the following
assumptions:

**Agriculture:**
- Accelerated implementation of the Green Scheme
- Accelerated implementation of land reform policies
- Improved implementation of resettlement programmes
- Effective agricultural credit services
- Control of bush encroachment

**Fisheries**
- Additional investment in aquaculture

**Mining**
- Recent demand and high prices will continue
- Non-diamond mineral production including uranium will expand

**Manufacturing**
- Increase in value-adding addition to products from primary industries including diamonds as well as diversification into other manufacturing

**Electricity & Water**
- Investments in electricity generation plants

**Hotels & Restaurants**
- Increased demand from 2010 African Cup of Nations and World Cup as well as private spending

**Transport & Communications**
- Expansion of Walvis Bay harbour

In terms of focus areas identified in NDP 3, most of the expectations directly related to the activities of the Kuiseb Basin Management Committee are related to the fishing industry, mining, manufacturing, hotels and restaurants, and transport in terms of the expansion of the Walvis Bay harbour. However, it is known that the direct impact of changes in economic activities is frequently much smaller than the subsequent indirect impacts in terms of impact on land use and resource utilisation. In order to be prepared it would be necessary to monitor and evaluate on a continuous basis developments in these sectors.

Direct reference to the water sector as a critical factor of production within NDP 3 is made in connection with the sustainable utilisation of natural resources, also as part of improved quality of life, and lastly as a contributor towards regional and International Stability and Integration.

4.2.1 **Sustainable Use of Natural Resources**

Meeting the target growth scenarios for NDP 3 the expected contributions from the water sub-sector are:

- To find new sources of water to meet growing demand. This would include investigations as well as monitoring the utilisation of existing sources, especially ground water;
- Comprehensive data collection;
- Increased water use efficiency through Water Demand Management;
- Increased understanding of water use productivity;
- Increased water supply reliability in terms of quantity and quality to households, agriculture and industry, especially in rural areas; and
- Formulation of Regional Water Supply Development Plans
4.2.2 Quality of Life

Meeting the expectations under the Quality of Life aspect of Vision 2030, NDP 3 has a stated goal of “Affordable and Quality Health Care”. The Water Sub-sector is required to ensure that sufficient and good quality water is supplied to users to reduce the health risks associated with drinking poor quality water. The provision and monitoring of sanitation services to those still without access to the minimum required levels of service delivery is another expected output from the water sub-sector.

Although many of the assumptions on which targets for NDP 3 are based have been turned on its head that will have a serious negative impact on achieving these targets, the expectations from the water sub-sector remains unchanged. The implications of this for the KBMC in terms of developing the IWRMP therefore are that the KBMC will need to spent considerable effort on developing knowledge management systems that would lay the foundation for improved WDM and increased value addition to water resources.

4.3 IWRM and Agenda 21

The worsening poverty, hunger, ill health and illiteracy, as well as the continuing deterioration of the ecosystems on which we depend for our well-being necessitated a different approach to the way development has been approached in the past. However, integration of environment and development concerns and greater attention to them will lead to the fulfilment of basic needs, improved living standards for all, better protected and managed ecosystems and a safer, more prosperous future.
Agenda 21 is a development agenda for the 21st century agreed upon and ascended to by 179 countries in Rio de Janeiro in 1992 at the Earth Summit. At the World Summit on Sustainable Development held in Johannesburg in 2002, this agenda was re-affirmed together with the framing of the Millennium Development Goals.4

Agenda 21 consists of a set of basic development principles with 30 specific development dimensions divided into 3 sections with a fourth section focussing on the means of implementation. The following Table lists the 30 development dimensions with an indication of the relevance of each of these dimensions to the work of the Kuiseb Basin Management Committee; red indicating highly relevant, green relevant, and yellow less relevant but still important.

The purpose of Agenda 21 is to provide a framework within which countries should attempt to approach development agendas and programmes. It makes specific mention of the difficulties that will be faced by developing economies and that it must be “… recognized that these countries are facing unprecedented challenges in transforming their economies, in some cases in the midst of considerable social and political tension.”

In terms of the activities of the KBMC, all programmes should aim to comply with the aims and objectives as set out in each of the 30 development dimensions, but there are certain leeway in terms of absolute compliance especially where the developmental nature of the operating environment would impose severe constraints on the options available.

### 4.4 IWRM and the MDGs

Namibia has played a key role in the formulation of the Millennium Declaration, which has been adopted by all UN member states at the end of the World Summit on Sustainable Development (WSSD) that took place during 2002 in Johannesburg, South Africa. The Millennium Declaration sets out within a single framework the key challenges facing the developing world while at the same time outlines a response to these challenges, and establishes concrete measures for assessing performance through a set of interrelated goals on development, governance, peace, security and human rights. The eight Millennium Development Goals (MDGs) are to:
• Eradicate extreme poverty and hunger
• Achieve universal primary education
• Promote gender equality and empower women
• Reduce child mortality
• Improve maternal health
• Combat HIV/AIDS, malaria and other diseases
• Ensure environmental sustainability
• Develop a global partnership for development.

The Government of the Republic of Namibia is implementing the Millennium Declaration and systematically monitoring the MDGs within the context of national and sectoral development frameworks. Commitment towards achieving these MDG goals has to be integrated into the national process of strengthening policies and programmes to fulfil the grand Vision for the year 2030, through which Namibia will enjoy “Prosperity, Harmony, Peace and Political Stability”.

IWRM provides an excellent framework within which to consider tradeoffs between different development objectives and, where possible, to identify win-win water investments. IWRM can foster more efficient and sustainable use of water resources to achieve the MDGs by aligning and integrating development demands that have traditionally been seen as unrelated or that have never been coordinated. With the Namibian context an IWRM approach will not just support the achievement of the MDGs but also lay the foundation for long-term integrated economic development, poverty reduction and environmental sustainability policies and programmes that will be needed to sustain that achievement. The multi-faceted role that water, as certainly one of the most important enabling factors of production on the one hand and a serious constraint on the other, plays poverty alleviation, environmental protection, and economic development and the various tradeoffs that will need to be made, or possible synergies that can be created, in order to achieve the various national and regional developmental goals can be properly investigated and understood if IWRM processes flowing from the MDG process is applied.

Although it might appear that water management might contribute to only two or three of the MDGs, it in actual fact plays an important role in achieving all of them. Following is a short overview of how improved water management can contributes to the achievement of the various MDGs as well as to highlight opportunities where water can complement other development investments where there are opportunities to contribute to multiple MDGs.

4.4.1 Goal 1 - Eradicate extreme poverty and hunger

It is the poor who must spend most of their resources (money and time) carrying water to their homes and at the same time it is also they who carry the greatest burden of productivity-sapping disease as a result of not having access to safe water and sanitation. Water is essential to economic development, which can create productive livelihoods for the poor. Water can also offer important direct opportunities for the poor to address their food and income needs. In many rural communities, the availability of food on which to subsist is dependent on the uncertainties of nature’s cycles—on whether the rains come and the rivers flow. Creating conditions in which the poor can benefit from opportunities offered by access to water is one of the more important contributions that IWRM can make to poverty reduction.

As will be seen in sections to follow, the basin area is relatively well off in terms of national targets related to access to safe drinking water. This aspect however remains a critical issue that needs to form part of any socio-economic assessment of water resources management planning and monitoring and evaluation.

Poor communities, especially those in the Walvis Bay Rural constituency, are also particularly vulnerable to floods, droughts and similar water-related disasters which destroy their assets and incomes. It is possible to manage climatic uncertainty, to understand and predict the water cycle, to
store and distribute water when it is scarce and protect communities from it when it is over-abundant. These activities are only possible through an integrated approach to resource management. We have seen in the recent past the crippling effect floods and droughts can have in the basin area and it would appear that in the past, predicting, planning for, and responding to these events in a strategic manner continued to be a near impossible task when approached from a silo perspective.

4.4.2 Goal 2 - Achieve universal primary education

The challenge of primary education may seem removed from that of water until it is recognised that in many communities, children’s time is a valuable commodity and school attendance competes with work such as carrying water. Water-related disease also affects school attendance. And the availability of adequate sanitation is a key determinant, for girls in particular, of attendance at school. Once again, the socio-economic profile of the various communities in the basin area is such that access to primary education is not that much of an issue, at least for now. The economic development and associated population dynamics in the area are however of such a nature that this current position can very easily change for the worse.

It is also a common phenomenon in Namibia that the development of new schools many acts as a catalyst for the formation of new settlements and population concentration. New schools developed in the rural parts of the basin area could have an impact on human settlement and migration patterns that could have a knock-on effect on water demand and visa versa.

4.4.3 Goal 3 - Promote gender equality and empower women

Within rural communities, the burden of sustaining households traditionally fell on women. The fetching and storing of water is a task which takes much of their time and that of their female children in many poor communities. Women are also often the primary users of water for productive activities such as agriculture. Properly applied, IWRM approaches can ensure that they have a voice in decisions about water that affect them and can gain access to water to help boost their incomes. Some of these aspects are already being addressed, especially through water point committees in the rural parts of the basin area, but still more could be done to increase the role women play in this process.

4.4.4 Goal 4 - Reduce child mortality

In most poor communities, the health of children is directly related to the quality of their immediate nurturing environment, in which access to safe and clean water plays a key role. Children are at risk when they are without safe water to drink, without adequate water to stay clean and when their caregivers are without the knowledge or power to make decisions about these issues. In developing countries, water-related diseases are almost always amongst the most important causes of death of children under the age of five, using deaths from diarrhoea as a proxy. The basin area is fortunate in this regard that it boasts with relatively excellent statistics. Monitoring this aspect will however remain an important activity to ensure that current performance levels are maintained.

4.4.5 Goal 5 - Improve maternal health

The burden of fetching water and dealing with water-related disease in the family falls disproportionately on women and puts pressure on their own health. Measures that help women to reduce this burden and to improve family health, will contribute to improved maternal health specifically, as well as to gender equality more generally. Once again this will be more related to service delivery to the rural population within the basin area.

4.4.6 Goal 6 - Combat HIV/AIDS, malaria and other diseases

Access to safe water and sanitation services can help to reduce poverty—which in turn is an important determinant of HIV/AIDS—and help to keep HIV-infected people healthy and productive. Water borne diseases are relatively unknown in the area as a result of excellent levels of service delivery. The
basin area is considered as one of a few economic growth hubs in Namibia and industrial development means increased human settlement and both could, if not well managed and controlled, become source of pollutants that may negatively affect the quality of water supply. It would therefore be one of the objectives of integrated water resources management to closely monitor the potential for subsurface water pollution and ensure that preventative measures are put into place well in advance. This would be a typical example of applying the precautionary principle.

4.4.7 Goal 7 - Ensure environmental sustainability

Water is key to the sustainable utilization of land, plant and animal resources. In many countries the main environmental problems, whether it is pollution, erosion or the loss of biodiversity in wetlands and estuaries, relate to water. If the water resources environment is not managed and protected, it will not be able to sustain human communities. A direct contribution offered by IWRM to Goal 7 is to facilitate, in a structured way, the achievement of a balance between economic, social objectives and activities, and environmental sustainability. Although abstraction from the Kuiseb aquifers is considered to be well within sustainable levels, there are claims of negative impacts on the livelihoods of those dependent on natural vegetation such as !Nara due to reduced yields as well as dying of trees in and along the Kuiseb River, which is a major source of fodder for the livestock farmers in the basin area.

Similarly, IWRM can help to ensure that the provision of water supply and sanitation services (the other dimension of Goal 7) is reliable and sustainable. Certainly, the disposal of waste water from sanitation is a major environmental challenge in many countries and there are numerous international examples how this is best addressed through IWRM. Similarly, the reliability of domestic water supplies in dry seasons often depends on influencing the behaviour of other water users. This would therefore not only call for ensuring water supply, but also to put a lot of emphasis on water demand management. The fishing industry in Walvis Bay is an excellent example of how innovative an industry can become in adopting alternative technologies, such as using sea water for cleaning purposes, which can reduce the pressure on supply sources.

4.4.8 Goal 8 - Develop a global partnership for development

Water is a resource that knows no political boundaries. Just as many communities depend on water shared with their neighbours, so too do many countries. What is also shared between countries is the common commitment to achieve the MDGs and, if water is key to meeting the MDGs, cooperation in its management is critical. There are many ways in which countries will need to cooperate if the MDGs are to be reached, by no means limited to financial and technical support for specific activities. Integrated water resource management is one mechanism through which such partnerships can be built, particularly where rivers are shared between more than one country.

The Kuiseb basin is not part of an international border that would involve other countries in terms of managing the basin. However, there is room for developing global partnerships from a different perspective. The area is, as will be discussed in the text to follow, very rich in uranium. With the world demand for uranium as a nuclear fuel ever on the increase, global development partnerships can be developed with foreign investors to invest in sustainable economic development projects as part of their social responsibility towards creating a sustainable future for the communities of the basin area who currently rely on the abstraction of a non-renewable resources to make a living as well as utilising water from the basin for this purpose.

4.5 Managing water within the Vision 2030, NDP3 and MDGs context

Traditionally the provision of piped water merely focussed on providing potable water for drinking and sanitation purposes. It is however recognized that without investment in water resource development and greater attention to the management of water resources, any gains in water services were unlikely to be sustained and that it would be difficult to achieve the goals and objectives in Vision 2030 and the broader Millennium Development Goals. Namibia is fortunate in this context in that having been faced
with severe water supply limitations, authorities have already made considerable progress in adopting an integrated management approach because the situation has required it. In many aspects Namibia has already set a benchmark example for other countries to follow. However, having said this, there are always opportunities to improve on current performance.

To understand how an IWRM approach may contribute to sustainable development and the achievement of the national development goals and MDGs, it is helpful to consider the challenges of the water cycle. The first challenge is the distribution of water. As a rule, communities normally deal with the uneven physical distribution of water by going to where it can be found. This is why great civilisations grew along the rivers of the world, which provided not just the water they needed but also a range of associated goods, including security and transport as well as food and building materials and the removal of human wastes. The Kuiseb basin scenario is however the reverse situation. Human settlement and economic development have taken place in an area faced by constant water scarcity. This therefore requires a management task of not only securing sufficient supplies to provide in existing demand levels on a sustained basis, but it must also ensure that future growth in demand can be supplied with in an environment where supply and resources are not a constant. Changing weather patterns are increasingly becoming a source of concern on a global scale and Namibia is not an exception. Recent extreme events are proof of this.

The second set of challenges relates to the quality of water resources. As population densities and economic activities increase, so too does their impact on water, particularly the impact of human wastes. While the first concern tends to be the impact on the health of people, water quality is also threatened. The Kuiseb aquifers are known for their vulnerability to sea water intrusion as water tables drop. Pollution as well as over-use can also destroy aquatic ecosystems on which communities depend for their livelihoods.

The human “demand side” of water is also complex. The growth of human settlements complicates water supply and management. Small settlements can meet their needs from local resources but, as they grow, water has to be brought from farther away. Similarly, human impacts on water quality in small settlements can be relatively easily managed. However, as settlements grow, their environmental impact spreads well beyond their boundaries. In both cases, the “environmental footprint”, the area affected by the human settlement, expands with both economic development and population numbers.

These impacts will limit our abilities to achieve and deliver on the national development objectives in two ways. First, where services require more infrastructure and supplies come from farther away, they tend to cost more; access increasingly becomes a function of income and wealth rather than a simple relationship with the local environment. This is already evident in that exploration for new aquifers higher up in the Kuiseb basin as well as to the south in less accessible areas is becoming an increased necessity. In the competition for more and higher quality water services, wealthier households and communities tend to fare better. The sources of water of poor households, especially in the rural areas, are claimed by other users, impacting their domestic supplies and their ability to generate at least survivalist levels of incomes. As will be shown in sections to follow, there is a conflict scenario busy developing between farmers upstream of the Topnaar communities that are restricting flows in the Kuiseb river by constructing dams in the upstream contributories and overexploitation of the aquifers in the past by mines and for domestic use led to serious sustainability issues for the Topnaar way of life.

Whereas an IWRM approach to water management cannot in itself deal with all these impacts, it can, if properly implemented, provide some opportunity for the needs of poor communities to be considered and for the communities themselves to engage in management processes and decisions. At the same time, it can enable decisions to be made about environmental protection and the tradeoffs that need to be made between environmental sustainability and economic and social priorities.
5 Socio-economic assessment of Kuiseb Basin

5.1 Social Aspects - Demographics

Analysing demographics in terms of the impact on water resources management and vice-a-versa will necessitate exploring various perspectives of development. As already stated, development initiatives that will impact on the human or bio-physical environment will have to be approached along the guidelines set in vision 2030 and the MDGs.

The population living within the Kuiseb basin can essentially be divided into three main categories, namely the residents of the greater Walvis Bay enclave, the population in the communal area which essential is populating the lower and middle basin areas and lastly the farming community found in the upper basin area.

According to the 2001 Population and Housing census, the Walvis Bay Urban enumerator area had 6,471 households and a total population of 25,026. The statistics for the Walvis Bay rural enumerated area is 4,426 households with a total population of 16,293. The population in the commercial farming area has been estimated according to the following assumptions:

- There are 102 farms falling within the Khomas Region that are also within the Kuiseb basin.
- It is assumed that there will be an average of 4 families living on each farm; the owner with three labourer families.
- The average family size for the Khomas Rural enumerated area was 3.8 in 2001, giving a total farming community size of 1,550 persons from 408 households.

The total population of the basin area is therefore estimated to be 42,869 with a total of 11,305 households. These figures are strictly according to the 2001 Census and it is known that many of these have been disputed as not accurate. The latest estimates provided by the Walvis Bay Municipality are a total permanent population size of approximately 70,000 for the town. This is nearly a three-fold increased based on the 2001 census figures. If this figure is accepted as a more up-to-date and accurate estimate together with the numbers for the rural and farming communities as relatively constant, the total population in the basin would be approximately 88,000 persons.

Table 5.1.1 overleaf summarises the age structure of the population of the Erongo Region. It is interesting to note that nearly 64% of the population of the region is in the age bracket 15 to 59. This phenomenon is mirrored by the population in the Kuiseb basin with the Walvis Bay rural constituency reflecting an even higher percentage of 70.6%. This should be an indication that population growth is not only as a result of natural increases, but includes a large proportion of migration into the region, especially into Walvis Bay as a result of socio-economic factors and considerations.

The rather huge difference between Census figures for total population in the area and the seemingly different population growth profile of the basin area would suggest that the KBMC should attempt to develop a more accurate database on population figures in order to have more reliable planning information at hand for planning and monitoring purposes. Either, the figures have been completely understated as a result of incorrect baseline data or the population growth profile was developed using an incorrect set of assumptions in terms of those issues that influences population growth in the basin area.
Table 5.1.1: Population distribution by area and age group for the Erongo Region – 2001 Census

<table>
<thead>
<tr>
<th>Area</th>
<th>Percentage in age group</th>
<th>Not State</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-4</td>
<td>5-14</td>
</tr>
<tr>
<td>Erongo</td>
<td>10.7</td>
<td>17.6</td>
</tr>
<tr>
<td>Urban</td>
<td>10.0</td>
<td>16.4</td>
</tr>
<tr>
<td>Rural</td>
<td>13.6</td>
<td>22.4</td>
</tr>
<tr>
<td>Arandis</td>
<td>11.3</td>
<td>21.8</td>
</tr>
<tr>
<td>Daures</td>
<td>14.8</td>
<td>23.9</td>
</tr>
<tr>
<td>Karibib</td>
<td>12.7</td>
<td>23.1</td>
</tr>
<tr>
<td>Omaruru</td>
<td>12.2</td>
<td>20.6</td>
</tr>
<tr>
<td>Swakopmund</td>
<td>9.9</td>
<td>16.7</td>
</tr>
<tr>
<td>Walvis Bay</td>
<td>10.8</td>
<td>15.9</td>
</tr>
<tr>
<td>Rural</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walvis Urban Bay</td>
<td>8.5</td>
<td>12.8</td>
</tr>
</tbody>
</table>

It is expected that the basin area will experience accelerated population growth rates based on projected sectoral development plans such as expansion in uranium mining activities, industrial development in Walvis Bay, and developments in the port of Walvis Bay.

5.2 Human Development Index/Human Poverty Index

Development is about enlarging the array of choices for people to choose from in order for them to lead long and healthy lives, to be knowledgeable, to have access to the resources needed for a decent standard of living and to be able to participate in the life of the community. Without these, many choices are simply not available and many of life’s opportunities remain out of reach. Based on this assumption human poverty must be defined and measured to reflect the deprivation of capabilities. Measuring human development therefore requires a set of measures that goes beyond merely looking at GDP and average incomes.

In order to measure progress on achieving the MDGs, the UNDP developed a standard methodology for measuring human development and human poverty. This standard methodology is in the form of two main composite indices, the Human Development Index (HDI) and the Human Poverty Index (HPI).

There are at least three broad purposes for this type of analysis:

- To highlight to stakeholders involved in implementing Vision 2030 and the National Development Plans (NDPs) the progress made on local and regional level towards achieving national goals and objectives.
- To highlight differences in capabilities and deprivations within Namibia between regions and communities, across gender, ethnicity, and other socioeconomic groupings, in order to facilitate the targeting of policies and interventions to achieve the greatest possible impact.
- To facilitate comparisons and the exploration of why human development and poverty regions or targeted areas such as the Kuiseb basin is deteriorating while other regions are making progress.

The HDI seeks to provide a quantitative representation of three main dimensions of human development: a long and healthy life, knowledge and a decent standard of living. These three dimensions are represented by their three associated indices namely the Life Expectancy Index, the
Educational Attainment Index, and the Income Index. A range of values have been set for the achievement of these indices as per Vision 2030. These values are:

<table>
<thead>
<tr>
<th>Index</th>
<th>Minimum Value</th>
<th>Maximum Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Expectancy</td>
<td>35 years</td>
<td>69 years</td>
</tr>
<tr>
<td>Adult Literacy</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>Gross enrolment</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>Adjusted Income per Capita</td>
<td>N$1,400</td>
<td>N$90,000</td>
</tr>
</tbody>
</table>

Table 5.2.1 reflects how the Erongo Region fared against national achievement and a couple of other regions within Namibia.

<table>
<thead>
<tr>
<th>Table 5.2.1: HDI Indicators for Erongo Region compared to national and regional indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erongo Region</td>
</tr>
<tr>
<td>Namibia</td>
</tr>
<tr>
<td>Urban</td>
</tr>
<tr>
<td>Rural</td>
</tr>
<tr>
<td>Khomas Region</td>
</tr>
<tr>
<td>Karas Region</td>
</tr>
<tr>
<td>Omusati Region</td>
</tr>
<tr>
<td>Ohangwena Region</td>
</tr>
</tbody>
</table>

According to Table 5.2.2, the Erongo region outperformed the national averages in all but one aspect, which is that of gross enrolment. The Erongo Region achieved the second highest HDI rating in Namibia only to be beaten by the Khomas Region. What is significant however is the fact that the Erongo Region is the only region to achieve an improvement in its HDI from 1991-1994 to 2001-2004. All the other regions experienced a decline as mirrored by the national index.

This will have certain implications on the region in terms of inter- and intra regional migration patterns as people, especially the unskilled unemployed part of the Namibian nation will flock to the region in order to share in its relative wealth and progress. This requires the KBMC to continuously monitor these aspects to ensure that water as one of the enabling as well as limiting factors of production is utilised in a sustainable and economically optimized manner.

### 5.3 Economic Active Population

According to the 2001 Census, there were 74,902 persons in the Erongo Region 15 years and above, effectively constituting the potential labour force in the region. Of these, 17,938 could be considered as economically inactive being students, homemakers, income recipients, old aged, or retired. A total of 3,747 persons did not state whether they were economically active or inactive. The remainder, 53,217, could therefore be considered as economically active, which is 71% of the population. Of the 53,217 economically active persons, 18,113 or 34% were unemployed.
5.4 Access to Water

Vision 2030 has as its 7th Theme living increasingly a healthier life, which includes issues such as access to clean water as well as food security. Table 5.4.1 provides an overview of the type of access the communities falling within the boundaries of the Kuiseb River basin have in terms of their access to clean drinking water.

Table 5.4.1: 2001 Census – Households by main water source for Walvis Bay Urban and Rural enumerated areas.

<table>
<thead>
<tr>
<th>Source of water supply</th>
<th>Walvis Bay Urban households</th>
<th>Walvis Bay Rural households</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piped water inside</td>
<td>4,801</td>
<td>2,554</td>
</tr>
<tr>
<td>Piped water outside</td>
<td>1,478</td>
<td>1,806</td>
</tr>
<tr>
<td>Public Pipe</td>
<td>129</td>
<td>21</td>
</tr>
<tr>
<td>Borehole</td>
<td>16</td>
<td>7</td>
</tr>
<tr>
<td>Borehole with open tank</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>Borehole with covered tank</td>
<td>26</td>
<td>5</td>
</tr>
<tr>
<td>River/Stream/Dam</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Well</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Not stated</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>6,471</td>
<td>4,426</td>
</tr>
</tbody>
</table>

Table 5.4.2 below shows the distance that people need to walk to the nearest water point.

Table 5.4.2: 2001 Census – Households by walking distance from water source for Walvis Bay Urban and Rural enumerated areas.

<table>
<thead>
<tr>
<th>Source of water supply</th>
<th>Walvis Bay Urban households</th>
<th>Walvis Bay Rural households</th>
</tr>
</thead>
<tbody>
<tr>
<td>0m</td>
<td>6,392</td>
<td>4,372</td>
</tr>
<tr>
<td>1 -100m</td>
<td>74</td>
<td>33</td>
</tr>
<tr>
<td>101 – 200</td>
<td>-</td>
<td>16</td>
</tr>
<tr>
<td>1001+</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Not stated</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>6,471</td>
<td>4,426</td>
</tr>
</tbody>
</table>

It is clear from Tables 5.4.1 and 5.4.2 that the water sector has come close to achieve the national goal of giving the Namibian population total access to clean drinking water. The target for NDP 2, ending 2006, was to achieve 90.7% access for rural communities and 98.4% for urban areas. The inhabitants of the Kuiseb basin enjoy more than a 99% access to clean drinking water. The main issue would therefore not be to have a major drive to provide increased access, but rather to ensure reliable and sustained supply and use of potable water.

5.5 Economic Aspects

5.5.1 Mining

The Erongo Region is probably one of the riches regions in Namibia in terms its mineral wealth. The Kuiseb basin historically played a key role in the development of the mining industry in the region through providing water to the Rössing Mine during its early years of operations. Map 5.5.1.1 below provides a clear picture of current mining activities in the basin area as well as the mineral deposits already identified. It is clear from the map that the area is especially rich in copper and uranium deposits. There are a number of active mining operations in the basin area, mostly granite/marble (3 mines), salt (1 mine), and the part of the Langer Heinrich Uranium Mine that partly falls in the basin.
It was interesting to discover that, when consulting the Ministry of Mines and Energy, they did not carry any knowledge about Hope and Gorob mines and there are no references to any current mining licenses for the areas the two mines are situated at.

Apart from the known copper and uranium deposits there are also substantial gypsum and marble deposits that are not yet mined. Based on this brief desktop analysis it would appear that the basin area holds substantial potential for mining development. This is confirmed by Map 5.5.1.2 overleaf showing all exploration that is currently being conducted or for which EPL applications are pending in the basin area.

The exploration activities appear to be in line with the known resources as reflected in Map 5.5.1.2. Towards the eastern parts of the basin exploration focuses on base metals and minerals which are mainly copper, zinc and to a lesser extent gold. The central part of the basin is heavily explored for uranium and latest reports suggest that significant findings have been made especially towards the south-western part of the basin. Closer to the coast exploration activities focuses on marble, granite and other industrial minerals.

As part of the Vision 2030 theme of the sustainable utilization of natural resources certain performance outputs are being expected from the mining sector. During the period 2001 to 2006, the mining sector in general grew at a rate of 7.7% per year with an average contribution of 10.4% to the GDP. In formulating NDP 3 a specific strategy is stated that the Namibian mining sector will be promoted to further grow, although a smaller contribution to GDP is expected, but with an emphasis on mineral processing and value-adding. With the current growth phase in global demand for base metals and minerals as well as uranium, mainly spurred by China and India, it can be expected that commodity prices will continue to rise. This scenario makes mining development very attractive for investors and the recent interest shown in mining development in Namibia, especially in the target area, is evidence of this. However, such dramatic expansion has its downside in terms of its impact on human settlement and health as well as on the environment and services it demands from the
environment.

Table 5.5.1.1 provides an overview of the impacts that the various mining developments in the recent past and up to 2014 will have in terms of resource input requirements. It is expected that a total of 6,100 new jobs will be created meaning approximately the same amount of households to migrate into the Swakopmund-Walvis Bay area. This would be as a result of the fact that the greater majority of jobs to be created by these new developments would be in the fields of technical and management expertise, skills not readily available in the basin area, region or even the country.
Table 5.5.1.1: Cumulative Impact of new mine developments in Erongo Region

<table>
<thead>
<tr>
<th>Mine</th>
<th>Estimated Year of Commissioning</th>
<th>Estimated Year reaching full production</th>
<th>Estimated No of employees at full production</th>
<th>Power use at full production</th>
<th>Water use at full production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Langer Heinrich</td>
<td>2007</td>
<td>2010</td>
<td>400</td>
<td>15 MW</td>
<td>3 Mm$^3$</td>
</tr>
<tr>
<td>Uramin Trekkopje</td>
<td>2008</td>
<td>2009</td>
<td>800</td>
<td>90 MW (+ Desal)</td>
<td>15 Mm$^3$</td>
</tr>
<tr>
<td>Valencia</td>
<td>2009</td>
<td>2010</td>
<td>600</td>
<td>20 MW</td>
<td>3 Mm$^3$</td>
</tr>
<tr>
<td>Rössing 2</td>
<td>2010</td>
<td>2011</td>
<td>300</td>
<td>10 MW</td>
<td>4 Mm$^3$</td>
</tr>
<tr>
<td>Swakop Uranium</td>
<td>2010</td>
<td>2011</td>
<td>500</td>
<td>15 MW</td>
<td>5 Mm$^3$</td>
</tr>
<tr>
<td>Bannerman Goanikontes</td>
<td>2010</td>
<td>2011</td>
<td>600</td>
<td>20 MW</td>
<td>5 Mm$^3$</td>
</tr>
<tr>
<td>Reptile Uranium</td>
<td>2012</td>
<td>2013</td>
<td>500</td>
<td>15 MW</td>
<td>5 Mm$^3$</td>
</tr>
<tr>
<td>Namura</td>
<td>2011</td>
<td>2013</td>
<td>1000</td>
<td>20 MW</td>
<td>5 Mm$^3$</td>
</tr>
<tr>
<td>Marenica</td>
<td>2013</td>
<td>2014</td>
<td>800</td>
<td>15 MW</td>
<td>5 Mm$^3$</td>
</tr>
<tr>
<td>Erongo Uranium</td>
<td>2013</td>
<td>2014</td>
<td>800</td>
<td>15 MW</td>
<td>5 Mm$^3$</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>6100</td>
<td>270 MW</td>
<td>55 Mm$^3$</td>
</tr>
</tbody>
</table>

In addition to the human migration impact, these mines will require an estimated 270MW of electricity. It is known that Namibia is already at its limits in terms of electricity production capacity and imports from other SADC countries. These requirements will most probably have to be generated close to the demand, which will require an enormous amount of water. The total projected water demand as a direct mining development impact has been estimated to be 55 million cubic meters per annum. This is not considering the multiplier effect of these developments in terms of the forward and backward linkages when one considers the entire value chain in the context of increased local processing and value-adding. The quantity of water required as inputs to these developments will be well beyond the sustainable delivery capacity of the Kuiseb aquifer system. As already is the case, fresh water supplies will have to be augmented by alternative supplies such as desalination.

This development and expected future growth in the mining sector would therefore require close monitoring of the situation, in all its aspects, from the side of the Basin Management Committee.

### 5.5.2 Tourism

The Kuiseb River Basin is relatively well endowed in terms of tourism potential. Map 5.5.2.1 overleaf gives an indication as to the tourism potential based on a combined index calculated taking into consideration the landscape diversity, large herbivore diversity, carnivore diversity, bird population and human settlement. The largest part of the area has been classified as very high to medium high potential. A total of 15 tourist accommodation establishments have been developed in the upper and middle basin areas with 6 camping sites. Statistics provided by the Namibian Tourism Board indicate that there are 43 tourism establishments within the basin area of which 28 are situated in Walvis Bay. Together these 43 establishments can offer a total of 652 rooms or 1,432 bed nights to accommodate tourists. Compared to the Erongo Region, establishments in the basin area constitutes approximately 21% of the total bed nights on offer and 6% of the total number of beds offered nationally.
In terms of national statistics, direct jobs created by the tourism industry were approximately 0.88 per bed offered. Based on this, the tourism industry contributed a total of 1,260 jobs to the total job market in the basin area. In terms of the economic value of each bed night sold, the value added to the total economy of the basin has been N$688 per bed night sold. At an average rate of 30% occupancy and based on these averages, the tourism industry within the basin contributed an estimated N$107 million to the total economy of the basin area in 2006.

However, based on the calculations contained in the tourism satellite accounts as published by the Namibian Tourism Board in collaboration with the World Travel & Tourism Council⁵ the total direct and indirect impact on the economy in terms of jobs created was 71,777 from 2,300,740 bed nights sold in 2006 or 0.031 per bed night sold. The total impact on the national job market as contributed by tourism from the basin area was therefore 156,804 jobs created and/or maintained.

### 5.5.3 Fishing

It is generally accepted that Namibia has one of the most productive fishing grounds in the world rich in populations of demersal and large and small pelagic fish. The fishing industry has always been one of the mainstays of the Namibian economy and Walvis Bay and its economy have developed around this industry. Revenue from fisheries is the second most important foreign exchange earner in Namibia after mining and it contributed on average about 4.8% percent to GDP during the period 2001-2006. In addition, onshore fish processing contributed 1.7% to GDP.

Recent instabilities in the quantities of different fish species caught sent shock waves through the local economy of Walvis Bay and major corrections and structural adjustments took place for the industry to align processing capacity to a level that can be sustained by the resource. Not only had the instabilities in the resource had a negative effect on the industry in Walvis Bay, but other factors such as volatile exchange rates and cost of inputs such as energy also played a significant role in the sharp
decline in the viability in the industry. A number of lay-offs were necessitated which had a negative impact on the employment situation in the town with its associated impacts on the socio-economic conditions.

During the period 2001-2006, Namibia’s annual fish catches averaged about 572,460 tonnes, valued at N$3.6 billion. The total industry employed about 13,400 persons, a number that remained fairly stable over the last 5 years. Although major lay-offs were experienced, the increase in onshore processing created additional job opportunities.

In addition to mainstream fishing, a small but lucrative mari-culture industry also developed in Walvis Bay. Nationally, oyster mari-culture production amounted to 670 metric tonnes, valued at N$64 million per year. Although this year proved to be a disastrous the industry as a result of major losses suffered due to sulphur outbreaks. It is however expected that the industry will recover and that substantial growth can be expected during the next few years.

It was unfortunately not possible to obtain from official sources an industry split between Walvis Bay and Lüderitz to estimate the direct contribution the industry makes to the Walvis Bay economy. However, if a 50-50 split is assumed, the industry would contribute approximately N$1.8 billion to the Walvis Bay economy and provide employment to 6,700 people. This is not taking into account the forward and backward linkages in the total value chain for the industry.

According to the Natural Resource Accounts published by the Department of Water Affairs and Forestry in the Ministry of Agriculture, Water and Forestry the fishing industry in total consumed 0.7 million cubic meters of water in 1997/98 and 1.6 million cubic meters in 2001/02 nationally. This represents less than 0.6% of total national water demand. Given the fact that the fishing industry is the second largest contributor to GDP, this shows that the industry is a very efficient user of water as an input resource.

The expected growth target to be achieved by the fishing industry in NDP3 is 3.6% against a past performance of -0.5% for the last 5-year planning cycle. This could be considered rather optimistic. However, the growth will not only come from increased tonnage landed but also from increased on-land processing and value addition as well as from aquaculture. This will have a definite impact on the demand for fresh water as processing input. The fishing industry has however showed that it is a very efficient user of fresh water for processing. This should however be continuously monitored.

5.5.4 Shipping and the Walvis Bay Harbour

Walvis Bay is a natural gateway for international trade and is strategically located half way down the coast of Namibia with direct access to principal shipping routes. It is Namibia’s largest commercial port, receiving approximately 1,000 vessel calls each year and handling about 3.4 million tonnes of cargo. It is a sheltered deepwater harbour benefiting from a temperate climate and as a result of this it can offer a no-delays service because of bad weather.

The container terminal at the port of Walvis Bay can accommodate ground slots for 380 containers with provision for 210 reefer container plug points. In order to deal with even higher levels of throughput, Namport have steadily improved its cargo-handling facilities. The container terminal can host about 150,000 containers per annum.

Namport has completed the implementation of its Port Master Plan to develop the Port of Walvis Bay as a Hub Port for Southern Africa. The Port Authority is currently busy updating this Master Plan to cater for developments for the next five to ten years that would include an investment of some N$50 million in not only deepening the harbour but other infrastructure to position the Port of Walvis Bay as the gateway to countries in Southern Africa through the Walvis Bay Corridor.
Table 3.5.4.2: Key Statistics on Namport

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(Metric Tonnes)</td>
<td>99/00</td>
<td>00/01</td>
<td>01/02</td>
<td>02/03</td>
<td>03/04</td>
<td>04/05</td>
</tr>
<tr>
<td>Walvis Bay Cargo handled</td>
<td>2,223,698</td>
<td>2,229,362</td>
<td>2,419,158</td>
<td>2,350,120</td>
<td>2,763,446</td>
<td>3,031,357</td>
</tr>
<tr>
<td>National Cargo handled</td>
<td>2,387,316</td>
<td>2,509,233</td>
<td>2,722,096</td>
<td>2,664,506</td>
<td>3,131,822</td>
<td>3,411,754</td>
</tr>
<tr>
<td>%WB</td>
<td>93%</td>
<td>89%</td>
<td>89%</td>
<td>88%</td>
<td>88%</td>
<td>89%</td>
</tr>
<tr>
<td>Turnover (N$ '000)</td>
<td></td>
<td>166,274</td>
<td>181,219</td>
<td>211,270</td>
<td>220,858</td>
<td></td>
</tr>
<tr>
<td>Profit (N$ '000)</td>
<td>33,519</td>
<td>34,141</td>
<td>12,357</td>
<td>32,479</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employees</td>
<td>459</td>
<td>472</td>
<td>591</td>
<td>569</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based on the table above, the Walvis Bay Port constitutes approximately 90% of Namport’s cargo volume. Assuming that Namport’s turnover is related to its cargo volumes handled, the company adds about N$2.7 billion to the Walvis Bay economy.

What is significant about the harbour is the enormous amount of related business activities that is generated by shipping traffic and cargo handling such as Chandlers, maintenance and the ever expanding dry docking facilities at the harbour. Expansion of docking facilities and cargo handling capacity will lead to increased ship traffic that will result in multiple economic effects.

5.5.5 Agriculture

Commercial Agriculture

Most of the land in the upper catchment area of the Kuiseb River Basin has been subdivided into commercial farming units. According to official records there are 109 commercial farms of which one has been bought for resettlement purposes in the Khomas Hochland with another nine farms belonging to affirmative action loan scheme farmers. According to Wittneben & Klintenberg\(^6\) approximately 500 farm workers are being employed on commercial farms supporting approximately 2000 people.

Large stock farming is the most common form of agriculture in the commercial farming area that intersects with the basin area but there are only a few permanent commercial farmers in the area below the escarpment as a result of the high variability of rainfall that makes income from farming financially a non-viable option. Farmers therefore have to rely on a second source of income, mostly permanent employment in Windhoek, Swakopmund or Walvis Bay.

The southern and south western parts of the Basin have also been used for small stock farming, especially Karakul sheep being well adapted to the extreme arid conditions on the edge of the Namib Desert.

Map 3.5.4.1.1 overleaf gives an indication of the carrying capacity of the rangeland in the river basin. In the most eastern part of the basin the average carrying capacity is estimated to be between 30 and
39kg live weight per hectare. As one moves towards the west, the carrying capacity decreases to as little as 10kg/ha.

The Map overleaf reflects the actual live weight in kg/ha of livestock on the rangeland in the basin area.
When compared to the carrying capacity in Map 3.5.4.1.2, it becomes obvious that the area is overgrazed which poses long-term risks in terms of permanent damage to grazing. Bush encroachment has been identified as one of the challenges faced by livestock farmers in this area. Recent studies showed that bush encroachment has a negative effect on ground water recharge as well as moist availability to grasses during the growth season. The net effect would be a continuous reduction in carrying capacity.

The total commercial farming area that falls within the Kuiseb River Basin is approximately 1.18 million hectares. The national average net return per hectare is in the region of N$30/ha. The gross figure varies significantly, depending on land use and the agricultural potential of the area. For large stock farming, the national average is between N$250/ha to N$350/ha. At an average of N$300/ha, the annual gross economic value of agricultural production in this area would therefore be approximately N$354 million. This figure is however a rough estimate. It is very difficult to obtain data related to agricultural production on a regional basis as information in Namibia is mostly collected from a national planning perspective on a macro level and not for regional or micro planning.
Access to water is a critical issue for farmers in this area. Surface water in this area is very limited and farming is dependent on subsurface water. In addition to their reliance on subsurface supplies, these farmers also are faced with a high variability in the yields of these boreholes. These could be supplemented by dams that collect run-off and then allow recharge of subsurface aquifers to happen. There is therefore an increased need for farmers to optimize run-off collection for recharge purposes. This position however puts farmers in serious conflict with the needs and expectations of water users downstream in the lower basin areas. Research completed by the Department of Water Affairs identified more than 300 dams in the commercial farming area within the upper basin area covering a total area of 3.928 km2 which is about 10% of what DWAF records reflect. This is an indication of major illegal reservoir construction in the commercial farming area. The major disadvantage with these dams are the massive volume of water lost as a result of evaporation meaning that very little of the stored volume actually recharge aquifers. As much as 80 to 90% of the stored volume can evaporate.

Communal Agriculture

The Topnaar community is the most significant communal farming community that is found in the Kuiseb basin where farming takes place along the Kuiseb River with the most important source of fodder for the livestock coming from riverine vegetation. Livestock movement is mainly restricted to the riverbed and riverbanks.

Although there are very little accurate or reliable statistics regarding livestock numbers it is commonly known that livestock is kept and bred to maximise livestock numbers and is not necessarily to be marketed. Selling only happens when there is an immediate need for money, e.g. for school fees, weddings and funerals.

The Topnaars also harvest and process the !Nara as a supplementary agricultural activity. Traditionally, !Nara plants were demarcated and individual plants were owned by families. This system has changed during the recent past to an open access system in which everyone competes for the !Nara fruits. It would appear that the !Nara yield has declined over the last couple of years. One of
the factors that is believed to contribute towards the declining !Nara productivity is the dropping water tables of the various Kuiseb River aquifers. This trend has been observed since the early 70’s when wells in the river bed started drying up as a result of over extraction to supply Walvis Bay and Rössing mine. It was observed that !Nara plants as well as trees and other riverine vegetation started dying.

6 Gap Analysis

In terms of viewing integrated water resource management from a Vision 2030 and MDG perspective certain gaps exists in terms of planning information. These gaps are:

1. Known planning targets: Although certain sectoral targets are specified in NDP 3 it would appear that there is very little connection between these and Vision 2030 targets. The KBMC should guard against managing the basin in a reactive manner. Instead, clarity should be sought in terms of the longer-term targets that would guide the KBMC in planning the management of the basin in a sustainable and responsible way.

2. Accurate population statistics: It would appear that information contained in published census statistics is not very accurate and reliable. The KBMC will have to ensure that they have access to reliable population statistics and demographics to ensure that strategic planning and management are executed on accurate and reliable statistics. Partnering with local managing authorities could overcome this problem by collecting relevant population data in their immediate environment as well as on a more frequent basis.

3. Industry water use profiles: Once again it would appear that water demand analysis is done on an aggregate basis. To understand the impacts on water demand in the future the demand profile of the various industries within the basin area should be analysed.
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WATER RESOURCES MANAGEMENT PLAN FOR THE KUISEB BASIN

Water and wetland related environmental education in Namibia and an environmental education strategy for integrated water resources management of the Kuiseb Basin.

Shirley Bethune

with contributions by

Mary Seely and Maria Amakali

October 2008
Table of contents

1 Summary 1
2 Development of Water and Wetland related Environmental Education 3
  2.1 The National Water Awareness Campaign 4
3 Annual celebration of World Wetland Day and World Water Day 7
  3.1 Involvement of Scholars and Students and production of resource materials on water 7
  3.2 Education of Water Point Committees 8
4 River Basin Management in Namibia 8
  4.1 The Kurseb Basin Management Committee 8
  4.2 River Basin IWRM Demonstration Projects 9
  4.3 Guidelines to improve River Basin Management. 10
  4.4 River Basin Profiles 10
  4.5 Education as a tool in River Basin Management 11
  4.6 Proposed Education for Basin Management Committees 12
5 An Environmental Education Strategy for IWRM of the Kurseb River Basin 13
  5.1 Short term Actions 14
    5.1.1 Review lessons learnt: 14
    5.1.2 Coordinate preparation of expert information in lay terms: 14
    5.1.3 Establish Integrated Water Resource Management (IWRM) demonstrations: 14
    5.1.4 Take up offer of training course for KBMC members 15
    5.1.5 Commission, complete and publish the Kurseb Basin Profile 15
    5.1.6 Host World Wetland, World Water Day event 2009: 15
  5.2 Longer term Actions 16
    5.2.1 Arrange exposure excursions associated with Stakeholder Forum meetings: 16
    5.2.2 Involve Regional Councils, division for Rural Services and planners actively 16
    5.2.3 Involve the Ministry of Environment and Tourism and Namib Naukluft Park staff: 16
    5.2.4 Involve NamWater actively in KBMC meetings and activities: 16
    5.2.5 Identify larger water users with money and involve them in KBMC water awareness activities: 17
    5.2.6 Target different levels of community - grassroots, learners and students, urban and rural users and technical stakeholders and extension workers and build up a library of suitable environmental education resource materials: 17
    5.2.7 Organise internships in the basin for both local and international students 17
6 Conclusion 18
7 Acknowledgements 19
8 References 20
1 Summary

This report gives a brief history of water and wetland related environmental education in Namibia since Independence and based on this experience presents an environmental education strategy for integrated water resources management of the Kuiseb River Basin for the Kuiseb Basin Management Committee to consider. This report informed Action Plan 7 dealing with Stakeholder Participation that gives a programme to ensure progressively increasing community participation in relevant aspects of basin management such as water conservation, water awareness, pollution prevention, water demand management and ongoing sharing of information about the Kuiseb River Basin and its water and wetland resources.

The drought of 1992 focussed the attention of the Government of Namibia on the importance of educating the Namibian public about the importance of our scarce water and wetland resources and the National Water Awareness Campaign was launched. In 1995, Namibia joined the Ramsar Convention to affirm its commitment to the conservation of its water resources and wetlands, recognising their international importance. Over the last 16 years, the Directorate of Resource Management in the Department of Water Affairs and Forestry together with the Wetlands Working Group of Namibia and the Desert Research Foundation of Namibia, have been responsible for coordinating the efforts of Government, NGOs and the private sector to create an awareness and appreciation of our vital water and wetland resources.

The Ministry coordinates the annual World Water and Wetland day event. For example, in April this year, an awareness conference on “Healthy River Basins” was held alongside the Okavango River to mark World Wetland and World Water days. This allowed those involved in the river basin management throughout Namibia to share experiences. Mr Usurua Usurua, vice chairman of the KBMC, attended and gave a presentation on the Kuiseb Basin Management Committee. It is recommended that the KBMC continues to be involved in the annual World Water Day and World Wetland Day national events and possibly take the lead in the 2009 celebration, hosting it in the Kuiseb Basin.

Each year, schools are invited to participate in annual, national water and wetland competitions and Nature Conservation students at the Polytechnic of Namibia, who, in future, will be the ones responsible to care for our precious water and wetland resources, are encouraged to do their practical research projects, investigating pertinent river basin issues. During the last 15 years several Polytechnic Nature Conservation, UNAM and international students have been based at Gobabeb for their in-service training and have focused their research on aspects important to the Kuiseb River and its management.

The new Water Resources Management Act No. 24 of 2004, made provision for the establishment of river basin management committees run by representative stakeholder organisations within each river basin. This decentralisation of functions is a challenge that can only succeed if the members of the basin management committees share their knowledge and experience of the basin and collaborate with each other. The formal establishment of the KBMC in 2003, preceded this legislation as a pilot project called ELAK (Environmental Learning and Action in the Kuiseb) to test the viability of the initiative. The ELAK project made a concerted effort to educate and raise awareness of the Kuiseb River and its resources amongst all the stakeholder groups in the basin and arranged several successful exposure visits for stakeholders to gain first-hand knowledge of their basin.
Other basin management committees have not had the benefit of such environmental education initiatives and even for the Kuiseb many of the original members who were involved during the ELAK process have since been replaced by new members. Therefore there is a need to assist both the members of new basin management committees and new members of existing basin management committees, to gain some basic knowledge about their responsibilities in terms of general river basin management and more specific knowledge about their own particular river basin.

This has created a new challenge to the team that over the years, has worked towards educating the public about water and water resources in Namibia. With financial assistance from GTZ, the Namibia Nature Foundation, NNF, and the Southern African Institute of Environmental Assessments, SAIEA, is developing a generic basin management training course, that will be tested first on the newly established Omaruru Basin Management Committee this year before being made available to other basin management committees in Namibia. It is recommended that the KBMC arrange to have a specific basin management training course for their members next year. This generic training course is designed in such a way that it can be adapted specifically to the particular needs of each river basin, a six week period is allowed prior to each course to enable the lecturers to customise the course in consultation with the KBMC chairman.

This narrative report provides the background that informed the development of Action Plan 7 on Stakeholder Participation for the Water Resources Management Plan for the Kuiseb Basin commissioned by the KBMC. Essentially the action plan outlines the environmental education strategy proposed for the KBMC. The goal of the action plan is to achieve extensive well-informed stakeholder participation in Kuiseb Basin Management and the implementation of the water resources management plan for the Kuiseb Basin. The strategy involves both short term actions to be implemented within the next year to 18 months as well as several longer term, ongoing actions that the KBMC should consider implementing.

In the short term it is considered important to remain involved in the annual, national World Water and World Wetland Day events, particularly as the theme for 2009 will be river basins and their management under the slogan “Upstream – Downstream, Wetlands connect us all”.

To better share information on the Kuiseb River, the KBMC is strongly recommended to commission, complete and publish the “Kuiseb Basin Profile” and to include pertinent information gained during the course of the development of this water resources management plan for the Kuiseb Basin. The KBMC should consider making the information collected for the Kuiseb Basin Profile and from the specialist reports from the water resources management plan development available as simple, easy to read fact sheets for schools, visitors to the Gobabeb Training and Research Centre and to hand out at public meetings in Walvis Bay or elsewhere. KBMC should consider supporting community IWRM demonstrations at Walvis Bay and Gobabeb and holding “open days” where these can be demonstrated to share this experience with other basin groups. Another short term activity suggested is to co-operate with the DWAF river basin co-ordinator, Ms Aune Amwaama, and to participate in national river basin meetings and meetings of other river basin committees, to review lessons learnt and to maintain an active ongoing file of these.

In the longer term, the strategy proposes that the KBMC continues to offer at least one exposure visit a year to a place of interest to basin stakeholders in the Kuiseb Basin and that this coincides with the annual Stakeholder Forum meetings. To improve “buy in” from the regional councils, both Erongo and Khomas, MET and NamWater. Attendance of their representatives on the committee could be improved by actively targeting the Deputy Director of the Division Rural Services and planners on the councils, by holding discussions with both the Minister and the PS of MET, possibly inviting them to an “open day” and by requesting NamWater to provide a practical demonstration.
with information at or about the Kuiseb Water Supply Scheme and water supply to the communities alongside the river. KBMC should consider including a session to provide feedback from the WADE project to the Regional councillors, MET, NamWater and other stakeholders within the KBMC.

The KBMC is urged, possibly through the Coastal Bulk Water Users Forum, to make a concerted effort to identify and actively involve larger water users in KBMC activities as sponsors of awareness and information sharing activities and publications. With time they should slowly continue to build up the educational resource materials available on the Kuiseb Basin, by each year targeting a different group of stakeholders in the basin and preparing sound, factual resources for their use. Here the KBMC should consider linking some of these activities to the Coastal Environmental Trust of Namibia, CETN who have an annual water and wetland quiz for all the high schools at the coast.

Finally it is recommended that together with the GTRC, the KBMC continue to offer opportunities for young Namibians from the Polytechnic of Namibia and UNAM to do their in-service training and applied research projects with the Kuiseb Basin environment. The KBMC should provide guidance on research projects appropriate to the ongoing implementation of the Kuiseb Basin Management Plan and other activities of the KBMC.

2 Development of Water and Wetland related Environmental Education

Despite being moved to emergency grazing on the verges of national roads, cattle were dying. Crop fields were laid waste, dust coated the parched earth and water was rationed in towns and cities. After that drought of 1992 the Government of Namibia launched the National Water Awareness Campaign, with founding President, Sam Nujoma, as patron, to educate the Namibian public about the importance of our scarce water and precious wetland resources. Since then, a variety of educational resources have been jointly developed and funded through the collaboration of Government, NGOs and donors such Sida, Norad, GTZ and USAID.

In Namibia, our water resource challenge is not only our limited water resources but more often the sound management of these water resources and the maintenance of the infrastructure to store and distribute this water at basin level. The Government aims to teach all water users, be they large mining companies or a small rural community dependent on hand-dug wells in an ephemeral river, about the wise use of water and making the most efficient and productive use of the little water we have, without polluting or harming the wetlands and aquifers that supply this water.

In December 1995, Namibia affirmed its commitment to the conservation of wetlands by ratifying the Convention on Wetlands of International Importance, better known as the Ramsar Convention (Kolberg undated) and designated the Walvis Bay wetlands, Sandwich Harbour, the Orange River Mouth and Etosha Pan as its first four Ramsar sites (Shaw et al.2004, Bethune et al. 2008, Kolberg & Kolberg undated). The Kuiseb, like all rivers, is included in the Ramsar definition of wetlands.
As can be seen in Figure 1, all Namibia’s perennial rivers originate in neighbouring countries, whilst the rivers within the country are all ephemeral. Meaning that they flow only in direct response to good rains, usually for a few days to a few weeks only, and sometimes not for several years. In good rain years they may flow several times. These rivers, although dry, serve as “linear oases” in that they recharge groundwater and thus maintain a dense strip of riparian vegetation alongside the rivers in otherwise arid conditions (Heyns et al. 1998). This narrow strip of vegetation and good groundwater is essential to the survival of man, his livestock and wildlife particularly where these rivers cross our deserts and semi-deserts (Jacobson et al. 1995).

All our rivers, whether internationally shared perennial rivers, or our ephemeral rivers, shared internally by users in different parts of the catchment (or even across catchments in the case of basin transfer schemes such the link from Calueque to Oshikati) need to be understood and jointly managed by all the users (Pallett et al.1997). Improving this understanding has been the task of the National Water Awareness Campaign.

2.1 The National Water Awareness Campaign

Following the severe drought of 1992, a National Water Awareness Campaign was set up within the then Department of Water Affairs and a publications unit established to oversee the production of suitable and useful resource materials on pertinent water issues. Its main task is to educate the public about our water and wetland resources, shared responsibilities and shared river basins.
The Department of Water Affairs, in collaboration with NGOs like DRFN and donor partners have made a concerted effort to produce at least one factual, educational, resource on water or wetlands each year. A special publications committee, headed by Piet Heyns, was formed under the National Water Awareness Campaign to oversee this. Table 1 lists the water education materials produced in collaboration with the MAWF over the last 16 years, many of them with the DRFN.

Table 1. Educational resources on water developed in collaboration with MAWF since 1992

<table>
<thead>
<tr>
<th>Year</th>
<th>Educational Resource on Water</th>
<th>Reference</th>
<th>Collaborating Partners</th>
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<tbody>
<tr>
<td>1992</td>
<td><strong>Oshanas – sustaining people, environment and development in central Owambo</strong> &lt;br&gt; <strong>Water in Namibia – a resource package to develop awareness of water</strong></td>
<td>Ward 1992</td>
<td>DRFN, DWA, Sida</td>
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<td></td>
<td></td>
<td>Marsh &amp; Seely 1992</td>
<td>DRFN, NORAD, DWA, WWGN</td>
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<tr>
<td>1993</td>
<td><strong>Managing boreholes and grazing areas in Namibia, Okavango &amp; Otjozondjupa</strong></td>
<td>Katjiua <em>et al.</em> 1993 <em>a</em> 1993 <em>b</em></td>
<td>DRFN, SARDEP, MAWRD, UNICEF, MHSS, Sida</td>
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<tr>
<td>1994</td>
<td><strong>More about...water in Namibia</strong> &lt;br&gt; <strong>Understanding the Oshana Environment</strong></td>
<td>Ward 1994 Pallett 1994</td>
<td>DRFN, NORAD, DWA, WWGN DWA</td>
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<tr>
<td>1995</td>
<td><strong>Sink or swim. Water and the Namibian Environment</strong> &lt;br&gt; <strong>Ephemeral rivers and their catchments – sustaining people and development in western Namibia</strong></td>
<td>Jacobson <em>et al.</em> 1995</td>
<td>EnviroTeach -DRFN, DWA, Sida</td>
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<td></td>
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<td>Du Toit <em>et al.</em> 1995</td>
<td>DRFN, Sida</td>
</tr>
<tr>
<td>1996</td>
<td><strong>Managing water points and grazing areas in Namibia, the Cuvelai</strong></td>
<td>Forbes-Irving 1996</td>
<td>DRFN, SARDEP, MAWRD</td>
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<td></td>
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<td>UNICEF, MHSS, Sida</td>
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<tr>
<td>1997</td>
<td><strong>An environmental profile and atlas of the Caprivi</strong> &lt;br&gt; <strong>Sharing water in southern Africa</strong></td>
<td>Pallett <em>et al.</em> 1997</td>
<td>MET, DWA</td>
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<td></td>
<td></td>
<td>Mendelsohn &amp; Roberts 1997</td>
<td>DWA, DRFN, WWGN</td>
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<tr>
<td>1998</td>
<td><strong>Guide to the common plants of the Cuvelai wetlands</strong> &lt;br&gt; <strong>Namibia’s Water – a decision makers guide</strong></td>
<td>Heyns <em>et al.</em> 1998.</td>
<td>DWA, DRFN</td>
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<td></td>
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<td>Clarke 1998</td>
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<tr>
<td>1999</td>
<td><strong>Managing water points and grazing areas in Namibia, Erongo &amp; northern Kunene &amp; Caprivi</strong> &lt;br&gt; <strong>Managing water points and grazing areas in Namibia, Karas and Hardap &amp; Omaheke &amp; southern Kunene</strong> &lt;br&gt; <strong>State of the Environment Report – Water in Namibia</strong></td>
<td>Seely 1999</td>
<td>MET, MAWRD, DFN, WCE</td>
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<td></td>
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<td>Ward 1999</td>
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<tr>
<td>2000</td>
<td><strong>A profile of north-central Namibia</strong></td>
<td>Mendelsohn <em>et al.</em> 2000</td>
<td>MET, DWA</td>
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<tr>
<td>2001</td>
<td><strong>Water Plants of Namibia</strong></td>
<td>Clarke &amp; Klaassen 2001</td>
<td>DWA, NBRI, Sida</td>
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<td></td>
<td></td>
<td>Mendelsohn <em>et al.</em> 2002</td>
<td>DWA, WWGN, Sida</td>
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<td>MET, Govt of Finland.</td>
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<tr>
<td>Year</td>
<td>Educational Resource on Water</td>
<td>Reference</td>
<td>Collaborating Partners</td>
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<tr>
<td>2003</td>
<td><em>Sand and Water: a profile of the Kavango Region</em></td>
<td>Mendelsohn &amp; el Obied 2003</td>
<td>MET, DWA</td>
</tr>
<tr>
<td>2004</td>
<td><em>Teachers Resources on the Okavango River Basin</em></td>
<td>Bethune &amp; van Wyk 2004</td>
<td>Every River Project – Sida Kalahari Conservation Society</td>
</tr>
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<td></td>
<td><em>Best practices and approaches for promoting shared river basin management</em></td>
<td>Every River has its People 2004</td>
<td>DRFN, WWGN</td>
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<td></td>
<td><em>Okavango River: the flow of a lifeline</em></td>
<td>Mendelsohn &amp; el Obied 2004</td>
<td>NNF, Sida, ERP</td>
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<td></td>
<td><em>Wetlands of Namibia</em></td>
<td>Shaw et al. 2004</td>
<td>Every River Project – Sida, WWGN</td>
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<td></td>
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<td></td>
<td>DWA, WWGN, Sida, IUCN, NNF</td>
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<tr>
<td>2005</td>
<td><em>Exploring the Okavango River, a teachers guide to: Okavango River: the flow of a lifeline</em></td>
<td>Ward 2005</td>
<td>DRFN, DWA, EU</td>
</tr>
<tr>
<td></td>
<td><em>Okavango River and Basin – One river, three countries: African tapestry of people and wildlife. Tourist Information Map</em></td>
<td>Ward 2005</td>
<td>DWA, WWGN, EU</td>
</tr>
<tr>
<td>2006</td>
<td><em>Namibian wetlands- Wetlands are special places – lets preserve them</em></td>
<td>Shigwedha &amp; Bethune 2006</td>
<td>MET, WWGN, The Namibian newspaper</td>
</tr>
<tr>
<td></td>
<td><em>Caring for our water – a resource book</em></td>
<td>Roberts &amp; Sguazzin 2007</td>
<td>DWAF, WWGN, GEF SGP, Sida</td>
</tr>
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<td></td>
<td><em>Field Guide to select trees of Kaundo Kubango</em></td>
<td>Curtis &amp; Mannheimer 2007</td>
<td>DWAF, WWGN, Sida, GEF SGF</td>
</tr>
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<td></td>
<td><em>Etosha Pan a wetland of international importance</em></td>
<td>Bethune &amp; Roberts 2007</td>
<td>IRBM, USAID, WWGN, NBRI</td>
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<td></td>
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<td></td>
<td>MET, WWGN, DWAF</td>
</tr>
<tr>
<td>2008</td>
<td><em>Wetlands of Namibia</em></td>
<td>Bethune et al 2008</td>
<td>WWGN, DWAF, Sida</td>
</tr>
<tr>
<td></td>
<td><em>Okavango River- Whose delta is it?</em></td>
<td></td>
<td>MET, WWGN, DWAF</td>
</tr>
</tbody>
</table>

DRFN – Desert Research Foundation of Namibia  
DWAF – Department of Water Affairs and Forestry  
GEF SGP – Global Environment Facility, small grants fund  
MET – Ministry of Environment and Tourism  
MAWRD – Ministry of Agriculture, Water & Rural Development (now MAWF)  
NBRI – National Botanical Research Institute  
NORAD– Norwegian Agency for Development Cooperation  
USAID- United States Agency International Development  

DWA- Department of Water Affairs (now DWAF)  
IRBM– Integrated river basin management project  
MAWF–Ministry of Agriculture, Water & Forestry  
NNF – Namibia Nature Foundation  
Sida – Swedish international Development Agency  
WWGN- Wetland Working Group of Namibia
3 Annual celebration of World Wetland Day and World Water Day

Over the last 16 years the Directorate of Resource Management in the Department of Water Affairs and Forestry together with the Wetlands Working Group of Namibia has been responsible for coordinating the efforts of Government, NGOs and the private sector to celebrate World Wetland Day (2 February) and World Water Day (22 March) every year, to create an awareness and appreciation of our vital water and wetland resources.

Each year, different partners within the water sector collaborate to create a national water event linking these two international water awareness days. In addition to the staff from the MAWF and the Wetlands Working Group, stalwart members over the years have been NamWater, the water utility company, the Ministry of Environment and Tourism, the Namibia Nature Foundation, the Desert Research Foundation of Namibia and the Coastal Environmental Trust of Namibia. The international themes for world water and world wetland day are taken into account when selecting a national theme. Materials produced include wetland and water posters, brochures and stickers.

Ten years ago, the Coastal Environmental Trust of Namibia, CETN, initiated an annual wetland quiz for all the high schools in the coastal towns of Walvis Bay and Swakopmund as well as Arandis. With time this evolved into a series of regional school quizzes or art competitions that culminate in a national competition. The aims of these annual celebrations are to educate the general public and to teach our scholars and students about important water issues.

This year the joint celebration for World Wetlands Day and World Water Day focused on River Basin Management and was held beside the Okavango River.

The objectives of this national “Healthy River Basins” conference were to:

1. Celebrate World Wetland and World Water days,
2. Create an awareness of keeping our River Basins Healthy and actively involve students and scholars,
3. Allow different national and international river basin organisations to share their experiences and so learn from one another,
4. Allow those responsible for managing the water and wetland resources of the Okavango River to share their experience and learn from one another,
5. Gauge local interest in the establishment of a national Okavango Basin Management Committee.

Next year the international theme selected by the Ramsar secretariat, will be river basin management under the slogan “Upstream – Downstream, Wetlands connect us all”, and provides an opportunity for the KBMC to collaborate with the national World Water/Wetlands Day committee to host the event in the Kuiseb Basin, possibly at Friedenau Dam.

3.1 Involvement of Scholars and Students and production of resource materials on water

Each year, schools are involved in national water and wetland competitions. The annual water and wetland quizzes organised by CETN, involve all 10 high schools at the coast and in some years these quizzes are also held in other regions with the winners then competing nationally at the World Wetland/Water day event. In 2003 the NNF produced a poster on Wetlands of Namibia and the next year a booklet specifically for schools was launched (Shaw et al. 2004) this year it was revised, updated and reprinted by Sida (Bethune et al. 2008). Two books on water pollution issues using
Namibian examples have been produced, one aimed at high schools (Tarr et al. 2002) and the other for junior schools (Roberts & Sguazzin 2007).

For the last decade students from the Polytechnic of Namibia have been encouraged to base their practical research projects on pertinent river basin issues. For the last three years the Okavango IRBM project has sponsored 12 such projects on the Okavango River (Bergmann 2008) and this year the Omaruru Basin project sponsored four students. The Wetlands Working Group has sponsored and supervised an additional eight students and has funds for two more students working on wetland birds in 2008 and 2009. Currently, interns from the Polytechnic of Namibia are working with an in-depth study of water recharge in the Kuiseb alluvial aquifer funded by the Gobabeb Centre. This is part of a long-term programme held at Gobabeb to provide hands-on experience of research for development.

As the concept of basin management was developing, Sida funded a thirteen-year programme known as the Summer Desertification Projects, SDP, whereby tertiary education students spent two intensive months learning about and researching key aspects of river basins under the supervision of the DRFN. These took place in the Kuiseb (3x), Omaruru (1x), Cuvelai (2x).

3.2 Education of Water Point Committees

During the 1990s, the Directorate of Rural Water Supply set up a multitude of Water Point committees across the country with the aim of allowing rural water users to manage the maintenance and distribution of local water supplies. This initiative was supported by a strong education campaign that included posters, brochures and a series of books on *Managing water points (including boreholes) and grazing areas in Namibia*. A book was produced for each region and translated into the most widely spoken language (Katjiua et al. 1993a, 1193b, Forbes-Irving 1996, Forbes-Irving et al.1999a, 1999b, 1999c, Ward et al. 1999a, 1999b and 1999c). These addressed the very real concern that opening up new water points could lead to unsustainable grazing practices in dryland areas. These books were prepared for use by Rural Water Supply Extension Offices and were used with varying degrees of success in the various regions. The book specific to the Erongo Region and thus much of the Kuiseb Basin is by Forbes-Irving and Ward (1999a) entitled "*Managing water points and grazing areas in Namibia, Erongo.*"

4 River Basin Management in Namibia

To devolve water resource management to the lowest appropriate level, Namibia’s new Water Resources Management Act 24 of 2004 makes provision for River Basin Management Committees, BMCs. These BMCs will allow stakeholders within each designated river basin to manage their own water resources. To date, two river basin management committees have been set up, the Kuiseb Basin Management Committee (KBMC) established in 2003 and the Ilishana sub-basin Management Committee (IBM) established in 2005. Several more, including ones for the Omaruru, Okavango, Fish and Ugab rivers have been initiated. There are also two active groundwater basin committees, one for the Karstveld aquifer in central Namibia, which predates the new Act, and one for the Stampriet aquifer in the south.

4.1 The Kuiseb Basin Management Committee

The KBMC emerged from the Environmental Learning and Action in the Kuiseb (ELAK) project, funded by EU, which represented a first response to the Namibian Water Resources Management
Review undertaken to review water management in Namibia. This Review proposed the concept of basin management in Namibia and developed the Water Resources Management Act which was signed-off in 2004. The ELAK project pioneered the concepts surrounding the development of a BMC, including initial awareness raising and involvement of a larger Forum of interested people ranging from local subsistence farming communities to the responsible bulk water supplier. ELAK also undertook training and educational activities for the forum members, including such activities as exposure excursions so that forum members could learn about their basin. The project integrated the results of the SDP projects on the Kuiseb Basin and used this overall approach to raise awareness on various fronts about IWRM in general and basin management in particular.

The KBMC includes representatives from twelve different institutions: the Coastal Environmental Trust of Namibia CETN, the commercial and communal farmers, NamWater, Government service providers – DEES, DWAF, MET, RWS, the Erongo and Khomas regional councils, the Walvis Bay Municipality and the Gobabeb Research and Training Centre (Usurua 2008).

4.2 River Basin IWRM Demonstration Projects

An emerging concept in river basin management is the involvement of communities through support of pilot projects that practically demonstrate integrated water resource management. The newly formed Omaruru Basin Management Committee, OmBMC, supports two such projects. The initial establishment of the OmBMC is being funded by the SADC Water Sector through Danida support of IWRM, Integrated Water Resource Management, projects. Here, the Namibia Nature Foundation is actively involved in assisting the stakeholders within the Omaruru Basin to initiate an Omaruru Basin Management Committee and community members are directly involved in practical water resource management issues though selected community IWRM demonstration pilot projects.

The two community-driven IWRM demonstration pilot projects are:

- A women’s garden project at Hakahana that aims to improve the livelihoods of women in an informal settlement on the riverbank, through improved productivity and the incorporation of sound water and energy practices.
- A *Prosopis* harvesting project that aims to maximise environmental and economic benefits of harvesting alien invasive trees alongside the Omaruru River near Okambahe, providing employment to 20 community members including women and youth.

These community projects serve an educational role in that they provide practical demonstrations of integrated water resource management and serve as examples that can be replicated elsewhere. The Stakeholder Forum members have been given the opportunity during their regular meetings to visit both projects and it is hoped that in future members of other BMC’s may visit too and be encouraged to promote similar community-driven IWRM projects in their areas. Four Nature Conservation students from the Polytechnic of Namibia have been directly involved in assisting these communities and have based their water and natural resource related research on aspect of these pilot projects, further emphasizing the educational value of this project.

Throughout this process awareness and education have played a vital role in firstly soliciting the interest of stakeholders and later to improve their knowledge of the river basin and its resources. Currently a poster showing the main features of the basin, its water resources and water supply infrastructure is being developed in consultation with the eighty members of the Omaruru Basin Stakeholder Forum (Muroua 2008).
It is recommended that the KBMC explore opportunities to support similar community pilot projects demonstrating IWRM with the Kuiseb River Basin. It has proved a successful way of engaging grassroots community members in the activities of the OmBMC.

4.3 Guidelines to improve River Basin Management.

To assist new and emerging BMCs, the DRFN in collaboration with GTZ has produced a useful guidebook to explain a practical and tested Basin management Approach (DRFN undated). This useful resource booklet clearly sets out the background to river basins management, the legal obligations and simple steps to soliciting interest and setting up a basin stakeholder forum and a eventually a BMC.

The Basin Management Approach guidebook was part of a GTZ-funded programme establishing a training programme for the lishana sub-basin management committee. Components of the training programme prepared and used with lishana sub-basin committee included: training in the roles and responsibilities of a BMC, the meaning of ‘representation’ while serving on a committee, how to mobilise the community being represented, how to develop awareness raising materials and to raise awareness, how to study water issues in the sub-basin, monitoring water issues in the sub-basin, how to raise funding for the BMC and similar aspects.

It is recommended that this booklet be revised and updated to reflect lessons learnt over the last few years with the implementation of river basin management in Namibia.

In the Okavango River Basin the Every River has its People project, funded by Sida, has actively contributed towards educating stakeholders living alongside and dependent on the resources of, the Okavango River for the past six years (Mwazi 2008). Working with the Every River Project has given rural communities the confidence to engage other stakeholders. This confidence has been achieved by expanding their knowledge, helping them to understand the views and perspectives of others and exposing them to best practices in basin management (Waminyuma 2008). Based on their experience in community- based natural resource management (CBNRM) within the Okavango River basin, the Every River Project, has published a booklet that provides practical information for stakeholders to use to carry out joint planning of basin development and monitoring (Every River has its People 2004).

4.4 River Basin Profiles

The Okavango Basin also serves as an excellent example of the value of basin profile publications in sharing information about river basins. Two important resource books with excellent maps on the Okavango River have been produced by the Every River project in collaboration with the Research and Information Services of Namibia, RAISON. One is a profile of the Namibian section of the river called Sand and Water (Mendelsohn and el Obied 2003) and the other is on the Okavango Basin as a whole called Okavango River: the flow of a lifeline (Mendelsohn and el Obied 2004). In addition to this the project developed a detailed resource package for scholars of all age groups living in the 50 villages around the Okavango Delta in Botswana (Bethune and van Wyk 2004). A teachers guide directly interpreting and keyed to the book Okavango River: the flow of a lifeline (Mendelsohn and el Obied 2004) was developed under the Water and Ecosystem Resources in Regional Development project (WERRD) funded by the EU (Ward 2005).

Prior to the profile on the Kavango Region, the Ministry of Environment and Tourism, produced profiles on the Caprivi, (Mendelsohn and Roberts 1997) the region richest in surface waters mainly linked to the Zambezi River and its floodplains and the north central regions (Mendelsohn et al. 2000) that includes the Cuvelai drainage area, a largely shallow area subject to seasonal flooding.
via a network of “oshanas” from Angola that in exceptional years culminates in the inundation of the Etosha Pan. DRFN has produced useful educational resource materials on these Oshanas (Marsh & Seely 1992, Pallett 1994) and translated it into Oshiwambo to be truly useful. To share information about the Kuiseb River amongst its diverse stakeholders, a Kuiseb Basin Profile has been started by Carole Roberts at DRFN. It will outline the water and other natural resources of the basin and highlight current concerns such as the high water supply requirements of the new and proposed uranium mines. It is strongly recommended that this work continues and that new or pertinent information from the work on the Water Resources Management Plan for the Kuiseb Basin be incorporated into the Kuiseb Profile as appropriate. This profile should be completed and published as a priority KBMC activity within the next 18 months.

4.5 Education as a tool in River Basin Management

The new Water Resources Management Act, 24 of 2008, currently under revision, makes provision for the establishment of river basin management committees run by representative stakeholder organisations within the main river basins and sets out their obligations. (MAWF, 2004)

All surface water resources are closely linked to the hydrological cycle and a report commissioned by the water ministry and funded by GTZ identified 24 hydrological basins (Bittner & Dierkes 2004). See Figure 1. As it would be difficult to manage all 24 basins, experts used agreed criteria to reduce these to 11 proposed water management units that take into account both surface and groundwater sources and present water transfer schemes so combining the water source, water use and water users. Figure 2 shows the proposed main river basin management units (Bittner & Dierkes 2004).

![Figure 2. Proposed Basin Management Units (Bittner & Dierkes 2004)]
As set out in the new Water Resources Management Act, Namibia seeks to establish Integrated River Basin Management “to ensure equitable access to, and sustainable use of, water resources without detriment to the environment nor functioning of the water cycle.” (MAWF, 2004).

Such an integrated management approach takes the wetland resources, their uses, all users and their impacts into account. This integrated basin management approach is a community-centred approach that links people, water, land, plants, animals and the whole basin ecosystem.

According to the Water Resources Management Act 24 of 2004, this approach aims “to ensure equitable access to and sustainable use of water resources; to decentralise water resources management to communities; to recognise the unity of the hydrological cycle and to encourage stakeholder participation in the management of our national water resources.”

This new law states that the establishment of basin management committees can be initiated by Government or by interested persons. It further requires that: it should be an open and transparent process with the focus on hands-on management; the members should undertake to communicate with the communities they represent and that although their main task is advisory, their active support with data collection, water use monitoring, planning of water-related development activities and financing the committees is encouraged (MAWF 2004).

Currently the Kuiseb and lishana BMCs have been formally established, whilst the Omaruru, Ugab and Fish rivers each have an active Stakeholder Forum working towards the establishing BMCs soon. The Okavango has recently formed the Okavango Basin Management Committee and there are two recognised basin management units dealing with groundwater; the Karst and Stampriet Water Management Bodies. To help interested stakeholders form their own river basin management committee the GTZ recently commissioned a guidebook on “Basin Management Approach” (Desert Research Foundation of Namibia undated). This serves as a practical illustration of the role of education in river basin management.

4.6 Proposed Education for Basin Management Committees

The proposed decentralisation of river basin management functions to stakeholders at basin level is a challenge that can only succeed if the members of the new basin management committees are well able to handle their responsibility. This has created a new and challenging role for education in basin management that is being embraced by the same team that over the years has worked to improve the public perception of water and wetlands in Namibia. With financial assistance from GTZ, water scientists and educators are developing a generic basin management training course. This training course on “Sustainable Development and Environmentally Sound Decision-making in river basins” for BMCs is being developed by NNF and SAIEA in close cooperation with the Department of Water Affairs and Forestry and the Ministry of Environment and Tourism. It will be undertaken in two phases:

- Phase 1. Development of a generic training course for all river basins in Namibia and the development of a specific training course on the Omaruru Basin and testing the first training course for the future Omaruru Basin Management Committee in November 2008.
- Phase 2. If successful, rolling out this training to at least eight other river basins in Namibia on request over the next two years 2009 – 2010.

Maps and posters giving background material will be prepared for each Basin, starting with the Omaruru River Basin and a manual compiled for each specific basin. Available resource materials developed over the last 16 years by the DWAF - National Water Awareness Campaign, the DRFN, the NNF, MET (particularly the regional profiles and atlas), and the Wetlands Working Group of Namibia will be available as background reading to the participants – available maps and videos on Namibian water resources will be incorporated into the presentations. Excellent maps include the
ephemeral rivers map developed by DRFN for Sida and the ERP project map of Okavango Basin (Ward undated). Both include pertinent facts about the basins on the reverse side.

Table 2 sets out the proposed components of the planned training course.

Table 2. Main components of the proposed Basin Management Committee course.

<table>
<thead>
<tr>
<th>Components of the proposed Basin Management Committee (BMC) Training: 2008 – 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The BMC’s mandate:</strong> based on revised Water Resources Management Act 24 of 2004 –</td>
</tr>
<tr>
<td>Using material developed by Department of Water Affairs and Forestry – Namibia</td>
</tr>
<tr>
<td><strong>What is sustainable development?</strong></td>
</tr>
<tr>
<td><strong>The Basin in perspective:</strong> Maps and background material will be prepared for each River Basin to show available water resources, wetlands, developed water supply infrastructure, demand and current water users and utilization as well as vulnerable wetlands.</td>
</tr>
<tr>
<td><strong>Introduction to water resources planning:</strong> information will be shared about future demand, infrastructure expansion, water demand management, environmental flows + wetland conservation</td>
</tr>
<tr>
<td><strong>Introduction to sound land use planning</strong> including a comparison of land-use options</td>
</tr>
<tr>
<td><strong>Basin opportunities:</strong> specific to each River Basin</td>
</tr>
<tr>
<td><strong>Introduction to Development Planning:</strong> with emphasis on the challenges of sustainable development in a country with limited water resources.</td>
</tr>
<tr>
<td><strong>Community-based Natural Resources Management CBNRM</strong> including water resource management and the role of water point committees and water point associations</td>
</tr>
<tr>
<td><strong>Integrated Water Resource Management IWRM</strong></td>
</tr>
<tr>
<td><strong>Sustainable resource management plans:</strong> using river basin and water case studies – where available, from the specific basin, e.g. Omdel dam for the Omururu River</td>
</tr>
<tr>
<td><strong>Checklist for consideration of sustainable development and environmental issues</strong> in BMC planning and coordination</td>
</tr>
<tr>
<td><strong>Monitoring, Research and data sharing</strong> – a practical component on what to monitor, how to monitor e.g. rainfall, water quality, pollution, water quantity, flows, environmental health, where to obtain such data and how to use it – with assistance of the Hydrology and Water Quality and Environment sections at the Department of Water Affairs and Forestry and the Wetlands Working Group of Namibia.</td>
</tr>
</tbody>
</table>

5 An Environmental Education Strategy for IWRM of the Kuiseb River Basin

Based on the last sixteen years of experience in water and wetland related environmental education nationally, and to address issues pertinent to the Kuiseb Basin, a practical environmental education strategy is suggested targeting schools and communities in the Kuiseb Basin. This strategy includes awareness and training components and recommends activities to be implemented in the short term as well as several ongoing activities that the KBMC should consider over the longer term.

This first half of this report provided the background information used to design this environmental education strategy. This strategy was used to develop Action Plan 7: Stakeholder Participation for the Water Resources Management Plan. Essentially the action plan outlines and gives a timeframe to the environmental education strategy proposed here for the KBMC.

The goal of the action plan is to achieve extensive well – informed stakeholder participation in Kuiseb Basin Management and the implementation of the water resources management plan for the Kuiseb Basin. It lists six short term actions to be implemented within the next year to 18 months.
as well as seven longer term, ongoing actions for the KBMC water resources management plan. Action Plan 7: Stakeholder Participation is given as Annexure 1 of this narrative report.

5.1 Short term Actions
Taken together these six actions will serve to initiate an effective environmental education strategy and should continue to promote water awareness and the involvement of stakeholders in integrated water resource management within the Kuiseb Basin. Compared to other BMCs in Namibia, the KBMC is already well ahead and should continue with their active engagement in environmental education activities in collaboration with partners such as the GTRC, CETN, GTZ and the basin coordinator at DWAF. The six short term actions are:

5.1.1 Review lessons learnt:
With the co-operation of the Department of Water Affairs and Forestry river basin co-ordinator, Ms Aune Amwaama, the KBMC should request information on river basin management elsewhere in Namibia. KBMC representatives should continue to actively participate in the annual national river basin coordination meetings and whenever possible try to attend the BMC meetings of other river basin committees to gain an insight into other basin management approaches and to share the experience of the KBMC. The KBMC together with the national BMC coordinator should review lessons learnt in their own and other basins and maintain an active ongoing file of these. Initially the KBMC was very active in assisting the newly formed Omaruru River Basin Committee but over the last year their meetings have often coincided making it impossible for them to attend each others meetings. One of the tasks of the national coordinator at DWAF should be to keep a record of proposed meetings and avoid simultaneous meetings in future. The KBMC already takes their task of assisting other emerging basin committees seriously and will host the OmBMC as observers at their meeting in November 2008.

5.1.2 Coordinate preparation of expert information in lay terms:
The KBMC should consider making the technical information collected and contained in the specialist reports for this water resources management plan development available as simple, easy to read fact sheets for schools, visitors to the Gobabeb Training and Research Centre and to hand out at public meetings in Walvis Bay or elsewhere in the basin. Similarly the information available about water management for the Kuiseb Water Supply scheme and produced over the years by DRFN as well as the information collected for the for the Kuiseb Basin Profile and from research activities such as the recently completed WADE project on the recharge of alluvial aquifers in ephemeral rivers including those in the lower Kuiseb Basin should be made available in clear, easy to follow, lay mans language and disseminated to the public when the opportunity arises.
Information from the Coastal Bulk Water Users Forum, about the desalination plants to supply the new Uranium mines should be made available as fact sheets. Earlier resource materials such as the EnviroTeach book “Sink of Swim” and in consultation with teachers from schools in the Kuiseb Basin ways should be explored of how best to make such resource material on water issues available to schools. Such an ongoing environmental education programme should be integrated into the Gobabeb Training and Research Centre’s training and education programme.

5.1.3 Establish Integrated Water Resource Management (IWRM) demonstrations:
The KBMC should try to arrange practical IWRM demonstrations at Walvis Bay and Gobabeb on “open days” where information about integrated water resource use can be shared and made
available to interested school and other groups. Here too it might be possible to work with the GTRC and even with teachers to develop suitable resource materials to provide the participants with factual, written, take – home information after the demonstrations. Schools, students and community groups should be encouraged to develop their own practical IWRM demonstration projects and to serve as guides to share their experiences with others.

Over the last year the Omaruru Basin project has supported two community based IWRM demonstration projects, one a women’s gardening project at Hakahana on the outskirts of Omaruru and the other a Prosopis harvesting project at Okambahe where youth are involved in the clearing of alien invasive trees and wood product sales an alternative income source in the village. It is suggested that representatives of the KBMC visit these projects and consider supporting similar IWRM community projects in the Kuiseb Basin.

5.1.4 Take up offer of training course for KBMC members

It is strongly recommended that the KBMC make use of the opportunity offered by the week-long GTZ–funded basin management course next year. This basin management committee training course is designed in such a way that it can be adapted specifically to the particular needs of each river basin and allows a six week period prior to each course to enable the lecturers to customise the course in consultation with the particular BMC. The KBMC chairman, should approach the GTZ to request a customised training course for the BMC members, given that many of the present members did not have the benefit of the ELAK training and exposure prior to 2003.

5.1.5 Commission, complete and publish the Kuiseb Basin Profile

To better share information on the Kuiseb River, the KBMC is strongly recommended to commission, complete and publish the “Kuiseb Basin Profile” and to include pertinent information gained during the course of the development of this water resources management plan for the Kuiseb Basin as well as new information from the Uranium mine EIA;’s and recent desalination developments.

Work on the Kuiseb Basin Profile should continue and aim to be completed within the next 18 months possibly targeting World Water Day (22 March) 2010. If it is at all possible to complete the profile and publish it by this time next year, the publication could celebrate the 6th anniversary of the establishment of the KBMC. As with other river basin profiles such as “Okavango River – a flow of a lifeline” (Mendelsohn and el Obied 2004), once published the Kuiseb Basin Profile will serve as an important reference for all future studies on the Kuiseb system and provide important factual information to future KBMC members.

5.1.6 Host World Wetland, World Water Day event 2009:

Also important in the short-term is for the KBMC to remain involved in the annual, national World Water and World Wetland Day events. According to Ramsar (The international convention on wetlands), the 2009 international theme for World Wetland Day (2 February 2009) will be river basins and their management under the slogan “Upstream – Downstream, Wetlands connect us all”. It should be remembered that the Ramsar definition of wetlands includes ephemeral rivers such as the Kuiseb. The KBMC should grasp this opportunity to liaise with the national World Wetland/Water day committee via their chairperson, Ms Cynthia Ortmann of the Division Resource Management at DWAF to collaborate to host the 2009 celebration in the Kuiseb River Basin, possibly at Friedenau Dam. This national event annually involves scholars, students, NGOs, the
regional councils, municipalities, the media and government departments responsible for water and wetland resources in Namibia.

5.2 Longer term Actions
In addition to the short term activities discussed above, there are several ongoing actions that will help to ensure the long term effectiveness of the KBMC environmental education strategy. Some of these are already being implemented by the KBMC and the message is simply to continue with them whilst others specifically address shortcomings identified at the 2007/2008 national basin coordination meetings. They are:

5.2.1 Arrange exposure excursions associated with Stakeholder Forum meetings:
The strategy proposes that the KBMC continues to offer at least one exposure visit a year to a place of interest to basin stakeholders in the Kuiseb Basin and that this coincides with the annual Stakeholder Forum meetings. Such visits should involve visits to the IWRM practical demonstration sites discussed in 4.1.3. Funding for these exposure visits could be requested from local sponsors or donors involved in research in the Kuiseb or in basin management projects nationally. The excursions could also target pertinent water developments outside the basin e.g. the desalination plant at Wlotzakasbaken. The opportunities to participate in these exposure excursions would attract more stakeholders to the annual meetings. Learners and students could be involved in the identification of and presentations at interesting sites for such visits.

5.2.2 Involve Regional Councils, division for Rural Services and planners actively
To improve “buy in” from the regional councils, both the Erongo Regional Council and the Khomas Regional Council its is suggested that this could be done by actively targeting the Deputy Director of the Division Rural Services that has now taken on the tasks of the former Directorate of Rural Water Supply and the planners on the councils. It is important that the KBMC identifies individuals, in consultation with Mr Usurua, the vice chair of the KBMC, who is the regional head for DRWS in the Erongo Region. Regional council members should be invited on the exposure visits (4.2.1.)

5.2.3 Involve the Ministry of Environment and Tourism and Namib Naukluft Park staff:
To ensure the attendance and active involvement of MET in KBMC meetings and activities it is suggested that discussions be held with both the Minister and the PS of MET to discuss the best approach regarding official invitations to KBMC meetings. Further consider inviting the Minister and PS to an “open day” event at Gobabeb where the KBMC activities are included in the activities on display. Include the activities such as the anniversary of the Namib Naukluft Park, impacts of Uranium mine exploration, tourism in the NNP, in the KBMC agenda to make the work of the KBMC more relevant to MET officials. Consider asking the MET member on the KBMC to organise the next KBMC exposure visit to the park. If necessary, request the assistance of the basin management coordinator at DWAF.

5.2.4 Involve NamWater actively in KBMC meetings and activities:
To improve attendance and interest from NamWater consider requesting the NamWater representative on the KBMC to provide a practical demonstration with information at or about the Kuiseb Water Supply Scheme and water supply to the communities alongside the river. Further, in consultation with the GTRC, consider inviting the NamWater representative to a special session at
the GTRC to provide feedback from the WADE project, also invite other interested stakeholders within the KBMC to this feedback session. Include time to show and demonstrate the interesting equipment installed in the river for the monitoring of groundwater recharge at Gobabeb.

5.2.5 **Identify larger water users with money and involve them in KBMC water awareness activities:**

Possibly through the Coastal Bulk Water Users Forum, the KBMC should make a concerted effort to identify and actively involve these larger water users in KBMC activities, possibly as sponsors of awareness and information sharing activities and publications in the long term. The KBMC should send personal invitations to identified CEOs of larger industries such as the mines and institutions such as the banks at the coast and invite them to exposure excursions and “open days” to provide them with information about KBMC. They may be willing to assist with the publication of information and educational resource materials about the Kuiseb Basin in exchange for advertising i.e. having their logo on the published materials. The KBMC should identify selected activities for corporations to sponsor e.g. the publication of the Kuiseb Basin Profile mentioned in 4.1.5, school exposure visits to Gobabeb, prizes for school quizzes.

5.2.6 **Target different levels of community - grassroots, learners and students, urban and rural users and technical stakeholders and extension workers and build up a library of suitable environmental education resource materials:**

With time slowly continue to build up the educational resource materials available on the Kuiseb Basin. This can be done by each year targeting a different group of stakeholders in the basin and preparing sound, factual resources for their use.

The KBMC should consider linking some of these activities to the Coastal Environmental Trust of Namibia, CETN who have an annual water and wetland quiz for all the high schools at the coast. CETN can be requested to include information made available by the KBMC like the fact sheets mentioned in 4.1.2 for the annual school quiz competition and to include questions about river basin management and the Kuiseb River Basin and the activities of the KBMC. KBMC should involve CETN and groups such as Rotary to help identify clubs, educational programmes, actively interested school teachers and programmes of other organisations that could assist to improve the outreach of KBMC.

5.2.7 **Organise internships in the basin for both local and international students**

Finally it is recommended that together with the GTRC, the KBMC continue to offer opportunities for young Namibians from the Polytechnic of Namibia and UNAM to do their in-service training and applied research projects with the Kuiseb Basin environment. The KBMC should provide guidance on research projects appropriate to the ongoing implementation of the Kuiseb Basin Management Plan and other activities of the KBMC. This could involve an internship with NamWater to develop suitable resource materials to better explain the bulk water supply scheme in the lower Kuiseb or it could involve the GIST programme at Gobabeb. Such ongoing six-month internships could if properly managed and supervised, could contribute to all the other Environmental Education outreach activities of the KBMC and would equip young Namibian professionals with a sound appreciation of river basin management in their future careers.
6 Conclusion

To achieve the Southern African Vision for Water, Life and Environment in the 21st Century: “Equitable and sustainable utilization of water for social and environmental justice, regional integration and economic benefit for present and future generations”, Namibia has chosen an integrated river basin management approach with a strong educational component to enable the stakeholders within our river basins to effectively implement sound river basin management both within the country and for our internationally-shared river basins (Ortmann 2008).

This narrative report explores the practical implementation of water education through the National Water Awareness Campaign and other environmental education initiatives and traces some of the successes in Namibia. This experience is now being harnessed to develop educational resources and a training course to prepare stakeholders to manage the water resources within their river basins successfully and to use our scarce, valuable water and wetland resources sustainably.

Over the last 16 years a variety of water and wetland educational resources have been developed and the Department of Water Affairs and Forestry together with partners such as the Wetlands Working Group has also been responsible for coordinating the efforts of Government, NGOs and the private sector to celebrate World Wetland and World Water day each year. This year a national conference on Healthy River Basins was held.

Since its Independence, Namibia has done much to implement a successful National Water Awareness Campaign that is effective, not only within Namibia, but also in the neighbouring countries sharing our international river basins. Now this experience is being harnessed to develop a training course to prepare river basin management committees responsible for our national and internationally shared river basins to successfully manage and sustainably use our scarce, valuable water and wetland resources without any detrimental impacts on our scarce water resources and precious wetlands.

Throughout the period under review community members particularly those involved in water point committees have been targeted by specific water education materials. Throughout the water awareness campaign, scholars and students have been actively involved to teach them a greater awareness and appreciation of our water and wetland resources.

Realising the need to assist these BMCs to better manage their water resources, a generic training course was proposed in the GTZ-backed proposal to the EU-ACP which was recently funded, and, more recently, a short, practical, training course tailored to each particular river basin, its resources and development potential was developed. These week-long training courses will be offered to BMC members to help them to better understand the responsibilities placed on them and to share knowledge of their river basin and its resources. Funding for this was made available by GTZ and the first training course will be held this year for the future Omaruru Basin Management Committee.

This narrative report provides the background that informed the development of Action Plan 7 on Stakeholder Participation for the Water Resources Management Plan for the Kuiseb Basin commissioned by the KBMC. Essentially the action plan outlines the environmental education strategy proposed in this report for the KBMC. The goal of the action plan is to achieve extensive well – informed stakeholder participation in Kuiseb Basin Management and the implementation of the water resources management plan for the Kuiseb Basin.

The proposed environmental education strategy involves both short term actions to be implemented within the next year to 18 months as well as several longer term, ongoing actions that the KBMC should consider implementing.
In the short term the environmental education strategy is that the KBMC should:

- Remain involved in the annual, national World Water and World Wetland Day events, particularly as the theme for 2009 will be river basins and their management under the slogan “Upstream – Downstream, Wetlands connect us all”,
- Take up the offer of training the present KBMC members next year,
- Complete and publish the Kuiseb Basin Profile to share information on the Kuiseb River soon,
- Compile easy to read fact sheets from the information collected for the Kuiseb Basin Profile and from the specialist reports for dissemination to schools, visitors to the GTRC and to hand out at public meetings in Walvis Bay or elsewhere,
- Consider supporting community IWRM demonstrations at Walvis Bay and Gobabeb and holding “open days” where these can be demonstrated to share this experience with other basin groups and,
- Co-operate with the DWAF river basin co-ordinator and participate in national river basin meetings and meetings of other river basin committees to share experiences.

In the longer term, this environmental education strategy proposes that the KBMC:

- Continues to offer at least one exposure visit a year to a place of interest to basin stakeholders in the Kuiseb Basin and that this coincides with the annual Stakeholder Forum meetings,
- Improves “buy in” from the regional councils, MET and NamWater by actively targeting the Deputy Director of the Division Rural Services and planners on the councils, holding discussions with the Minister and PS of MET, possibly inviting them to an “open day” and by requesting NamWater to provide practical demonstrations about the Kuiseb Water Supply Schemes,
- Make a concerted effort to identify and actively involve larger water users in KBMC activities as sponsors of awareness and information sharing activities and publications possibly through the Coastal Bulk Water Users Forum,
- Continue to build up the educational resource materials available on the Kuiseb Basin, by each year targeting a different group of stakeholders in the basin and preparing sound, factual resources for their use and possibly linking to CETN and their annual water and wetland quiz for all the high schools at the coast.
- Continue in collaboration with the GTRC, to offer opportunities for young Namibians from the Polytechnic of Namibia and UNAM and other students to do their in-service training and applied research projects with the Kuiseb Basin environment.

7 Acknowledgements

We would like to acknowledge the assistance of all who over the years have worked towards improving the awareness of Namibians from all walks of life about water and wetlands and we would like to thank the World Wetland/Water Day committee for each year organising a national event to celebrate water and wetlands.

To all the students and scholars who over the years have worked with us on water and wetland projects, or participated in our competitions and trips your enthusiasm and commitment are what
keeps us involved. Thank you to Piet Heyns for chairing the publications committee of the National Water Awareness Campaign. Finally, we would like to pay tribute to Keith Wearne of CETN, who sadly passed away this month, for his untiring efforts to instil an appreciation of wetlands and the life they support in our youth and the authorities who should be protecting these fragile habitats.

8 References


Every River has its People. 2004. *Best practices and approaches for promoting shared river basin management. Lessons learnt for methodologies used by the Every River has its People Project for the Okavango River Basin from 2000 – 2004.* Impression House, Gaborone.


Water Resources Management Plan for the Kuiseb Basin

Institutional Development and Capacity Building

Mary Seely
### Abbreviations and acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBWUF</td>
<td>Coastal Bulk Water Users Forum</td>
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<tr>
<td>CETN</td>
<td>Coastal Environmental Trust of Namibia</td>
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<tr>
<td>CoM</td>
<td>Chamber of Mines</td>
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<tr>
<td>DRFN</td>
<td>Desert Research Foundation of Namibia</td>
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<tr>
<td>ELAK</td>
<td>Environmental Learning and Action in the Kuiseb</td>
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<tr>
<td>GBB</td>
<td>Gobabeb Training and Research Centre</td>
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<tr>
<td>GM WWE</td>
<td>General Manager, Water, Waste and Environment</td>
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<tr>
<td>GRN</td>
<td>Government of the Republic of Namibia</td>
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<tr>
<td>HERS</td>
<td>Health, Environment and Radiation Safety</td>
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<td>IWRM</td>
<td>Integrated Water Resources Management</td>
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<td>KBMC</td>
<td>Kuiseb Basin Management Committee</td>
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<td>Local Authority</td>
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<td>MAWF</td>
<td>Ministry of Agriculture, Water Affairs and Forestry</td>
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<td>NGO</td>
<td>non-governmental organisations</td>
</tr>
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<td>Natural Resource Management</td>
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<td>Namibian Water Resources Management Review</td>
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<td>Southern African Development Community</td>
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</tr>
<tr>
<td>WRMP</td>
<td>Water Resources Management Plan</td>
</tr>
</tbody>
</table>
Table of Contents

1  Introduction: ..................................................................................................................... 1

2  Information sources: ........................................................................................................ 1

3  The existing situation: ...................................................................................................... 1

4  Implications for the KBMC: ............................................................................................. 4

5  Roadmap for implementation of the action plans in terms of institutional and capacity development for the KBMC. ........................................................................ 5

6  Conclusions: ..................................................................................................................... 5

7  Bibliography: ................................................................................................................... 6
1 Introduction:
Integrated water resources management plans are a key element for sustainable development generally and use of limited water resources particularly. This Water Resources Management Plan (WRMP) for the Kuiseb Basin represents a first attempt at the development of such a plan in Namibia. The compilation of such a plan usually requires an iterative process involving all stakeholders and wide participation. During the process, a variety of institutions are involved with varying levels of capacity to contribute to the plan according to their allocated or identified mandates. This report represents a preliminary assessment of the institutional framework in which the Kuiseb Basin Management Committee (KBMC) is operating and of the capacity of the components of that institutional framework. It also describes the shortcomings and a step-wise development/capacity building process for the KBMC.

2 Information sources:
To obtain information about the relevant institutions operating within or whose activities touch upon the Kuiseb Basin, a simple questionnaire was sent to 25 institutions or organisations who directly or indirectly are involved with Kuiseb Basin resource management. Three extensive replies were received, two of which directly addressed the queries for which information was requested and one of which simply provided an organogram of the relevant government department. Four additional replies referred the query to other institutions. An undated (+2003) strategic plan was acquired for one of the key institutions. The discussion and recommendations are based on these replies and available information as well as information derived from the records of the Environmental Learning and Action in the Kuiseb (ELAK) project which led to the formation of the KBMC. References consulted are listed in the bibliography.

3 The existing situation:
Management of water and other resources in the Kuiseb Basin involves, directly and indirectly, a number of government and non-government institutions. Those institutions that directly contribute to water management do so primarily through abstraction and use of water recovered from the alluvial aquifer in the lower Kuiseb. These are the institutions responsible for infrastructure development and maintenance and cost recover for water supply services and waste water management. Particularly the Municipality of Walvis Bay (and the Gobabeb Centre on a much smaller scale) implements a multifaceted programme of Water Demand Management (WDM) to ensure efficient water distribution and waste water management. Those institutions that indirectly contribute to water and other resources management do so primarily through their demand for and (in)efficient use of the varied resources including water supply.

Government: The Kuiseb Basin falls within the Erongo and Khomas Regions and peripherally within the Hardap Region and hence the respective Regional Councils have responsibilities within the basin. The Ministry of Agriculture, Water and Forestry (MAWF) is responsible for the management of the water cycle throughout Namibia and hence the water resources in the Kuiseb Basin. The Directorate of Rural Water Supply, within MAWF, provides water supply services to the rural Topnaar Community living in the upper part of the lower Kuiseb Basin, supported by the Directorate of Extension and Engineering Services. NamWater, a State Owned Enterprise also falling under the responsibility of MAWF, provides bulk water to Walvis Bay Municipality, the Topnaar Community who live within the area of their bulk water abstraction scheme and the Gobabeb Training and Research Centre further upstream. The Namib-Naukluft Park (NNP), which encompasses a majority of the lower basin, falls under the Ministry of Environment and Tourism, and uses groundwater to supply wildlife. Mineral rights are controlled by the Ministry of Mines and Energy which has an increasing role with the uranium rush currently being experienced in the Namib Desert. They have also granted copper mining and dimension stone mining rights within the NNP, both operations using water from the Kuiseb alluvial aquifer. The Ministry of Fisheries and Marine Resources controls the fishing industry, one of the major users of Kuiseb water in Walvis Bay. Most other Ministries have responsibilities for their mandate, e.g. health, education, labour, finance, within the Kuiseb Basin.
**Local Authorities:** The Municipality of Walvis Bay is the only Local Authority within the Kuiseb Basin. The Town Council and Rate Payers Association are both involved in water management decisions. In the past, Kuiseb water has supplied Swakopmund Municipality, Arandis and Rössing Uranium Mine, a situation that could recur if supply is temporarily limited.

**NGOs:** The Gobabeb Training and Research Centre is a strategic institution within the Kuiseb Basin responsible for research and training related, *inter alia*, to the Kuiseb River environment and the basin area within the Namib-Naukluft Park. The Gobabeb Centre is supported in its activities by the Coastal Environmental Trust of Namibia (CETN), based in Walvis Bay, and the Desert Research Foundation of Namibia. The free-hold tenure, commercial farmers are represented in the basin through their Farmers’ Associations.

The Southern African Institute of Environmental Assessment (SAIEA) is currently implementing a Strategic Environmental Assessment of the uranium development in the west coast area and, as such, is a key NGO currently operating in the area.

**Private Sector:** The upper, higher-rainfall part of the Kuiseb, from which most of the available water in the basin is derived, falls under the ownership of commercial farmers living on free-hold tenure farmland. The farming community in the lower Kuiseb is represented by the Topnaar Community Foundation. In the lower Kuiseb, Exclusive Prospecting Licenses and mining rights cover the entire Namib-Naukluft Park within the Kuiseb Basin. These involve primarily uranium, copper and dimension stone. The private sector in the form of the fishing and other industries in Walvis Bay and residents of Walvis Bay including Langstrand are major beneficiaries of the water provided from the Kuiseb Basin.

**Mandates and responsibilities:** Based on the information received, and not received, most of the relevant institutions are clear on their own mandates in a fairly narrow sense. All know what they are directly responsible for and, in most cases, to whom they are responsible. Most, based on economic reasoning, are attempting to use water as efficiently as possible even though water management is not their primary focus. Many are not aware, however, of the options and benefits of more efficient management or alternative sources. On the other hand, many are not aware of their responsibilities for, for example, integrated water resources management on a broader scale, including water demand management or the benefits that could be derived. Those who have been exposed to the ELAK project and the KBMC are more aware of their broader mandates and responsibilities than those who have not.

**Human resources and capacity requirements:** Two of the institutions that responded highlighted gaps in human resource availability and provided some examples of limited capacity to carry out their specific mandate. One institution for which information was available indicated that 70% of its workforce is considered semi-skilled. This correlates with the limited availability of supervisory-level staff indicated by other institutions. Another issue highlighted is the availability of staff with vast experience who lack formal qualifications and are consequently highly valued members of staff but disadvantaged in terms of employment conditions. Development of the capacity of mid-level managers, technical and supervisory staff appears to be a key area requiring attention.

**Links:** Those institutions that responded to the request for information indicated good links with other relevant institutions. Several networking/coordination institutions are of high relevance to the Kuiseb Basin and include:

- Coastal Bulk Water Users Forum. This is an organisation with representatives from all water managers and major users on the west coast. Although the Kuiseb Basin is supplying water only to Walvis Bay, Kuiseb water has been used outside of the basin in the past. The other main source of water currently used on the coast is the Omaruru Delta aquifer while desalination will serve the planned uranium mines by 2010 from private desalination plants and one to be erected by NamWater.
- Health, Environment and Radiation Safety (HERS) Technical Advisory Committee on Water and Waste Management (TAC WWM) initiated by the Chamber of Mines in response to the extensive uranium development taking place on the west coast
- Kuiseb Basin Management Committee and Forum
- Regional Council meetings (Erongo Regional Council)

Shortcomings of these existing linkage networks are two fold. The first two listed are well represented technically but focus closely on water supply and waste water management. They are not fully integrating IWRM and WDM in their overall strategies and planning. Primarily through the Walvis Bay Municipality, information from these forums is available to the KBMC. Representation on the third listed network is questionable in that only some of the members have a real mandate from their constituencies and report back to them concerning issues raised. Other KBMC representatives of key institutions sometimes attend meetings but do not actively involve themselves in the programme. Although the Municipality of Walvis Bay participates in Erongo Regional Council meetings, interactions and linkages are limited to the meetings and the minutes that arise.

An additional linkage known but not reported by interviewees and apparently not active in the Kuiseb Basin includes:
- a Basin Management Coordination desk that has been established within the Division of Hydrology, Directorate of Resource Management, MAWF, with a Project Coordinator funded by GTZ. This desk will coordinate issues of all the Basins in the country including the KBMC

**Functions**: In terms of functioning of the KBMC, they do have a common vision for the Kuiseb amongst KBMC and Forum members. Whether this vision is accepted and acted upon by the institutions represented on the KBMC and Forum is not evident. Interpretation of the vision and the actions necessary to address the vision are expected to vary amongst the institutions involved.

The KBMC has mechanisms for iterative, consultative planning that were fully developed at the time of the formation of the KBMC. Consultative planning takes place at the quarterly KBMC meetings although lack of time and staff limit ongoing implementation from taking place between meetings. Broader consultation takes place through KBMC representatives within their own institutions but the extent of this consultation varies widely.

Decision makers who are members of the KBMC have an understanding of the relevant issues and of basin dynamics. Nevertheless, as membership changes, this understanding has not been reinforced. It is questionable as to whether all the institutions from which the KBMC membership is derived have a good understanding and ongoing awareness creation has not been possible from within the KBMC.

Participation by stakeholders in the basin, in terms of monitoring, evaluation and adjustment mechanisms, is limited. The KBMC members meet quarterly and discuss developments within the basin based on their institutions’ ongoing monitoring and evaluation. The KBM Forum meets annually for report back from the KBMC. Adjustment mechanisms are available on an institutional basis. Participation is extended through membership, primarily by the Walvis Bay Municipality, in the two major networks of CBWUF and HERS. To date, as evidenced by the information provided by those queried for this plan, further participation will have to be actively solicited and encouraged by the KBMC. A process for which staff and time is currently not available.

Documentation and dissemination to interested parties at all levels of processes, actions, information and results is mixed. Within the KBMC itself, minutes of meetings and discussions are documented and disseminated. This includes information on various activities within and affecting the basin. Broader dissemination takes place through the newsletter of the Walvis Bay municipality and various articles in popular media.
The gaps and shortcomings in the functioning of the KBMC reflect the limited resources, particularly staff and time, available to devote to the KBMC and the inconsistent support from the side of the relevant government institution.

Adapting the scorecard used in the NWRMR Theme Report on Institutions and Community Participation (MAWRD 2000), the following analysis is presented:

**Clear accountability:** The concept of the BMC is clearly elaborated in the WRMA 2004, which has, however, not commenced. Different messages are conveyed to the KBMC concerning the value and expected orientation of their efforts - at different times by different people, often from the same Ministry. The KBMC has adopted their networking role on a low-key basis awaiting the implementation of the WRMA.

**Clarity of roles:** It is still not clear whether the BMCs are to implement, e.g. ‘prepare a water resources plan for the basin’, or ‘facilitate the establishment of an operational system and maintenance system’ as stated in the WRMA, or simply to familiarise themselves and advise government. This is expected to be addressed with the revision of the Water Resources Management Act. The KBMC continues, however, to network and play a role in information exchange within the basin.

**Efficiency and effectiveness:** This aspect is still constrained by the unclear role that the basin management is expected to take. Moreover, the KBMC requires more dynamic action and a greater staff presence to undertake its networking role more effectively.

**Being knowledge driven:** The KBMC is driven by the knowledge available to it – which is relatively extensive - provided by its individual members and derived from their institutions. Through its networking, however, it does not have easy access to a broader variety of information and knowledge; this deficiency could be addressed by this WRMP.

**Integration:** Based on its membership and the information available, the KBMC uses an integrated approach. The degree of integration could and should be expanded.

**Community participation:** The KBMC was founded on a very participative approach. Participation has decreased, however, as many of the participants have yet to recognise the advantage of the KBMC viewing it from their own narrow institutional perspective only.

**Regionalisation:** The current networking mandate of the KBMC is totally regionalised but additional local support for water management in the basin could be provided, if acceded to by the relevant government authorities.

### 4 Implications for the KBMC:

The Kuiseb Basin Management Committee operates within the above-outlined milieu. While having taken the lead in terms of the recommendations of the Namibian Water Resources Management Review (NWRMR) and the National Water Policy and being in line with the Namibian Water Resources Management Act, the KBMC has not realised its full potential. Two lines of development within the current framework present themselves. The KBMC could capitalise on its strengths and focus on establishing a vibrant institutional framework with dynamic participation involving all relevant stakeholders in the basin. The alternative approach would be to remain a reactive institution responding to changes taking place within the basin but mainly imposed from outside of the basin.

These two lines of development parallel the approaches taken by the networking institutions affecting the KBMC. The CBWUF and HERS are actively organising and planning involving all key players primarily involved in water supply. On the other hand, the Regional Councils and the Basin Management Coordination desk have appeared to take a passive role in terms of engaging or becoming engaged with the KBMC. Recently, however, Erongo Regional Council is being represented
by Mr Usurua of DRWS, since decentralisation of RWS is underway. Other than the last mentioned networking institution, none of these institutions are aware of the potential value of the KBMC. Nevertheless, the approach to be taken by the KBMC must include all the networking institutions to be fully effective.

5 Roadmap for implementation of the action plans in terms of institutional and capacity development for the KBMC.

The KBMC is first and foremost a networking institution to inform stakeholders on plans and developments within the basin and affecting the basin. It has the direct responsibility for developing institutional and human resource capacity within the members of the KBMC and the Forum and the indirect responsibility for involving stakeholders at all levels and providing information to enhance understanding of the various related institutions.

As an institution, the KBMC has been entirely dependent on its elected members who, in turn, are supported by their parent institutions. This has meant that limited resources, particularly staffing and time, are available to devote to the KBMC. Moreover, the members of the KBMC have demonstrated differing levels of proactive involvement to address the objectives of the KBMC. This has resulted in some of the members passively responding to KBMC activities initiated and planned by others or, in some instances, hindering planned actions.

As elaborated in the Action Plan, it is clear that the KBMC requires additional resources to energise and coordinate the activities of the KBMC. These resources should, in the first year, support the activities of two people, one volunteer to re-kickstart activities and one long-term employee. They would actively address the networking and information exchange mandate of the KBMC to raise the visibility and the status of the KBMC amongst members, member institutions and those managing and using resources in the basin in general. Outsourcing and mentoring approaches could be integrated into the implementation process. For this to happen successfully, however, strong and visible support must be provided from the Ministry responsible for overseeing Basin Management under the WRMA.

In terms of the capacity of the KBMC, it is essential that all committee members be provided with a constant flow of easily assimilated information concerning the basin and the activities of other institutions in the basin so that they can exercise their mandate effectively. It is also essential that short courses be implemented to address the several requirements of a BMC, as indicated in the WRMA. This would require the backing of the responsible Ministry to intervene on behalf of the KBMC members to allow their participation. Also in terms of capacity, the use of mentors and outsourcing should be undertaken by the KBMC to support their ongoing activities in terms of awareness raising and capacity building.

6 Conclusions:

Under the current circumstances, the KBMC is maintaining its institutional integrity although restricted in terms of staffing and time available. This situation could be rapidly strengthened with the addition of dynamic staff and a programme to address key issues throughout the basin.
7 Bibliography:


Databases for improved management of the Kuiseb River Basin, by the KBMC: Considerations, recommendations and an Action Plan

By:
Dr. Patrik Klintenberg
Table of contents

A. Database for use by the Project Team, and information processing........................................... 1

  Brief description of the three databases developed for the KBMC............................................. 1

  GIS database .................................................................................................................................... 1

  The Meta Database ......................................................................................................................... 1

  The searchable source material database ...................................................................................... 2

B. Database and GIS for the KBMC.................................................................................................... 2

  Annex 1. Database Survey form......................................................................................................... 5

  Annex 2 Quote for required hard and software for the KBMC database...................................... 7
A. Database for use by the Project Team, and information processing

The Geographer was asked to recommend database and information processing format(s) for hosting and referencing baseline information and other work produced in terms of this assignment, and to subsequently serve as initiating database for the KBMC. To achieve this it was important to consult with the rest of the team to find out what kinds of data they would make use of to compile the individual expert report. This was done by e-mail, see Annex 1. The query resulted in a very limited responses. The hydrology department within MAWF responded that they are making use of a hydrology database, however, no more specific information about kind of information, which variables and spatial and temporal extent of datasets was communicated. The second data set referred to by two of the consultants was the GIS database developed by the DRFN for the Kuiseb Profile. Based on these limited responses to the survey it can be concluded that most of the experts have compiled their reports without making use to any extensive datasets or databases that can be regarded to be useful to the KBMC and their decision-making. However, three different databases can still be developed, making use of the data referred to, i.e. the GIS data originally developed for the KBMC Profile, a Meta database describing this data, and other GIS data sources held by the Hydrology department in MAWF, and finally a searchable database comprising all experts reports and annexes to be produced for the Water Resource Management Plan.

Brief description of the three databases developed for the KBMC

GIS database
This database contains all the GIS files and related attribute data that have been created for the Kuiseb Profile. The database is ordered into a simple thematic structure, i.e. GIS files related to a theme, e.g. rainfall are all stored in the same folder, making the compilation of maps straightforward. Projects are saved in a separate folder on the same level as the theme folders.

Data format of the GIS database
All GIS files are in ArcView format, i.e. shape files (*.shp). ArcView is presently the most commonly used vector based GIS software in Namibia. The latest version of ArcView is called ArcGIS, which is a software package that provides far more analytical capabilities compared to ArcView, and a package that the KBMC should consider to use if the advanced GIS analysis is required by the committee. The ArcView shape files are compatible with ArcGIS which will make the use of the data in its present form possible without any complicated conversions.

All files are using the WGS84 map datum and decimal degrees. It is possible that other GIS data sets available for the basin are using the Schwartzek map datum, however, the differences between these two projections are negligible for the area covered by the Kuiseb River Basin. The metadata for these GIS files are presented in the second database developed for this project, the Meta database.

The Meta Database
This database contains all the information about the different GIS datasets that have been located during this consultancy. Sources are the DRFN, MAWF Hydrology department and the Atlas of Namibia. The Meta database is a basic searchable database with the following fields: ID, Type, Format, File name, Description, Source and Link. The ID is just a unique identifier for each file. The Types of data are: Text, Point, Polylines or Polygons. The Format of data is for instance ArcView shape file, Excel, Word. File name is the name of the file as stored on disk. The description field provides with additional information about the origin of the dataset and other descriptive information. The source gives an indication of which institution that has the original data. Finally the link field is a hyperlink that links the user to the dataset if it is on disk. Note that not all datasets are accessible via this Meta database. It is also important to note that this is a working database; it does not provide all necessary information required to locate each and every
dataset described. This database will have to be further developed and maintained by the KBMC according to the Action Plan 10 prepared for the geographic component of the WRMP. It is important that the Meta database of the KBMC does not try to replicate already existing data, i.e., to store copies of information already being maintained and stored elsewhere. Instead, it will be important to provide direct online links to these databases. The modalities of such a link have to be analysed and developed on a case by case level, as format of stored data, and possibilities of remote access to existing databases will differ between different databases. The requirements for such a database will be further elaborated in section B. below. The format of this Meta database is presently in Microsoft Access. However, if the KBMC intends to develop a more extensive Meta database with external links to the databases and data sets referred to in the Meta database, then a more advanced database engine would be required. For more details about the suggested design of such a database, see section B. below.

The searchable source material database
This database consists of all documents produced for the WRMP. All files are indexed and fully searchable via a web interface. All files together with the index and the search engine are stored on a CD, which makes distribution of the source material very convenient. Furthermore, the source material can be added to an existing web site, e.g., a KBMC web site and be made available to anyone with Internet access. The KMBC will be provided with the specialist software required for the indexing of source files. This allows KBMC to expand on the source documentation as new information of relevance to the WRMP is generated.

B. Database and GIS for the KBMC
Central to this task is to identify what databases the KBMC require. To answer this question all members of the KMBC were asked to give their views of how they perceive the database(s) and what data these should contain, and for what the stored data would be used. The query did not generate many responses, a total of three members of the KBMC gave their inputs, summarised below.

"...I have learned in the past that the issue about databases and appropriate software is almost as important as the study itself. It appears to me that the consultants wants to use a GIS application. I would recommend that the consultants consult your (GTRCs) drawing/GIS office to agree on compatible software. I believe that the database will be used to update and manage the existing and proposed outputs. These outputs will most probably be in the terms of reference." Nico vd Westhuizen.

"I have already given you my perspective based on what the PSC has discussed: the KBMC itself will require this database in order to be able to derive "informed decisions", such as license applications it is asked to comment on, and to serve the research community as well as incorporate their findings (e.g., water resources in dams in a particular year, or groundwater level status, or number of people in a given area). It will need to be "driven" by an institution, and Gobabeb is well placed to be this institution (this was previously proposed by others of the KBMC)." Dr. Joh Henschel, Gobabeb Training and Research Centre.

"The database should include metadata and, where useful and feasible, online links to other database systems. Replication of other database systems results in outdated and corrupted sets of data." Guido van Langenhove, DWA, MAWF.

Based on these three contributions from the KBMC the following recommendations towards the establishment of a KBMC database can be made:

1) It was stated that the design of the database and the software used for the database engine is as important as the data it stores. This is a true reflection. Therefore, the geography expert consulted with a number of database experts to find out what would be the best solution for a database to be used by the KBMC. It was suggested that the KBMC purchases a server, running SQL server and uses a web interface for both maintenance of the system and user access to
Databases for improved management of the Kuiseb River Basin

data. A quote for the suggested system is given in annex 2. The initial Meta database developed by the geographer, based on the data used by the consultants appointed for the development of the WRMP was done using Microsoft Access. However, this is only a temporary solution as Access is mainly suited for single user desktop solutions. As is further elaborated in Action Plan 10, based on the suggestions made by database experts, it is recommended that the KBMC secures funding to establish a web based SQL database, which would allow the committee to develop a database that allows multiple users to simultaneous access and manipulation the data and, maybe most importantly, provides external users of the information with a platform independent interface, only requiring access to the Internet and a computer with a modern web browser. However, one should note that for further analysis of data stored in such a database, special software, e.g. ArcView or statistical packages would be required. It is also possible to develop web based GIS applications, giving users the possibilities to carry our limited map production, e.g. overlaying different themes, producing thematic maps and carry out some limited spatial analyses. However, the author would not recommend the KBMC to adopt this approach as the analytical capacity of such a web based GIS system is limited and functionality is commonly severely hampered by slow Internet connections. It is therefore recommended that data that is made available from the KBMC database via a web interface is made downloadable, allowing the user of the data to analyse the data using local specialist software.

2) GIS data is central to the KBMC, therefore a user-friendly GIS database needs to be developed. A first database will be provided to the KBMC, giving them access to all data collected by the DRFN for the Kuiseb Profile together with the freely available Atlas data (Mendelsohn et al., 2002), see section A. All these datasets are ArcView Shape files that can be used for map making and further analysis of the resources of the Kuiseb River Basin.

3) it was recommended that the Geographer consult with the drawing/GIS office of GTRC. This has been done and it has been confirmed that the centre has access to the ArcView package. The same applies for the MAWF and its Directorates. It is recommended that WGS84 is used as the map datum for the shape files, and geographic coordinate system is applied. These are standards that are fully compatible with modern GPSs. By deciding on a specific system the KBMC minimizes the risks of collecting data without knowing what projection was used. The standard to finally be adopted by the KBMC should also consider the format of reporting of geographic coordinates as GIS systems think in decimal degrees, while humans tend to find it easier to communicate using degrees, minutes and seconds. Commonly there is confusion between data collected in degrees, and decimal minutes and the more common format of degrees, minutes and seconds. To avoid these misunderstandings a clear standard should be defined that suits everyone involved in data collection and analysis within the KBMC.

4) If the KBMC require the database to support their decision making for license applications, serve the research community as well as incorporate primary data, then the suggested web based SQL server seems to be the right way to go. The SQL server will be able to handle these diverse data sources, even the GIS data (that would have to be manipulated using ArcView/ ArcGIS or any other compatible GIS software). A main advantage of the SQL server is that it is a professional database system allowing multiple users that can maintain and access the data using a web interface, which benefits already have been alluded to.

5) The driver of the KBMC database is a central issue. It has been suggested by several members of the KBMC that Gobabeb should house and operate the KBMC database. This is a good suggestion as this is a training and research centre situated in the basin. The institution has a long history of data collection, storage and analysis. However, if the KBMC wishes to share the information in the database to a wider group than just the researchers at Gobabeb, then the present Internet connectivity at Gobabeb will not be enough. However, if a sustainable solution to the present Internet problems at Gobabeb can be found then the Geographer agrees with the suggestion that Gobabeb would be a suitable host of the database(s). It is important for KBMC to realise that they will have to secure funding for the purchase, design and operation of this database, aspects that are further elaborated in the proposed Action Plan 10.
6) The importance of Meta data and the problems associated with replication of other databases into a new database was emphasised. This is a very valid point that also already was elaborated above. The Meta database that should be further developed and optimised by the KBMC should, when possible, have direct online links, allowing the user of the Meta database to access the required data from the primary databases located elsewhere. There are several advantages with this. By only having one data set at one location, i.e. in the primary database, the user is always using the most recent up to date information. Copies of databases often leads to outdated information as the institution sitting with the copy of the active database normally don’t have the mandate, nor the resources to update the information. As was eluded above, the configuration of such direct linkages to primary databases has to be developed on a case-by-case basis. Central here is of cause data security and copyrights to the primary data. There are issues that the KBMC will have to negotiate with the individual institutions having databases that are of relevance to the KBMC.
Annex 1. Database Survey form

Survey of data used for the development of the KMBC WRMP

Dear KBMC WRMP Team member,

We are now well into our task of developing a water resource management plan for the Kuiseb Basin Management Committee. My role as the geographer on the team requires me to identify datasets (Table 1) and databases (Table 3) that would be of relevance to the plan and the KBMC. Now is the optimal time for this survey as all of you have spent time developing your individual expert contributions, and therefore would be well acquainted with the data that exists within your field.

A. Survey of datasets of relevance for the KBMC WRMP

I therefore kindly ask you to provide me with the following information about the data sources you have made use of, or are aware of, that are of relevance for the WRMP (please fill out one form per data set):

Table 1. Metadata form for datasets used for the development of the KBMC WRMP. Note that some of the requested information only applies to geo-referenced data. It is assumed that all datasets have a geographic extent, however, if you have used datasets that are not geographic, please add these as well. Please copy the table for each data set.

<table>
<thead>
<tr>
<th>Dataset title</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dataset reference date</td>
<td></td>
</tr>
<tr>
<td>Dataset topic category (see table 2)</td>
<td></td>
</tr>
<tr>
<td>Dataset type (tabular, vector GIS, raster GIS, satellite image, report, other publication)</td>
<td></td>
</tr>
<tr>
<td>Creator of the dataset</td>
<td></td>
</tr>
<tr>
<td>Point of contact (from where can the data be obtained)</td>
<td></td>
</tr>
<tr>
<td>Geographical location by coordinates (if applicable)</td>
<td></td>
</tr>
<tr>
<td>Geographical location by region (national, regional, Kuiseb River basin, specific part of the basin)</td>
<td></td>
</tr>
<tr>
<td>Spatial resolution (if applicable)</td>
<td></td>
</tr>
<tr>
<td>Reference system (e.g. WGS84, UTM)</td>
<td></td>
</tr>
<tr>
<td>List of relevant attributes (comma separated)</td>
<td></td>
</tr>
</tbody>
</table>
Databases for improved management of the Kuiseb River Basin

Table 2. Dataset topical categories

<table>
<thead>
<tr>
<th>ISO 19115 Topic Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>farming</td>
</tr>
<tr>
<td>biota</td>
</tr>
<tr>
<td>boundaries</td>
</tr>
<tr>
<td>climatology/meteorology/atmosphere</td>
</tr>
<tr>
<td>economy</td>
</tr>
<tr>
<td>elevation</td>
</tr>
<tr>
<td>environment</td>
</tr>
<tr>
<td>geo-scientific information</td>
</tr>
<tr>
<td>health</td>
</tr>
<tr>
<td>imagery/base maps/earth cover</td>
</tr>
</tbody>
</table>

B. Survey of databases of relevance for the KBMC WRMP
If you are working with, or are aware of any databases that would be of relevance for the KBMC, please provide me with the following information:

Table 3. Information about databases that would be of relevance for the KBMC. Please copy the table for each database.

<table>
<thead>
<tr>
<th>Database title</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Database topic category (see table 2)</td>
<td></td>
</tr>
<tr>
<td>Database content (list of relevant attributes is applicable)</td>
<td></td>
</tr>
<tr>
<td>Point of contact, who is maintaining and/or hosting the database?</td>
<td></td>
</tr>
<tr>
<td>Can KBMC make use of the database?</td>
<td></td>
</tr>
</tbody>
</table>

I would appreciate your contributions before the 15th of July. Please send your reply to patrik.klintenberg@drfn.org.na

Regards,

Patrik
Annex 2 Quote for required hard and software for the KBMC database

Software required:

<table>
<thead>
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**Comments**

| Subtotal: | N$22,907.00 |
| VAT 15%:   | N$3,436.05 |
| TOTAL:     | N$26,343.05 |

Terms and conditions:
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Business Development Department
# Databases for improved management of the Kuiseb River Basin

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Business Development Department
Aerial view of Sandwich lagoon to the north, showing vegetated dune embayments to the southeast where the archaeological sites occur.
Orthographical note: The Khoekhoegowab spelling "!Khuiseb" instead of "Kuiseb" appears in this report as it is used throughout the archaeological and anthropological literature.
The !Khuiseb Basin, showing the distribution of archaeological sites. Red rectangles enclose the areas of highest known sensitivity. Blue polygons enclose the gaps in survey cover.
Caption to map of the !Kuiseb River Basin:

1!Kuiseb Delta Group
**Importance:** Archaeology of contact, including the acquisition of pottery and the rise and collapse of pastoralism
**Vulnerability:** High, especially to uncontrolled tourism

2 Tubas Exploration Block and adjacent areas
**Importance:** Possible western extension of specialized subsistence techniques important in the Namib during the last 1,000 years, and particularly during the collapse of pastoralism
**Vulnerability:** High, especially to mining

3 Tinkasvlakte Group
**Importance:** At the foot of the escarpment, grass seed diggings with related base camp sites and hunting blinds representing the occupation of marginal areas and diversification and specialization of subsistence techniques during the decline of pastoralism
**Vulnerability:** High, especially to mining

4 Escarpment Zone
**Importance:** Low; does not appear to be of great importance, but the area is poorly surveyed, representing a gap in known archaeological distribution.
**Vulnerability:** Low

5 !Komas Hochland
**Importance:** High. Represents indigenous copper production related to pastoral economy, i.e. specialized hunter-gatherer production marginal to pastoralism.
**Vulnerability:** High, to any development
Important note on archaeological assessment and data conditions

Namibia has an exceptionally rich and well preserved archaeological record, with firmly dated sites spanning much of the last 700,000 years and beyond (Kinahan 2000). Archaeological sites in Namibia are protected under the National Heritage Act (27 of 2004) which makes provision for archaeological assessment, implemented either in the form of an independent investigation or as part of multi-disciplinary environmental assessment projects. The promulgation of the National Heritage Act, and within the last year, the Environment Management Act, has helped to put in place some essential guidelines and procedures. As a result, archaeological assessment has become a routine requirement for large projects in Namibia. The archaeological assessment process in Namibia involves three phases, commencing with a Phase 1 desk assessment. QRS maintains a cumulative GIS database of archaeological sites in Namibia which is designed to assist the Phase 1 stage of assessment by providing empirically-based estimates of likely archaeological impacts. The QRS site database is also used as a tool to assist cost estimation of field surveys and mitigation studies, by providing a means to predict likely archaeological site concentrations, and to allow comparative evaluation of site significance as a basis for mitigation proposals. Namibia has an exceptional number of Later Stone Age sites which document human adaptations to climatic shifts in the Namib Desert during the post-Pleistocene. These sites are considered to be of global significance for the understanding of human and environmental responses to climatic change (Smith & Hesse 2005). Archaeological knowledge of Namibia remains scanty and uneven, however, and large parts of the country are archaeologically unexplored. For this reason, rapid developments in the national infrastructure, including roads, power lines, dams, new mines, and railway projects, have the potential to destroy important components of the archaeological record before they are adequately documented. The results of archaeological impact assessments have contributed a large body of new knowledge to the archaeological record in Namibia. In the last ten years, field surveys for impact assessments have more than doubled the number of documented sites, and radiocarbon dating carried out as part of mitigation studies has contributed to a 20% increase in the number of firmly dated sites. These studies, when carried out at the pre-feasibility stage of large projects have also helped to guide project design so as to minimize impacts by making known the location and significance of important sites that the developer might otherwise not notice in time to avoid their disturbance or destruction.

QRS provides developer clients with digital data acquired in the course of field surveys, accompanied by a warning that uncontrolled distribution of digital data may threaten sensitive sites. QRS does not provide digital data acquired in the course of other field surveys or data capture exercises; these are used in desk studies and provided in map layout form only.
1. Introduction

The !Kuiseb River Basin is one of the most important archaeological environments in the country. The entire archaeological sequence is represented, from terminal Pleistocene artifact scatters associated with pans along the lower reaches of the river, to evidence of the contact period, which in the especially isolated example of Namibia, is visible in the material record from the late 18th century and into the early decades of the 20th century. The distribution of sites is patchy, with dense concentrations in specific areas. Although this pattern is related to patchy archaeological survey of the country, it also may be expected from environmental conditions where water and other resources are limited. The densest concentrations of sites occur in the /Khomas highlands where water, grazing and copper ore were abundant, and in the !Khuiseb Delta, with its limited fresh water and grazing, rich marine resources and contact points with seafarers and traders who came into the country through the natural harbour at Walvis Bay.

The earliest part of the archaeological sequence is represented by Pleistocene stone artefact scatters, commonly associated with drainage features such as pans, or with low rocky outcrops that may have served as vantage points during hunting expeditions. Most granite inselbergen are also notably rich in rock art. Research into the earliest phase of the sequence includes dating and description of sites, description and drawing of artefact assemblages, examination of site formation processes, the identification of fossil elephant, and an excavated rock shelter sequence, well known for yielding a date for the earliest exploitation of the !nara plant (see Shackley and Sandelowsky in the Bibliography).

Archaeological sites at Sandwich Harbour in the !Khuiseb Delta yield evidence of the acquisition of pottery in the 4th century AD, and the effects of sustained weathering processes active on the early shell midden settlement of the 8th century. The !Kuiseb Delta is unique in that the limited growth and development of Walvis Bay over an extended period, along with the difficulty of access to the dunefields has preserved archaeological evidence whereas, in other parts of southern Africa, and indeed the world, this evidence long disappeared under the foundations of cities which grew fast at the trading entrepôts of the coast. The Walvis Bay dunefields shelter particularly valuable evidence of the indigenous response to contact arising from the global spread of Western commerce. This subject has become a separate field of study in historical archaeology, and studies in the !Khuiseb Delta have made a major contribution internationally. The area has a virtually uninterrupted sequence stretching from the radiocarbon-dated Pottery and Pastoral Phases, to a three-part Contact sequence set up through the use of trade goods for high resolution relative dating (see Kinahan in the Bibliography).

On private farmland in the upper reaches of the Kuiseb Basin, archaeological sites are significant for evidence of both pre-colonial and historic copperworking. Indigenous copperworking inland produced beads which traveled networks of trade and alliance down to the coast, and are found on contact sites in association with the glass trade beads of Europe. The 19th century historic workings at Matchless Mine, near Windhoek are still in evidence, with corroborating photographs and archival records (see Kinahan in the Bibliography).

All archaeological remains in Namibia are protected in terms of the National Heritage Act (27 of 2004), and this extends to objects and sites more than 50 years old that may be considered to have national heritage significance. Sections 51 (3) and 55 (5) of the Act require that an archaeological impact assessment is carried out where large development projects are intended in areas of known archaeological significance, and proper mitigation of archaeological impacts is also required.

Quaternary Research Services was established with the support of the Swedish Agency for Research with Developing Countries (Sida-SAREC) to provide specialist archaeological consultancy services in 1990 when the need for this arose with the accelerated development of the Namibian economy and infrastructure after Independence. It is essential that any development in the Kuiseb River basin in the fields of mining, road construction, power transmission, water supply, tourism, urban development, planning and research take account of the significance and vulnerability of the archaeology.
2. Major archaeological sites in the !Khuiseb Basin

Of more than 700 rich and varied sites in the !Khuiseb Basin, the following 12 have been chosen as especially significant. They are the most representative of the sites found in each geographical unit. Two sites for each area represent a recent and an older component of the archaeological sequence. Each site has an abundance of material remains and a key role in the interpretation of Namibia’s archaeological past. None are completely protected, each site being subject to processes of degradation, either by human or natural agents. However, each has been documented and worked, with records being safely housed in the National Museum or with Quaternary Research Services.

SANDWICH HARBOUR

2.1 Site name: Spence’s Fishery
Location: Sandwich Harbour
Setting: Vegetated dune embayment on shores of Sandwich lagoon
Description: Shipwreck, with extensive surface scatter of European waste on a series of fishbone middens situated on lower northeastern dune slopes. The site had two components, the second having been inundated by dune movement and subsequently exposed.
Date: Mid-19th century
Work done: Mapping and surface collections with analysis and identification; archival studies
Significance: Represents 19th century commercial exploitation of the coast by outsiders
Reporting:
Material housed: National Museum of Namibia
Accession no. B2733

*Aquarelle of Spence’s Fishery at Sandwich Harbour by Thomas Baines, 1864, reproduced by courtesy of the Royal Geographical Society, London. Ref. no. X229/022053-(54)1864*
2.2 Site name: Liz’s Midden  
Location: Sandwich harbour  
Setting: Enclosed, grassy dune valley with !nara bushes  
Description: Dispersed swarm of one large shell midden with ashy patches and 6 lesser middens associated with sealbone, whale vertebrae, ostrich eggshell beads, utilized stone and indigenous ceramics.  
Date: 4th century  
Work done: Surface collection, radiocarbon dating  
Significance: Represents the beginning of intensive mussel exploitation with the introduction of pottery  
Reporting:  
Material housed: National Museum of Namibia  
Accession no. B2739

FREDERIKSDAM

2.3 Site name: Khaeros  
Location: Frederiksdam dunefields  
Setting: Exposed silts within dunes  
Description: Elephant spoor consolidated in silts; cultural material including glass beads and ceramics scattered on duneside; hearth and bone.  
Date: 1160 – 1800 AD  
Work done: Surface collection, photography, radiocarbon dating, casts of spoor  
Significance: Well-preserved evidence of the presence of elephant in an area where they do not occur today associated with archaeological evidence that points to a late 18th century date for a year of exceptional flooding in the !Khuiseb.  
Reporting:  
Material housed: National Museum of Namibia  
Accession no. B3775

*Elephant tracks leading to a tree stump on silts at Khaeros in 1986. Subsequent dune encroachments has obliterated most of the tracks and the silt pan*
2.4 Site name: Ward’s Midden  
Location: Frederiksdam dunefields behind saltpan  
Setting: Dune hummock hollow  
Description: Several shell middens filled together with associated hearths, birdbone and indigenous ceramics  
Date: 8th century  
Work done: Mapping, surface collection, analysis  
Significance: An early shell midden site with pottery that illustrates the destructive effects of wind as site formation process  
Reporting:  
Material housed: National Museum of Namibia  
Accession no.: B2936

WALVIS BAY DUNEFIELDS

2.5 Site name: Tag End  
Location: Northeastern edge of the Walvis Bay dunefields  
Setting: Raised beds of river silts among hummock dunes with Tamarisk trees  
Description: Midden heaps with associated scattered faunal and cultural remains, site of the indigenous village known as Sandfontein marked on the official German map of 1913 and visited and described by anthropologist Winifred Hoernle in 1913 and again in 1923.  
Date: 1907-1923 AD  
Work done: Mapping, surface collection, analysis and description of material  
Significance: Material remains that correlate with documentary evidence of the impoverishment of the Topnaar people in the !Khuiseb Delta  
Reporting:  
Material housed: National Museum of Namibia  
Accession no.: B3098

View of Tag End, on raised silts among the hummock dunes close to Walvis Bay townlands
View of #Khīsa-/gubus, with the dockyard cranes of Walvis Bay in the distance showing the site’s proximity to the town

2.6 Site name: #Khīsa-/gubus
Location: Walvis Bay dune fields
Setting: Exposed silts surrounded by dunes with Inara and tamarisk in the vicinity
Description: Mixed surface scattered faunal and associated cultural remains with human burials
Date: Late eighteenth century
Work done: Detailed mapping with subsequent additions and corrections as the dune alignments changed over the years; extensive surface collections and excavation of burials; sophisticated analysis and description of material
Significance: The key indigenous pastoral site of early contact date with an unusual abundance of material evidence that can be related to 18th century documentary evidence. No other contact site in southern Africa has yielded such remarkable information on the contact between indigenous people and early Europeans.
Reporting:
Material housed: National Museum of Namibia
Accession no.: B2740

LOWER !Khuiseb River & Dune Sea
2.7 Site name: #Hing-/hais
Location: On the south side of the !Khuiseb River, 26 km upstream from Gobabeb
Setting: A low col near the base of the linear dune system.
Description: Extensive high density stone artifact scatter with marine shell and ostrich eggshell beads. The majority of this stoneworking assemblage (quartz and quartzite) was quarried from rocks in conglomerate near the artifact scatter.
Date: c. 8 000 BP
Work done: Mapping, surface collection, spot samples sieved; analysis and dating
Significance: A dated and described stoneworking site in an area where little work has been carried out
Reporting:
Material housed: National Museum of Namibia
Accession no.: B3820

*Pointed ovate handaxe flaked on dorsal surface only, grey quartzite, Namib IV (from Shackley 1983: 41)*

2.8 Site name: Namib IV
Location: Namib sandsea south of Rooikamer on the !Khuiseb River
Setting: On pan calcrites near red sandstone exposures
Description: Acheulean butchery site with fossilized elephant bone, other fauna and especially remarkable heavy stone tools such as handaxes and cleavers
Date: 500 000 BP
Work done: Mapping, surface collection, analysis and dating
Significance: An Early Stone Age site with fossil elephant remains
Reporting:
Material housed: National Museum of Namibia
Accession no.: B2628, B2629, B3824

GRAVEL PLAINS
2.9 Site name: QRS 91 grass seed diggings
Location: Tumas Mountains
Setting: Namib inselbergen on gravel plains
Description: Rock shelters with grinding surfaces on bedrock, grindstones and grass seed diggings
Date: 1000 AD to late 19th century
Work done: Site record, photographs
Significance: Illustrates grass–seed foraging as a subsistence option available to impoverished people in the Namib
Reporting:
Accession no.: Not yet accessioned into National Museum.

Top: Granite inselberg on the gravel plains, environment of site QRS 91. Most of these features on the landscape have associated archaeological remains.

Bottom: Grave at site QRS 91

2.10 Site name: Mirabib
Location: Gravel plains
Setting: Granite inselberg on gravel plains
Description: Stratified occupation site in rock shelter that yielded amongst its assemblages stone tools, Inara seeds, ochre-coated human hair, grindstones, copper beads and few ceramics
Date: 8000 – 1500 BP
Work done: Excavation and analysis, radiocarbon dating
Significance: One of few excavated sites with a long stratified archaeological sequence, that established the antiquity of Inara exploitation
Reporting:
Material housed: National Museum of Namibia
Accession no.: B3823
2.11 Site name: Matchless Mine
Location: Matchless Mine is 30 km southwest of Windhoek
Setting: Historical sites form a tight cluster on both sides of the Minen River with pre-colonial settlement about 200 metres to the south, between the Minen River and a tributary coming in from the east. The focus of early mining activity was on the surface gossan, the northern and western slopes of which are partly covered by waste rock dumps from these early mining operations.
Description: Pre-colonial and historic remains of copper ore extraction and processing as practised by indigenous and early colonial miners.
Date: 13th to 18th centuries
Work done: Mapping and excavation; underground mapping
Significance:
Reporting: Preserved remains of historic and pre-colonial copper-working sites
Material housed: National Museum of Namibia
Accession no.: B3682

Timberwork in 19th century underground workings at Matchless Mine, courtesy of National Archives of Namibia (HMK 19/1/1). Photograph by Anneliese Scherz, c. 1950

2.12 Site name: Baumgartsbrunn
Location: Near the south bank of the !Khuiseb on Farm Baumgartsbrunn
Setting: Open valley among Khomas schist hillocks with waterholes in riverbed
Description: Copperworking sites including furnaces, tuyère fragments, stone anvils, mankala boards and hut circles near waterholes with rock paintings.
Date: 17th - 18th century
Work done: Mapping and excavation; documentary research
Significance: Representative of indigenous copper-working that has a low archaeological visibility, making sites extremely hard to find.
Reporting:
Material housed: National Museum of Namibia
Accession no.: B3684

*Mankala (/hus in Khoekhoegowab) gaming board, commonly associated with copper-working sites*
3. Conservation status of archaeological sites in the !Khuiseb River Basin

Archaeological sites occur in the following geographical units. The status of these areas affects the conservation of the archaeology, in some cases affording a measure of protection, and in others posing threats.

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<td>Frederiksdam</td>
<td>Part of Walvis Bay Nature Reserve</td>
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<td>Difficult terrain requires 4x4 vehicle</td>
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<td>Walvis Bay dunefields</td>
<td>Walvis Bay Townlands</td>
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<td>Uri Adventures concession area</td>
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<td>Topnaar !narafields</td>
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<td>Access unrestricted but 4x4 vehicle required</td>
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<td>Granite inselbergen</td>
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<td>Recreational areas</td>
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<td>Part of the Namib Naukluft National Park</td>
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<td>No camping or formal access allowed</td>
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<td>Topnaar grazing lands</td>
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<td>Gravel plains</td>
<td>Part of the Namib Naukluft National Park</td>
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<tr>
<td></td>
<td>Exploration tenements hold tracts of land under licence</td>
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<tr>
<td>Escarpment and highlands</td>
<td>Private land with restricted access</td>
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4. Threats to the archaeology of the !Khuiseb Basin

4.1 Uncontrolled tourism
The greatest threat comes from uncontrolled tourism and recreational use of the Walvis Bay dunefields, Sandwich Harbour, Frederiksdam and the granite inselbergen. People ignorant of the value of the archaeology may not recognize archaeological artefacts, drive over sites, crushing material and destroying its context, often coming back again and again to the same place. They pilfer items as curiosities or keepsakes, sometimes on a large scale, as bottle collectors do. The removal of material without documentation greatly reduces not only the value of the site but also of the artefact.

4.2 Unrestricted access
Increasing ownership of 4x4 vehicles and quadbikes, together with tour companies that hire these vehicles allows a great number of people seeking recreation access to areas of special archaeological significance.

4.3 Municipal activities
Urban expansion, dune control measures, roadworks, construction of culverts and drainage channels all affect the archaeology.

4.4 Commercial activities
The saltworks at Walvis Bay expand their roads and pans, and bring a high volume of heavy vehicle traffic in and out of the area. One of the largest shell middens on our coast, Wortel, was
situated here and has been completely destroyed. Fortunately, the site has been documented and researched (see Bibliography and List of radiocarbon dates). Dimension stone quarrying is a destructive and wasteful activity in the granite inselbergen.

4.5 National Park activities

Maintenance of the park and its roads, rubbish collection, borrow pits, and inappropriate siting of facilities can pose considerable threats to archaeological sites. Picnic sites deserve special mention because a number of important sites in the archaeological landscape, such as Mirabib, Tumas View, Blut Kopje, Vogelfederberg and Straussensicht have been made into public picnic sites. There is heavy visitor traffic which raises dust, compacts the ground, and introduces rubbish and ash from fires, degrading the site. Site maintenance carried out by park officials can also be destructive: trucks collecting rubbish, and cleaning up by raking can disturb the distribution of archaeological material. The siting of picnic spots at archaeological sites is in itself inappropriate without proper site caretakers and supervision.

4.6 Mining

The activities of exploration companies are now controlled by the issuing of licences dependent upon compliance with environmental and archaeological legislation. Mine safety legislation requires strict control of the area under licence, so that access is tightly controlled. However, drilling and trenching, construction of roads and camps, and misguided rehabilitation such as raking and sweeping of ground still pose threats. These risks are alleviated by having archaeological survey and assessment professionally done.

4.7 Private ownership

Although access is restricted and thereby protects the archaeology on farmland, land owners and farm management should be aware of legislation protecting national heritage and take appropriate measures to protect and maintain any archaeological sites, especially if undertaking tourist related activities.

4.8 Natural weathering

The nature of the archaeological sites on the coast and their abundance of material make them vulnerable to natural processes. The dunefields are created and maintained by natural agents including wind and river flooding, but the archaeological remains are exposed on the surface and can be sandblasted, buried, or washed away. Pottery and bone can be scoured paper thin, glass crackles and “sickens”, metal rusts and crumbles to dust and the weight of dunes can distort or crush bone and artefacts. In spite of these natural hazards, the amount of material preserved is remarkable and this threat is not as great as that posed by uncontrolled human agency.

4.9 Research

The presence of the Desert Ecological Research Unit at Gobabeb in the lower !Khuiseb introduces some threat to the archaeology of the area, such as uncontrolled driving across the plains, and the construction of buildings in the archaeological landscape.

4.10 Siting of new Topnaar settlements and structures

The significance of the archaeology is paramount to the Topnaar people. The archaeology is a material record of their history and provides evidence of their cultural practices such as the harvesting and processing of !nara melons and marine resources, for which exists specific botanical and ecological knowledge and skills, traditions, praise poems, property rights, stories and memories. There are direct links between the people, their knowledge, and this area. However, they are a presence in the area and their activities should be carried out with awareness of the fragile archaeology.
5. Recommendations
The following measures will help to ensure the conservation of the area and its sustainable use. The Kuiseb Basin Management Committee (KBMC) should take every step possible to support or carry out these measures themselves, familiarizing themselves with the kinds of archaeological sites in the different geographical units of the basin, and liaising with the National Heritage Council, the National Museum and Quaternary Research Services to ensure that research in the different disciplines and action plans co-ordinate with efforts to conserve and record the archaeology. The KBMC should strictly adhere to the legislation requiring archaeological impact assessments.

5.1 Management plans
Appropriate management plans for both archaeological landscapes and for specific sites should be professionally drawn up in consultation with the affected stakeholders. A management plan coordinates efforts in different spheres. It is essential to preserve the appropriate nature and feeling of the site in its landscape, and to develop it for tourist use without compromising its value and long-term preservation. This is generally required for any archaeological site opened to visitors, but should be extended to include the archaeological landscape in the dramatic but fragile environment of the !Khuiseb Basin.

Task: KBMC to commission archaeological management plan.

KBMC to approach MET to review the use of archaeological sites as picnic spots

5.2 Conservation Areas
Exceptionally significant areas (for example, the !Khuiseb Delta including the Walvis Bay dunefields and Sandwich Harbour) could be proclaimed a Conservation Area under Section 52 of the 2004 National Heritage Act. This provides recognition of the area’s significance and some protection measures.

Task: KBMC to facilitate proclamation of Section 52 Conservation areas

KBMC to oppose the uncontrolled use of archaeological sites for tourism

5.3 Guides
Suitable local guides should be appropriately trained. In the !Khuiseb Delta, Topnaar guides who are aware of oral traditions linking particular families to specific places and events, would provide an exceptional experience in historical continuity to the visitor. It would be preferable if trained Topnaar guides accompanied all visitors to archaeological sites in the delta. On private farmland in the upper reaches of the !Khuiseb river, local guides could be trained in site maintenance and supervision, and in taking visitors around appropriate sites with significant rock art or the remains of copperworking.

Task: KBMC to initiate schemes for the training of local guides

5.4 Information
Information should be provided through guides, pamphlets and other literature, and site museums. It is worth establishing a site museum at a suitable point of entry to be used for guided tours to archaeological sites. Problems of unrestricted access can be solved only if a portal is established to an area of archaeological significance, and other measures set up to prevent people from entering from other directions. An entranceway that prepares a visitor through providing suitable information on what he is about to see enhances his experience of the archaeology, rather than limiting it.

Task: KBMC to co-ordinate provision of information on archaeological sites

5.5 Research
Continued professional archaeological survey and documentation will add to the record and promote insight and understanding. The available information on the archaeology of the !Khuiseb Basin, although a considerable contribution, represents a survey of less than half of the area that is considered to be archaeologically significant.

Task: KBMC to commission research proposals
6. A list of radiocarbon dates, giving National Museum accession numbers for the site from which the sample was taken, the area of the site, the laboratory number for that sample, the uncalibrated radiocarbon age in years before 1955 AD, the standard error and 95% variation. From: Vogel & Visser (1981); Kinahan & Vogel (1982); John Kinahan (1991); John Kinahan et al. (1991)

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7. A list of relative dates for recent sites from the !Khuiseb Delta, calculated on the basis of associated artefacts and documentary evidence (from Jill Kinahan 2000: 47). National Museum accession numbers are given for each site, and names where these have appeared in this document

Relative dates
B2733 site1 Spence’s Fishery  !Khuiseb AD1851-77
B2733 site2 Spence’s Fishery  !Khuiseb AD1877-90
B2734  !Khuiseb AD1852-77
B2735  !Khuiseb AD1883-90
B2738  !Khuiseb AD1855-1908
B2740 #Khîsa-/gabus  !Khuiseb Post-1750
B3098  !Khuiseb AD1907-15
B3100  !Khuiseb AD1904
8. Annotated bibliography of source publications, research papers, popular articles and conference papers on the history, anthropology and archaeology of the !Khuiseb Basin.

The earliest of the explorer's accounts with observations on flora, fauna and peoples, and their distribution in the country. Alexander journeyed down the Kuiseb River to Walvis Bay.

Although writing for a public audience eager for adventure stories during the mid nineteenth century, Andersson, as well as being a hunter and explorer, was a naturalist particularly interested in birds. His contemporary, informed observations on the country and its fauna and flora provide us with a valuable perspective today.

Andersson’s last journey north, published posthumously.

Bird bone as evidence of summer occupation on an archaeological shell midden site on the Namib coast. The site has been destroyed by expansion of the salt works.

Starting off as an assistant to Andersson, Baines painted birds under his guidance but also numerous landscapes and scenes which have great historical value today. As he was Andersson’s contemporary, Baines' account informs Andersson’s.

A popular article.

A presentation and assessment of the legal arguments for South Africa to keep control over the strategic territory of Walvis Bay or for Namibia to gain sovereignty over it. Includes historical background and comments on the ethnic groups of Namibia.

The only existing microfaunal analysis for the Namib.

The prime historical ethnographic study of the Topnaar people with historical, cultural and ecological information which includes an excellent bibliography.

A popular article.

A summary form of the 1977 paper that has in addition praise songs in Nama and English translation.

Hoernlé had a special interest in the Topnaar of Walvis Bay. This book has an introduction to her fieldwork and diaries, transcriptions of the diaries and endnotes that give additional details. Diary of the second expedition to Namaqualand and South West Africa (1913) has details on Walvis Bay and its native inhabitants (pp70-75). Diary of the third expedition to South West Africa (1922-23) describes her experiences in the Kuiseb near Walvis Bay, Sandfontein and Swartbank, with information on Topnaar culture (pp 115-123) and a list of plants, foods and medicines (p 133).


Kinahan, Jill. 1992. *By command of their Lordships: The exploration of the Namibian coast by the Royal Navy, 1795-1895.* Windhoek: Namibia Archaeological Trust. Verbatim extracts from 24 Royal Navy Remark Books kept on surveys of the coast between Saldanha Bay and the Kunene River at a key time during the colonization of southwestern Africa. Includes an illustrated historical chronology and copies of original charts. Emphasis is on Walvis Bay.


A comprehensive investigation of contact between indigenous people and the outside world using glass trade beads and ceramics to set up a sequence and explore social issues.

Kinahan, John. 1984. Archaeology and the image of the Khoe in early historic contact on the Namib desert coast. *SWA Annual* 1984: 55-60. Short, well-illustrated popular article that presents the theoretical issues in an understandable way together with centrally important data.

Kinahan, John. 1991. *Pastoral Nomads of the Central Namib Desert: the people history forgot.* Windhoek: Namibia Archaeological Trust. The archaeology of the Brandberg and the Khuiiseb River Delta based on more than 200 sites and including the rock art sequence, ceramic sequence, the transition of the hunter-gatherer economy and the rise and collapse of pastoralism in the central Namib Desert.

Summary of the previous reference.

Archaeological, historical and geomorphological evidence shows that well-preserved tracks of people, livestock and domestic dogs in a lagoon siltpan relates to livestock trading activities occurring during two centuries ago in the vicinity of Walvis Bay.

Well-preserved tracks of elephant and other animals are described and dated to within the last three centuries by the radiocarbon method and archaeological associations.

The only publication to deal with this important subject, the indigenous production of copper beads. Presents sites, the method of smelting, dates and distribution of artefacts. Copper production formed the inland.


Source publication of Andersson correspondence.

Edited transcripts of the journals of an American trader, hunter and adventurer with accompanying map showing his travels from Walvis Bay to the north. Valuable for his comments on the natural world and way of life at this time. He travelled only a short distance of the Kuiseb River on his way north, and did not go to Windhoek but makes some observations on the Topnaar and the bay.

Type-scripts of German translations of early original accounts of explorers and travellers, e.g. Available in files in the National Library.


An early account of activities along the south west African coast by an American whaler and sealer who was known to fabricate stories. The existence of his original ship’s logbook has allowed some researchers to test his information but although interesting, some of his observations are problematic. The published diary of his wife, Abby Jane, who accompanied him, does not provide corroborating evidence to the most interesting of Morrell’s claims.

The original published report. See under Stals (1991) for the edited Van Riebeeck Society volume.

Contemporary minutes recording a wealth of verbatim evidence relating to indigenous, settler, commercial, mining and property rights along the Southwest African coast during the evaluation of British and German claims after the annexation of the territory by Germany. The Joint Commission consisted of a British and a German Commissioner.

Ross, E.S. 1971. The Kuiseb's Topnaar Hottentots. SWA Annual.
A popular article.

Comprehensive description of indigenous Khoekhoe pottery with standardized terminology and technical drawings. The reference work for the subject.

A popular article.


Detailed excavation report with specialist appendices on soils and microfauna.


Discussion of methods of archaeological survey.

With 49 figures, including maps and artefact drawings; and 8 plates, including site photographs and one of Elephas recki fossil tooth fragments. Shackley presents the dating and artefacts from six Late Stone Age sites, eight Middle Stone Age sites and one Early Stone Age site, mostly within the sand dunes on the south bank of the Kuiseb River drainage around Gobabeb. Two of the sites (Mirabib and Murphyspan) occur on the gravel plateau. All sites are within approximately 100 km of the lower Kuiseb drainage.


Discusses the importance of whales in the prehistoric diet and the general absence of archaeological evidence.

See Chapters 4 (Eitel), 9 (Kinahan) and 21 (Kinahan) for environmental history, dynamics of settlement and historical perspectives.

The official journals, minutes and reports produced during five consecutive commissions by Palgrave on behalf of the Cape Government to promote British influence in the territory of South West Africa before the German colonial period which started in 1884. Palgrave's discussion with the leading figures of the day about their issues and concerns are of historical value today. Illustrated with selected landscape photographs and portraits or groups of many of the protagonists.


Interesting and useful paper with information concerning dating of Dutch gin bottles. Rather outdated as far as the archaeology goes.


A Wesleyan missionary's account of his labours in South West Africa, primarily in the south of the country around Nisbett's Bath (Warmbad). He describes visits to Walvis Bay and to Concordiaville (Windhoek) but his emphasis is on the people, his missionary work and the political uncertainty of the time.


An introduction to the Topnaar people and the Kuiseb Valley is followed by colour photographs of the plants in the lower Kuiseb with botanical, Nama and Afrikaans names, descriptions, medicinal and other uses.


A magisterial reference work on the ethnic groups and history of the country. Unfortunately sources are not accurately given, rendering some of the historical information anecdotal. Much of the detail concerning habits and customs of peoples must be evaluated bearing the ideological approach of Vedder in mind. Nonetheless, this book is still a source of detailed information.


A very useful and accessible source of information on a range of topics from general history to specifics about the town itself.
9. Unpublished Quaternary Research reports relating to the !Khuiseb Basin


All Quaternary Research Reports are housed with the author and are available upon request, conditional upon permission from the client for whom the survey was conducted.

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Email: jkinahan@iafrica.com.na
P.O. Box 22407
WINDHOEK
Namibia

The B-numbers refer to numbers in the accessions register of the archaeology collection at the National Museum. The numbers up to B2694 (covering accessions to the collection during the years between 1946 and 1983) refer to individual items taken up into the collection, such as an artefact or document, or to small groups of artefacts, such as stone implements or potsherds. Numbers from B2694 on refer to archaeological sites, many of which have yielded a large amount of material accessioned into the collection with the same B-number.

These lists of accessions indicate the exceptionally large number of archaeological artefacts and sites that come from the !Khuiseb River Basin and provide a quick reference list if any of the material should be consulted.

### 10.1 !Khuiseb Delta, including Walvis Bay, Wortel, Frederiksdam, Sandwich Harbour

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Kuiseb Basin Water Resources Management Project

Development of a Water Resources Plan for the Kuiseb Basin

and a

Generic Water Resources Planning Procedure

LEGISLATION FOR WATER ABSTRACTION

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# TABLE OF CONTENTS

1. Introduction  
   2. Background  
3. Water Legislation  
   3.1 Introduction  
   3.2 Existing Water Policies  
   3.3 Existing Water Legislation  
   3.3.1 New Water Legislation  
   3.4 Existing Regulations  
4. The Role of the Kuiseb Basin Management Committee  
5. Evaluation of Permit Applications  
   5.1 Introduction  
   5.2 The Abstraction and Use of Public Water  
6. The Abstraction and Use of Water Under the Act  
   6.1 Background  
   6.2 Surface Water  
   6.3 Groundwater  
   6.4 Unconventional Water  
   6.5 Water Quality  
   6.6 Waste Water Management  
7. Evaluation of Permit Applications  
   7.1 Introduction  
   7.2 Surface Water and Groundwater Abstraction  
   7.3 Groundwater Development  
   7.4 Waste water  
8. Discussion of Permit Conditions  
   8.1 Abstraction of Water  
   8.2 Waste Water Disposal  
9. Other provisions in the Water Act  
   9.1 Protection of Water Resources  
   9.2 Efficient Water Management  
10. Conclusions  
11. REFERENCES
1. Introduction

Water resources in Namibia are very scarce due to the low rainfall and high evaporation. This complicates the availability and supply of water for domestic, industrial and agricultural uses. Water managers in arid areas must therefore have a very clear understanding of the constraints and opportunities when the utilization of water resources is planned. This will facilitate the development of an appropriate legal and institutional framework to address and direct the challenge of water management. This means that appropriate proper policy, laws and regulations should be in place to guide the water managers and water users.

The purpose of this document is to provide a brief overview of the of the existing policy, legislation and regulations regarding the abstraction of surface water from perennial and ephemeral rivers, including the construction of small dams, groundwater abstraction in water control areas and pollution control. Reference will also be made to the new legislation that will probably come into force in the near future.

A description will be given of how a water area management institution and the Department of Water Affairs and Forestry (DWAF) in the Ministry of Agriculture, Water and Forestry (MAWF) can cooperate when the evaluation of applications for the allocation of permits for the different water uses mentioned above are considered.

The application of these procedures in the Kuiseb Basin and how the Kuiseb Basin Management Committee (KBMC) could be involved constructively in the process of awarding permits or licenses will also be advised upon.

The present methodology to evaluate applications for permits to abstract surface and groundwater sources, or to construct farm dams or to dispose of waste water will be elaborated.

2. Background

The occurrence of the different sources of water such as rainfall, surface water runoff in rivers, as well as the water stored in aquifers, dams, lakes and wetlands are not only related to the hydrological cycle, but linked to each other. The quality and quantity of these resources are affected by the biophysical environment and human activities.

Other factors that complicate water management are population growth and urbanization which concentrates water users, as well as socio-economic growth which increase the potential for an improvement in the standard of living of the people and a subsequent increase the demand on already scarce water resources. The creation of job opportunities, poverty alleviation and food production are directly proportional to the demand of water for industrial, mining and irrigation development.

The development, use and management of water resources are also dictated by technical, environmental and socio-economic issues which must be considered as an integrated whole to support the sustainable, equitable and efficient use of water. The water demand, the availability of water to meet the demand, the quality of the water, the allocation of water to different uses, the way the water is used and conserved or wasted and how the waste water is disposed of must all be accounted for when water resources are managed in a holistic way.

This situation calls for clever resource management to ensure the equitable allocation of the available water resources to the different users, to reduce excessive demands, to stretch the quantity of water available to meet the reasonable demand of all potential consumer groups and to dispose of effluent in an environmentally sustainable way. An integrated approach is therefore required when water
managers are planning the development of water resources for human benefit in such a way that environmental integrity is maintained. This is the basis of the need for appropriate water legislation.

3. **Water Legislation**

3.1 **Introduction**

The administration of water affairs in Namibia is based on a number of pillars. These are the Constitution of the country, water policy, water law and water regulations promulgated in terms of the water legislation.

Article 95 of the Constitution of the Republic of Namibia deals with the maintenance of the welfare of the people. The adoption of water, sanitation and environmental policies, is facilitated by the provisions of Article 95 (1) which states that the Government must adopt policies for the maintenance of ecosystems, essential ecological processes and the biological diversity of the country, as well as the utilization of living natural resources on a sustainable basis for the benefit of all Namibians, both present and future.

In terms of Article 63 of the Constitution, the National Assembly has the power, subject to the Constitution, to make and repeal laws for the peace, order and government of the country in the best interest of the people.

Similarly, Article 100 of the Constitution deals with the sovereign ownership of natural resources. According to this Article, the land, water and natural resources of the country shall belong to the State, if they are not otherwise lawfully owned. The Constitution therefore enables the Government to promulgate water legislation to exert control over the allocation, use and disposal of scarce water resources in the face of competing demands on the resources and the environment.

3.2 **Existing Water Policies**

The existing water policies in place are the Water Supply and Sanitation Policy (WASP) adopted in 1993 (DWA 1993), the National Water Policy (NWP) adopted in 2000 (MAWRD 2000) and the Water Supply and Sanitation Sector Policy (WASSP) which will most probably be adopted in 2008 (DWAF2008).

What should also be kept in mind is that water policy has a formal and an informal side. It is possible that within the framework of formal, generic policy statements, such as the NWP, and the subsequent legislation to formalize the practical implementation of certain policies, there are many internal water management policies which are not enforced by law, but is practiced in the general administration of water matters. Some of these policies are contained in the regulations promulgated in terms of the law, others may be based on Cabinet decisions and some may part of the daily decisions by the management of the MAWF or the DWAF.

A few of the formal and informal policy issues that relate to the management of water abstraction, water allocation, water supply infrastructure development and pollution control will be highlighted here.

Water policy in Namibia is tailored to the availability of water in an arid, developing country and the specific needs of the population. The WASP policy states that essential water supply and sanitation services must become available to the whole population, and should be accessible at a cost that is affordable to the country as a whole. The equitable improvement of services should be achieved by the combined efforts of the Government and the beneficiaries, based on community involvement, community participation and the acceptance of a mutual responsibility. Communities should have the right, with due regard for the needs of the environment and the resources available, to determine
which solutions and service levels are acceptable to them. Beneficiaries should contribute towards the cost of services at increasing rates for standards of living exceeding the levels required for providing basic needs. The environmentally sustainable development and utilization of the water resources of the country should be pursued in addressing the various needs.

The overall water management functions and broad division of responsibilities within the water supply and sanitation sector are of extreme importance to achieve successful water management. The most important functions that are primarily the responsibility of the Government is the development of water policy and water legislation, the promulgation of water regulations, the strategic planning of water development and exercising control over the development, utilization, conservation and protection of the natural water resources of the country. This control is vested in the administration of the water legislation (DWA 1991).

Water supply services can be divided into three groups. These are firstly the formal, large scale or bulk water supply services, secondly the informal, small scale rural community water supply services and lastly the services related to the reticulation of water to consumers under the control of local authorities, as well as the disposal of waste water.

The allocated responsibilities in terms of the WASP policy have been implemented to a large extent because the formal bulk water supply services are provided on a commercial, full supply cost recovery basis by the Namibia Water Corporation (NamWater), rural water supply services are rendered by the Directorate of Rural Water Supply (DRWS) in the DWAF and local authorities are responsible for water reticulation and waste water disposal. The DWAF remains responsible for water resource management, including the control over waste water disposal.

The overall financial sustainability of the water and sanitation sector in Namibia is also addressed in the water policy. Financial sustainability will depend on the ability of the water sector to become self-sufficient by recovering capital investments and interest, as well as operating costs. However, when this is not immediately possible, at least the running and maintenance costs should be recovered from the consumer. The ability to pay and poverty issues should also be considered, but the detail of an appropriate tariff policy to achieve this objective should be worked out in consultation between the stakeholders and each of the institutions responsible for water supply, reticulation and sanitation. Some guidelines and basic principles are provided in the policy, but the detail will not be elaborated here.

Namibia has limited water resources and policy is required to prioritize the uses of water when it comes to the allocation of water for competing demands. In this regard, there are two priorities approved for the allocation of water to competing demands. The first priority is water for life and that includes the provision of water for basic domestic use and livestock. The second priority is the allocation of water for economic activities such as mining, industry, manufacturing and irrigation, but, the eventual allocation of water to any one of the economic uses will in each individual case be determined by its respective value in relation to the overall development objectives and plans for the country. The management of water demand, water conservation and environmental issues are also addressed in the policy.

The treatment of domestic and industrial waste water is a very important issue in any arid country, because pollution must be prevented and as much of the effluent as possible should be re used. Domestic waste water that discharged from individual premises into a sewage system under the control of a local authority must be collected for disposal and/or treatment at central sites dedicated to such disposal. The effluent can be disposed of by means of evaporation in evaporation ponds, or the treated water can be reused for the watering of gardens, parks and golf courses or released into a public stream if the quality of the treated water is of an acceptable standard. The water may also be reclaimed to potable water quality standards as is the case in the City of Windhoek. Formal water-borne sewage disposal services are generally only rendered in urban areas and larger villages or at
mining development sites and tourism centers in game parks, but other appropriate sewage disposal methods (dry or vacuum systems) are implemented where there is a scarcity of water. The responsibility to ensure that these services are provided is not only the responsibility of local authorities, but the private sector and government institution are (Ministry of Works) also be involved to assist.

Mining and industrial waste water is often of a very toxic nature and must be treated appropriately, especially within urban areas and at mining sites. In cases where the quality of industrial effluent in urban environments is too toxic for treatment in normal sewage treatment works, either the local authority or industrial concern must cater for its own wastewater treatment and disposal. In the case of mining activities the waste water should be recycled as far as possible and all tailings should be stored in properly constructed dams where the leakage of toxic water is prevented. The disposal of waste water by local authorities and the private sector is therefore controlled in terms of waste water disposal permits issued by the DWAF. These permits prescribe how the effluent must be treated and disposed of. It is the responsibility of the DWAF to monitor compliance with the permit conditions and to impose penalties when it is not done.

During 2007 a rapid assessment, funded by the African Development Bank, was made of the water supply and sanitation sector in Namibia and it was found that the coverage of safe sanitation services was only about 50% in comparison to the coverage of safe water supply services which stood at about 90% for the country as a whole. This called for a revision of the 1993 WASP and in the new WASSP was formulated and will probably be adopted in 2008. One of the most important recommendations is the proposed establishment of a Directorate of Water Supply and Sanitation Coordination the DWAF with a specific mandate and responsibility to improve the sanitation sector to the same levels of coverage as in the water sector.

### 3.3 Existing Water Legislation

The existing water legislation in Namibia is the Water Act, Act 54 of 1956, herinafter referred to as the Act. The Act was promulgated by the South African Government for South Africa (DWA 1956), but because the then South West Africa was under South African administration, certain Articles in the Act were made applicable in the country to administrate local water affairs. This Act remains in force in Namibia terms of Article 140 of the Constitution until such time as it is repealed or amended by an Act of the Namibian Parliament.

The Act is administrated on behalf of Government by the Division of Law Administration (DLA) in the Directorate of Resource Management (DRM) in the DWAF in the MAWF. The Act gives the Minister responsible for water affairs, the power to take all the steps considered necessary for the investigation, development, control and utilization of water resources, as well as giving effect to the provisions of the Act.

The ownership of water is an important issue when it comes to the authority to control the use of water and to take the responsibility to protect and conserve water resources. The Act makes a distinction between public and private water. Public water is water normally found in a public stream, whether the water is visible or not, for example water flowing underground in an ephemeral watercourse. There is no right of property in public water or private water and the use of the water is regulated by the Act. Private water is water that occurs naturally on the land and may be used exclusively for any purpose by the owner of the land on which the water occurs. The distinction between public and private water in the Act is therefore not meant to determine who owns the water, but to define who has the right to use the water and how it can be used. This is also consistent with Article 100 of the Constitution.

Surplus water is defined in the Act as all public water which is not normal perennial flow. Flood water flowing in a perennial river during the rainy season is water that is more than the normal flow. However, there are no perennial streams with normal surface flow in the interior of Namibia and runoff
is seen as floods or surplus water, which may occur from time to time in the dry rivers. This surplus water is available for further beneficial use, but cannot be utilized unless it is impounded and mobilized for public use. The construction of dams in ephemeral public streams are therefore unavoidable in an arid environment, but the development of dams and the permitted storage capacity of the dams must be authorized according to the conditions prescribed in the regulations promulgated in terms of the Act. This will ensure that an adequate balance of the runoff is available to downstream users and that the environmental integrity of aquatic ecosystems is protected as far as reasonably possible.

The Minister responsible for water affairs, is empowered by the Act to call for the construction of water works that may be deemed necessary or desirable for the purpose of supplying or conserving water. The Minister may also take measures to drain land, to store water, to prevent the wastage of water or the pollution of water sources by waste water and to control the abstraction of water from any surface or underground water source.

The Act allows for the use of water by people who are not owners of land or riparian to a water source. The Minister can supply water or arrange that water is supplied to any person for any use on any land and the same applies to private individuals, local authorities or any other legal person granted the right to supply public water to any consumer. This is why specific institutions such as NamWater and the DRWS in the DWAF in the MAWF had been established and why some local authorities, such as Otavi, Grootfontein and Windhoek) supply their own water.

The Act makes provision to control the purification or treatment and disposal of any kind of effluent or waste water, as well as preventing the pollution of fresh water sources or marine waters from sources of effluent located on land. In arid areas the disposal of any effluent into ephemeral watercourses is prohibited, unless regulated by a permit with conditions that prescribe the purification of the waste water to such an extent that the effluent is of an acceptable quality. This practice is normally not allowed in Namibia because ephemeral watercourses have very low and erratic runoff which will make it extremely difficult to rehabilitate or flush any pollution from the polluted alluvium in the river beds.

The Minister may also make regulations to prescribe technical requirements in connection with the development and management of water resources. These may make provision to pay subsidies on water works constructed, the levy tariffs and charges for water supplied, and the periodical revision of those tariffs. The Minister may also authorize any person to enter upon private land for the purpose of investigating the feasibility of any water work, or to monitor and inspect water supply schemes, mines, industrial installations and waste water disposal works to ensure that they comply with the provisions in the Act and the permits allocated.

Under the present Act water abstracted for domestic use and stock drinking, as well as for the irrigation of less than one hectare of land is exempted from a permit requirement because the quantity of water involved is relatively small. However, any person or institution that wants to abstract a large quantity of water for commercial use from a public stream or a groundwater resource must make an application for a permit to abstract the water. The applicant must give a description of the water works proposed to abstract the water, the particular water use and the economic viability of the project, as well as the quantity of water required. This application is considered in terms of the availability of water for allocation, other competing uses and the potential of the water resources to sustain the abstraction of the quantity of water requested.

### 3.3.1 New Water Legislation

Water legislation should be reviewed from time to time to accommodate the latest trends in integrated water resources management, including water conservation, water demand management and the protection of aquatic ecosystems. Water regulations should also be updated to provide for the latest technological advances and innovations to manage the water industry in a sustainable way.
Legislation for water abstraction

The Namibian Parliament promulgated the Water Resources Management Act, Act 24 of 2004, hereinafter referred to as the Water Act. The Water Act was signed by the President on 8 December 2004, but has not yet come into force and is at present subject to a complete revision. (MAWRD 2004)

The main reasons for amending or improving the Water Act is because it is considered to be inadequate to deal effectively with arid region water management and should be rationalized, modernized and simplified to ensure the sustainable management and conservation of scarce and vulnerable natural water resource in an arid country where there are increasing demands for water, as well as limited human and financial resource to manage water resources efficiently.

3.4 Existing Regulations

There are two important Regulations adopted in terms of the Water Act, Act 54 of 1956. Regulation R1277 was adopted on 23 July 1971 (DWA 1971a) in terms of Article 6 of the Water Act to control the use of surface water and subterranean water. Regulation R1278 was adopted on 23 July 1971 (DWA 1971b) in terms of Article 28 of the Water Act to declare certain areas in Namibia as subterranean water control areas in order to control the abstraction and use of groundwater in those areas.

According to the Regulations any person who plans to sink, enlarge, deepen or alter any borehole or well or to open up or clean any spring or to abstract or use subterranean water, shall apply for a permit. (DWA, 1971a)

4. The Role of the Kuiseb Basin Management Committee

The responsibility for sustainable resource management starts with the resource user, but the Government and non-governmental organizations and the public are also very important role players. Ministries responsible for planning, agriculture, natural resources, lands, public works, health, industry and energy must work together in a coordinated way. That means that there must be the political will, competent authorities and well-informed stakeholders to take the necessary action aimed at solutions that are affordable and within the technical and financial means of the concerned groups.

From the above it is clear that the competent management of water resources under arid conditions is not possible unless proper institutional arrangements are in place, but it also require inputs from a large number of organizations in different sectors. The most vital components to achieve the objectives of sound water management include an appropriate institutional framework, the employment of skilled human resources and the provision of adequate funds.

In order to manage the abstraction of water, the allocation of water, the monitoring of the water sources and the prevention of water pollution the Government encourages local water users to create a management institution to assist the Government to manage the water sources in order to maximize the benefits that can be obtained through the best joint utilization of the available water. This led to the establishment of water management institutions such as the Stampriet Aquifer Committee (SAC) the Karst Water Management Body (KWMB), the Kuiseb Basin Management Committee (KBMC) and the Ilishana Basin Management Committee (IBMC). The establishment of these institutions are all in line with the provisions in the Act, the National Water Policy (MAWRD, 2000) and the provisions in the Water Act, which will come into force in due course.

Decentralized water resource management by the public can be considered at the basin level because a drainage basin is normally defined as a geographical area determined by the watershed limits of a system of waters, including surface water and underground water, flowing into a common terminus. A drainage basin, and the natural resources contained in the basin, forms a unitary whole and the logical approach is therefore that a water management institution should be established at the basin level and that the allocation of its responsibilities should preferably be confined to the extent of the river basin.
However, this definition has its limitations because the groundwater resources of the Karst Area, which must be managed as a unit, are in the headwaters of three river basins and the management of the water resources in the Kuiseb Basin is not only confined to the basin because water is transferred from the basin for use in the Swakop River basin immediately to the north of the Kuiseb. The Kuiseb Basin Management Committee has an unavoidable responsibility to extend its mandate as part of a water area management institution for the Central Namib coastal area.

The common purpose of a basin management institution is to give effect to the principles of integrated water resource management by assisting the national government with the decentralized management of water resources in a certain area of jurisdiction. This means that the basin management body must be representative of and facilitate the involvement of the communities and other stakeholders in decision making about the water resources entrusted to the particular body.

A basin management institution may have numerous responsibilities, but one of the most important is to advise the regional or national government on water matters from their perspective and to ensure that everyone has access to sufficient water of acceptable quality; that the water resources are protected against pollution; that the water is used efficiently for the maximum benefit of the population and that environmental sustainability is not compromised in the process.

The KBMC should enter into consultations with the DWAF regarding the policy and strategy for the management of the Kuiseb Basin with regards to the award of permits for the abstraction of water, the allocation of water, the construction of farm dams and the control of waste water disposal by local authorities, the industry, mining operations and any other water users in their area of jurisdiction.

The present cooperation between the existing water management institutions and the Government could serve as an example for the KBMC. In the case of the SAC and the KWMB, the overall management of the groundwater stands on three pillars and is based on the integration of aquifer management, resource management and water demand management. Aquifer management relates to the scientific assessment of the potential of the aquifers, the allocation of water and the monitoring of the behaviour of the aquifers under operational conditions. Resource management refers to the appropriate management of the aquifers and the environment through cooperation between the users, the water area management body and the Government. Water demand management refers to the responsibility of all water users to ensure loss control, efficient water use and irrigation efficiency in order to make water available to as many irrigation farmers as possible, thus maximizing the socio-economic advantages that can be obtained.

The DWAF will not allocate a new permit for the allocation and abstraction of groundwater or withdraw any existing permit in the Stampriet Basin or the Karst Area without consulting the particular water management institution. If the DWAF must to take action against permit holders who fail to comply with the permit conditions, the particular institution will be informed to assist the Government in encouraging the water user to comply with the permit conditions in the interest of the other water users. The DWAF will monitor water levels and aquifer behaviour in order to assess the annual availability of the water that can be permitted for abstraction. The DWAF also keeps all the basin management institutions informed about the results of the monitoring activities and makes presentations about water management issues as part of a capacity building initiative to empower the community to better understand the management, behaviour and protection of the water resources. The results are encouraging because the community developed a better understanding of the groundwater systems over time, could make useful contributions to improve the administration of their water resources and became empowered to assist the Government with informed advice about the management and allocation of water.

This is what could be expected when closer cooperation between the KBMC and the DWAF is established when it comes to the allocation of permits for water use and disposal.
5. Evaluation of Permit Applications

5.1 Introduction

In this section the technical and legal aspects of water management which the KBMC should be aware of, will be elaborated in more detail to enable the Committee to make a constructive contribution to the allocation of water and the development of water supply infrastructure in the Kuiseb Basin.

From prior experience with the SAC and the KWMB it was clear that the community expects that the allocation of water should be more transparent and that the DWAF should solicit more community involvement to avoid conflict or fraudulent conduct before allocating a permit for the abstraction and use of water. In both cases it became clear that the management of the aquifers was compromised by persons who abstracted more water than the permitted quantity allocated, people who drilled boreholes illegally and those who did not submit their abstraction returns as required in terms of the permit conditions. Many of these issues had a detrimental effect on the management of the aquifers and the availability of water for all the other users. It soon became apparent that it was in the best interest of all stakeholders to get involved in the monitoring of the abstraction activities as well and to report those people that transgressed the permit conditions to the appropriate authorities to enable them to take remedial action. This understanding between the parties enhanced cooperation to the benefit of all

The priorities for the allocation of water were discussed with the local community and it was agreed to divide the priorities for allocation into primary, secondary and tertiary consumption. Primary consumption is water for domestic use in urban and rural areas, as well as for stock drinking on farms and in the rural areas. Secondary consumption is water for mining, manufacturing and industries. Tertiary consumption is water for irrigation. In the case of the Karst Area the transfer of surplus water to other areas in the country would only be allowed to meet primary and secondary water demands. This is consistent with the transfer of water from the Kuiseb to the Swakop Basin, because no water is used for irrigation.

The principles for, and the award of permits to abstract water should be fair, open and transparent. The stakeholders should be empowered to assist with the decision making process to award the permits as well was to have a say in the management of the available water sources. The requirements for the allocation of water from a dam or a groundwater source are that the water must be allocated for the most beneficial and sustainable uses; the quantity of water allocated should serve as an incentive to optimize irrigation methods, as well as the possibilities for re-use and water conservation. The use of the water should also facilitate further industrial, mining, agricultural and socio-economic development.

The maximum validity period of a permit is five years and the purpose of this is to ensure that the water that has been allocated is used. If the water is used for the intended purpose, the permit would normally be renewed, but if no development has taken place to use the water, the permit will be cancelled and the water allocated to other applicants. The reason for this is that some landowners apply for permits to abstract and use water without any real intention to invest capital in the proposed project to use the water, but just to be able to claim access to permitted water on the land and thus to improve the value of the land for speculation purposes. Permits will not be renewed, or can be withdrawn, if a permit holder fails to comply with the permit conditions, for example to install the required water meters on the abstraction equipment; fails to submit the returns of water abstracted to the DWAF; exceeds the permitted abstraction, does not use the water efficiently or does not use the water that had been allocated.
5.2 The Abstraction and Use of Public Water

According to the Act a permit is required to abstract and use water that is abstracted from a public stream or a groundwater source that is located in a water control area declared by a Regulation under the Act. The Water Act, which is not yet in force and presently under revision, makes provision for the licensing of the abstraction of water in water management areas. The application of the existing legislation will be discussed and reference will be made to the provisions of the Water Act, although it must be kept in mind that there may be amendments.

According to the Act, if a landowner has access to a water resource which can yield much more water on a sustainable basis that can reasonably be used on that land, then that water is considered surplus water. This water can be used by the State to supply other areas where there is a scarcity of water. This is why water is transferred from the Kuiseb Basin to the Swakop River basin. This principle also has the implication that a landowner must be compensated if he should be detrimentally affected by such abstraction and transfer of water in the public interest. That is why the Topnaar community is entitled to the water infrastructure provided free of charge to give the people access to the water and why there is still a responsibility to pay the cost for the operation of the water supply service.

6. The Abstraction and Use of Water Under the Act

6.1 Background

In view of the nature of the arid climate in Namibia, all the watercourses or “rivers” in the interior of the country are ephemeral. Runoff only occurs after a significant rainfall event and the only way in which the surface runoff can be abstracted is that it must be impounded for later use by constructing dams. The country also has perennial rivers on the borders in the north and the south and what should be understood is that the abstraction of water from a public stream in Namibia actually relates to the abstraction of water from a perennial river (abstraction from a continuously flowing source of water) or the abstraction of water from a dam in an ephemeral that impounded the seasonal surface runoff.

The abstraction of water from ephemeral public streams when there is no surface water flowing in the rivers actually means the abstraction of water or groundwater from an aquifer in the alluvium of the river bed. In all cases this abstraction requires a permit to abstract and use the water. However, no permits are required for the abstraction of groundwater from aquifers that are not in public streams, unless a regional aquifer has been declared as a subterranean water control area in terms of Regulation R1278. In such cases the Government controls issues regarding the allocation, abstraction, use and monitoring of the aquifers.

6.2 Surface Water

The consideration of the conditions for permits to abstract water from the perennial rivers will not be discussed because there are no perennial rivers in the Kuiseb Basin. Only the permit conditions for the abstraction of water from dams in ephemeral rivers and aquifers will be elaborated.

The construction of dams with a storage capacity of more than 20 000 cubic metres in ephemeral streams requires a permit. A large dam built in an ephemeral watercourse to supply water for bulk water supply purpose to domestic, industrial or irrigation users must be large enough to impound sufficient water to bridge at least two years of no inflow. The need to build such large dams does not apply to small scale farm dams that supply water for stock drinking and recreational uses. Permission to build large dams are subject to a comprehensive environmental assessment with the objective to identify fatal flaws in the design concept and to mitigate some or all of the adverse environmental conditions identified, if possible. This is not cost effective in the case of individual small dams, but may become an important consideration when a large number of dams are built in the same catchment.
A farmer may construct a small structure in badly eroded streambeds on his farm to capture sediment and reduce erosion as part of a soil conservation program. If the storage capacity of such a structure will be larger than 20 000 cubic metres it is not any more regarded as a soil conservation work, but classified as a farm dam and the farmer must obtain a permit from the DWAF to construct such a dam. In the case of soil conservation works, approval still needs to be obtained from the Department of Agriculture to ensure that the capacity of the dam and the design of the structure conform to the technical requirements specified in the Soil Conservation Act, Act 76 of 1969.

Small farm dams are normally developed to provide water for stock watering or the recharge of groundwater sources or irrigation or for recreational or aesthetic purposes. Such dams can make an important contribution to the water household on a farm. A farm dam can also augment underground water supplies on a farm and in cases where a dam is used to recharge groundwater sources, it must be located upstream of a geological structure through which the water that infiltrates from the dam can reach the aquifer designated to be recharged.

In the past some farm dams in Namibia were specifically developed to supply water for small scale irrigation, but the viability of irrigation with water from small farm dams proved to be inefficient, and of little economic value. Only very large dams (such as Hardap and Naute) have been successfully developed for irrigation purposes.

The emphasis on the need for the construction of farm dams on commercial farms in Namibia has shifted from water supply for domestic use and stock drinking towards enhancing the scenery for tourism, game farming and for professional hunting purposes. These dams are mainly there for recreational purposes, which is a lower priority for the allocation of water as far as the utilization of water for domestic use and other economic uses are concerned. The use of the very scarce surface water resources for recreation or irrigation should be rigorously scrutinized and only approved when an economic analysis shows that no other more efficient or beneficial use can be made of the water. In some cases it may be possible that the unit value of water for recreational purposes is much more than other uses, even if evaporation losses are large.

The application to obtain a permit to construct a farm dam is evaluated by the DWAF as far as the water household on the farm is concerned. The water household comprises the quantity of water required for primary purposes (domestic and stock use) and the ability of groundwater sources to supply in that demand. If the groundwater cannot supply in the demand, the construction of a farm dam can be considered to use surface water for some time during and after the rainy season, thus giving the groundwater source an opportunity to be rested and recharged. The impounded dam water can also be designed in such a way to recharge the groundwater sources.

However, a farm dam must be properly designed by a professional engineer and the DWAF can outsource the analysis of a proposed design to a professional engineering consultant for advice. The construction of the proposed dam may be approved only if the following major criteria are satisfied.

(a). Is the identified need for the dam justified in terms of the availability of other water resources?
(b). Will the dam be able to meet the designated water demand?
(c). Can the dam be used to recharge groundwater
(d). Are the water requirements of downstream consumers accommodated?
(e). Is the design of the dam acceptable in terms of the stability and safety?
(f). What would the environmental consequences be?

New farm dams may not be constructed within the catchment areas of major bulk water supply dams. It requires convincing motivation to obtain approval for the construction of such farm dams because
the surface runoff must be allowed to reach the major dams that provide water for high priority domestic, industrial and mining developments. The same applies to water that must recharge aquifers and permits for the construction of farm dams in the Kuiseb Basin should not only be a topic of informed and collaborative discussion between the KBMC and the DWAF, but the KBMC should consider the possibility to find support and funding to make a formal environmental assessment about the existing situation in the basin in order to assess what the real impacts of the farm dam developments are and if there is scope for any further farm dam developments.

6.3 Groundwater

All groundwater comes from rainfall and if a groundwater source is recharged regularly (meaning it is not fossil water, which is not recharged at all) then the reliability and sustainable yield of the groundwater resource depend on the hydroclimatic conditions prevailing in the recharge area of the aquifer, the hydrogeological environment (the aquifer) and the quantity of water that will be abstracted between recharge events (DWA 1992).

The erratic climatic conditions make it very difficult to predict the recharge of groundwater sources in arid areas, but to enable the development of groundwater resources under these conditions, certain best estimates of the long-term sustainable yield are made by determining the aquifer parameters, through test pumping and taking the hydrological conditions into consideration. The aquifer parameters are the possibility of the particular geological environment to be recharged (the recharge coefficient), the storage capacity, or the volume of water which can be stored in the aquifer (storativity), and the rate at which the water moves through the aquifer (the permeability). After the sustainable abstraction has been estimated a water scheme is designed according to the available information, but the subsequent behavior of the resource under operational conditions is determined by monitoring and comparing the response of the resource to the theoretical assumptions about the recharge and abstraction. In this way the utilization of the source can be adjusted according to its actual long-term performance under the prevailing operational and climatic conditions. It can therefore be safely said that in the design of a borehole installation, the hydrogeological environment is adequately taken into consideration and the abstraction adjusted over time when it becomes necessary to protect sustainability.

If a borehole is drilled into a hard rock formation, such as most of the boreholes in the Kuiseb Basin, the water is normally found in a geological feature like a fracture or fault. The hydrogeologist will make an estimate of the aquifer parameters by doing a pumping test on the borehole to measure the drawdown of the water table, transmissivity, storativity and yield. The volume of stored water and the possible recharge, taking the erratic rainfall conditions into consideration, will also be considered, and in the final analysis the long-term sustainable safe yield of the borehole will be estimated. In some cases, where the boreholes will serve small communities or for animal watering, the cost to do a full scale hydrogeological investigation to determine the extent and capacity of an aquifer is not economical or affordable. In such cases it will be prescribed, as a rule of thumb, that the borehole should not be pumped at more than 65% of the test pumping yield, that the borehole should not be operated for more than 10 hours per day at the specified yield, that water levels should be recorded, abstraction be measured and a record should be kept of the rainfall in the recharge area of the aquifer.

The only proof of the accuracy of these best estimates obtained with scientifically collected information will become apparent when the borehole has been in use for a number of years and all the relevant parameters (quantity abstracted, fluctuations in water levels, rainfall received etc.) have been monitored. The accurate monitoring of boreholes over a long time is a prerequisite for sound aquifer management in arid regions.

The determination of the safe yield of alluvial aquifers in ephemeral rivers is less problematic than aquifers in hard rock geological structures. The volume of sediment in an alluvial aquifer can be measured relatively easily, and the volume of stored water determined fairly accurately. The volume of
Legislation for water abstraction

water abstracted and the volume of water actually recharging the aquifer can be determined by measuring the fluctuations in the water levels, the runoff in the river and the recharge across the surface of the aquifer. By monitoring the behavior of such aquifers under operational conditions, the theoretically estimated sustainable safe yield of the system can be adjusted accordingly, as is the case in the Kuiseb Aquifers at the coast.

It is clear that in the long term, a borehole cannot supply more water than what is replaced by rainfall. All groundwater resources, which are recharged, are renewable water resources, but their sustainable yields or the quantity of water that can be abstracted over time, are finite in terms of the prevailing climatic conditions. By pumping water out of a borehole at a higher rate or over longer hours per day, will certainly yield more water in the short term, but the aquifer will then be depleted faster and the borehole will run dry. It also does not help to maintain the abstraction rate and keep to the specified number of hours per day, but drill more boreholes in the same aquifer, to get out more water. The short-term benefits of abstracting more water with more boreholes in the same aquifer will just deplete the aquifer faster. The bottom line is that groundwater in arid environments cannot yield more water than is replaced by nature, and therefore the magnitude of the groundwater source is finite.

Groundwater in the Kuiseb Basin is barely sufficient to supply the domestic, stock and industrial water demand. To use groundwater for irrigation or recreational purposes, is normally not sustainable in the long term and should not be encouraged, especially when higher priority demands are competing to be met from the same resources.

From the above, it is clear that groundwater sources are sensitive to exploitation and are exhaustible. Where they are replenished by natural recharge, they can be utilized for almost unlimited periods, provided that abstraction does not exceed the long-term recharge potential. Efficient management and the protection of these renewable sources are therefore of vital importance. This can be achieved when the hydrogeological environment is well understood, but reliable data about water levels should be available to measure the abstraction and estimate the recharge accurately. The water storage characteristics of the aquifers should be understood, the impacts of a reduced water table on the environment should be studied and an assessment should be made of the risks of climate change and the seasonal rainfall variability on the long term sustainability of an aquifer. Effective aquifer management can also be enhanced with modeling techniques, demand management and resource conservation.

A permit allocated to develop a groundwater source and to abstract water has conditions that require from the permit holder to provide information about the lithology of the geological formation in which the boreholes have been drilled, the quantity of water abstracted and the fluctuations in the water table, especially before and after the rainy season, in order to assist the DWAF to determine the behaviour of the aquifers under operational conditions and to improve the assessment of the sustainable potential of the aquifers.

6.4 Unconventional Water

In arid areas domestic sewage water and industrial effluent should be regarded as potential sources of water, which could be used conjunctively with other fresh water sources, or could replace the use of additional fresh water sources. This would enhance the integrated, optimal utilization of all water resources. In this regard, a distinction is made between the recycling, re-use and reclamation of water.

Recycling is the direct re-use of industrial effluent in the industrial or mining processes. The effluent is therefore not treated in any way after use, but re-used directly in a particular process. The Rössing Uranium Mine is an excellent example of an industry where the initial daily consumption of potable groundwater has been reduced by up to 60% as a result of the direct recycling of the mining effluent.
Re-use is the use of purified and disinfected domestic sewage effluent that has been treated to an acceptable standard for disposal, but is not of potable quality. This water is suitable for the watering of gardens, sports fields, golf courses and parks. The re-use of domestic effluent can serve as a major source of non-potable water. The golf course in Windhoek and the vegetable gardens that were in operation at Arandis are good example of how domestic sewage effluent can be put to good use.

Reclamation is when domestic sewage effluent is reclaimed and purified to drinking water quality standards. This is seen as an important additional source of water, especially in times of drought, when there may be severe limitations on the availability of other fresh water sources. The reclaimed water can also be mixed with purified water from the other fresh water resources.

As a result of the observation of natural phenomena and a research program to study the recharge mechanisms of alluvial and fractured rock aquifers in Namibia, artificial recharge enhancement and water banking were accepted as viable concepts. Artificial recharge is the infiltration of clarified surface water runoff into an aquifer. This achieved by impounding the runoff in a dam to allow the silt and colloidal material in the water to settle so that the clear water can be recharged into the aquifer under gravity. Water banking is the injection of purified raw water obtained from surface runoff collected in a dam. Examples are the Omdel Dam artificial recharge enhancement project and the Windhoek Aquifer artificial recharge water banking project.

The desalination of sea water and brackish groundwater is an example of the innovative use of non-conventional sources of water to meet water demands, especially in the Central Namib Area. It is estimated that new mining developments would soon increase the water demand beyond the capacity of the local water sources and the available water resources can be augmented effectively through the desalination. The most suitable desalination technologies for a specific type of water should be identified and implemented if the selected process would be economically feasible, but in all cases, the energy requirements are of critical importance. The capital investment and operating costs for desalination plants are normally too high to allow the use of the water for anything else than industrial and mining demand.

Better quality (potable) water used in industrial processes can also be substituted with brackish water or more saline water. As an example it can be mentioned that seawater is used for washing and cleaning purposes in the fishing factories in Walvis Bay, instead of using potable water.

Water demand management can be defined as an integrated approach towards the sustainable development of water supply infrastructure and the utilization of water resources. This involves the implementation of efficient water use practice, economic efficiency and protecting the water resource environment from over exploitation. Managing water demand can reduce the excessive consumption of water, delay the development of additional capital intensive water supply infrastructure and conserve scarce water resources.

A water awareness campaign should form part of a water demand management strategy to achieve effective water conservation in all sectors. The important components of a strategy to enhance the sustainable and conservative use of water would be to obtain public participation, to inform the public about practical measures to reduce water wastage and to conserve water, as well as to introduce punitive water tariffs to discourage high water consumption. If water is used more efficiently at the consumer point, less water has to be supplied from the primary water sources.

Water demand management is relevant to any water supply situation, but in arid areas the scarcity of water makes it an unavoidable imperative to utilize every drop of water to best advantage and maximum benefit. The allocation of a permit by the DWAF to abstract water should always be considered in consultation with the KBMC and against the background of more efficient water use, as well as the possibilities for water conservation and water demand management.
6.5 Water Quality

The potability of water is determined by its aesthetic (taste, smell, turbidity), chemical and bacteriological quality. Water from perennial or ephemeral rivers is generally of excellent chemical quality, but the runoff in the ephemeral rivers during the rainy season has high turbidity. In most cases the water in the large storage dams only requires clarification and disinfection to render it suitable for human consumption. In some cases the water may have unacceptable tastes and smells (For example at the Von Bach Dam) that must be removed in the water treatment process. Under prolonged drought conditions, the concentration of the total dissolved solids in the water in dams will start to rise as a result of evaporation and may render the water less suitable for certain industrial uses (For example in boilers).

The chemical quality of groundwater is determined by the abundance of rainfall and the chemical composition of the geological formations through which the groundwater percolates before it accumulates in an aquifer. The age of the water is also important, because it relates to the time that was available to dissolve the soluble rocks in an aquifer. Groundwater in arid regions tends to have elevated concentrations of dissolved solids that may, in some cases, render the water unfit for human and/or animal consumption. The detrimental constituents and their effect on health are indicated below:

(a). Nitrates: Methaemoglobinaemia
(b). Sulphate: Diarrhea
(c). Fluoride: Bone fluorosis
(d). Chloride: Taste, hypertension

An acceptable level of aesthetic and bacteriological quality for potable water can be achieved with an appropriate water treatment process, but it is more difficult to deal with unacceptable concentrations of dissolved solids. The chemical treatment of water with a high concentration of unwanted total dissolved solids is expensive, but this can be overcome by mixing the unsuitable water with suitable water to produce blended water with an acceptable quality.

Corrosive water or hard water may also cause damage to water supply equipment and needs careful consideration in the design of water treatment works and water supply infrastructure. The use of surface water or groundwater for irrigation in arid areas should be considered very carefully to avoid the salinization of the soil. Scientific analysis is called for to ensure that the chemical quality of the water and the available soil is compatible for irrigation purposes.

The required bacteriological quality of potable water can be achieved by disinfecting the water with chlorine or by using other methods, but the bacteriological quality of potable water should conform to the Namibian Water Quality Guidelines or the standards of the World Health Organization.

The allocation of permits to institutions (For example NamWater) that would abstract and supply water to their customers, should always prescribe the quality of the water to be supplied and the KBMC should be involved in a process of consultation regarding the allocation of such permits.

6.6 Waste Water Management

The treatment of domestic and industrial waste water is a very important issue in any arid country because the pollution of surface water, groundwater and the environment must be prevented. As much of the effluent as possible should also be reused in some way. Due to the absence of large quantities of water to flush pollutants from contaminated water resources, it is virtually impossible to restore the quality of such water resources once polluted. It is therefore a requirement that local authorities who must treat domestic sewage effluent and industries or mines that produce waste water or toxic waste water must be in possession of permit issued by the DWAF. The main purpose of the
permit is to prescribe how the effluents should be disposed of and to impose penalties for those institutions that do not comply with the permit conditions.

Domestic waste water in towns must be discharged from the individual premises into a sewerage system where the effluent is collected to be treated by the local authority at a central site. Smaller quantities of effluent can also be disposed of in oxidation dams and evaporation ponds instead of being treated. The treated water can be disposed of by means of evaporation in ponds or released into a public stream, if the quality of the effluent meets certain standards. Formal water-borne sewage disposal services are generally only rendered in urban areas and larger villages or at mining development sites and tourism centres in game parks. French drains and other appropriate sewage disposal methods are also used, but where there is a scarcity of water, the implementation of dry disposal systems should be investigated. It is the responsibility of certain Ministries, local authorities and the private sector to ensure that proper sanitation services are provided.

Industrial waste water may not be discharged into any public stream and must be treated in the same manner as sewage effluent, especially within urban areas and at mining sites. However, in cases where the quality of the industrial effluent is too toxic for treatment in normal sewage treatment works, the industrial concern must cater for its own wastewater treatment and disposal or it must dispose of the waste at a site prescribed and controlled by the local authority. The treatment and disposal of industrial and mining effluent in an area outside the control of a local authority must be done according to a permit which is issued by the DWAF in terms of the Act.

In view of the fact that the quality of industrial and mining effluent depends on the specific treatment process, the producer of the effluent must assist the DWAF by providing information about the quality of the waste water and to specify the treatment process proposed to dispose of the effluent to the satisfaction of the requirements of the DWAF in terms of the Act and any regulations. In the application for a waste water disposal permit it is required that a full environmental assessment should be done and the results submitted a part of the application. The proposed treatment process is then evaluated by the DWAF or the evaluation may be outsourced to a competent consultant that can advise the Ministry about the adequacy of the procedures proposed by the applicant to deal with the disposal of the waste water in such a way that there would be no unmanageable detrimental environmental effects.

7. Evaluation of Permit Applications

7.1 Introduction

This section will cover the procedures for the evaluation of permits for the abstraction and use of water, as well as the disposal of waste water according to the Water Act promulgated in 2004. The Water Act is at present under revision and some of the provisions in the Water Act will most probably change and many will become part of the regulations to be made under the Water Act.

7.2 Surface Water and Groundwater Abstraction

A person has the right to collect rainwater or to abstract water from a water resource or to dig a well by hand outside a local authority area or water management area to obtain water for domestic use and is exempted from the acquisition of a licence to abstract and use such water. However, a person may not abstract or use groundwater or surface water, including brackish or marine water for any other purpose than domestic use, except in accordance with a license issued under the Water Act.

A person who wishes to abstract and use water may apply to the Minister for a license to abstract and use water in the manner prescribed in the Regulations. The application must include:
(a). The name of the applicant;
(b). The names of owner and occupier of the land upon which the proposed beneficial use will be made;
(c). The water resource from which the proposed abstraction will be made;
(d). The proposed location of the abstraction;
(e). The type and location of the proposed beneficial use;
(f). The proposed rate and volume of the abstraction;
(g). The proposed timing of the abstraction;
(h). A description of any waterworks necessary to accomplish the proposed abstraction and a proposed schedule for the completion of such waterworks;
(i). A description of the proposed treatment that will be given to the abstracted water, including any chemicals proposed to be applied to the water;
(j). A description of the volume, rate and chemical composition of any effluent or return flow resulting from application of the abstracted water to beneficial use and a description of the place where any such effluent or return flow is expected to enter a water resource; and
(k). Any additional information the Minister may prescribe.

An applicant for a license to abstract and use water must, at least 60 days before the application is submitted to the Minister, issue a notice in the Government Gazette to invite all interested persons to submit their objections within 30 days in writing, if any. The application must be accompanied by proof of the publication of the notice, the response from affected parties, representations by the applicant in support of the application in case of any objection and an environmental impact analysis of the proposed abstraction of water upon the water resources, the environment and existing water users as well as the prescribed fee.

Upon receipt of the application the Minister must refer the application to the basin management committee concerned for investigation and recommendations before a decision is made about the award of the permit or license. If there is no basin management committee established for the area concerned the Minister may take the decision. A basin management committee must:

(a). Investigate all matters pertaining to the application;
(b). Consider the objections and representations, if any;
(c). Make recommendations to the Minister.

After considering the recommendations of the basin management committee, the objections by interested persons, the representations of the applicant and the environmental impact analysis the Minister may grant the application to abstract water, with or without conditions, or deny the application. The applicant may appeal against the decision of the Minister and may file a notice of appeal to the Water Tribunal within 14 days of the decision.

A license to abstract and use water issued may be renewed and an application must be made at least three months prior to the expiry of the licensee.

The Minister may at any time review, amendment, suspend and cancel a license to abstract and use water if the licensee fails to abide by any of the terms and conditions of the license or fails to commence with the abstraction of water within the period specified in license or ceases with the abstraction of water for a continuous period of three years or if it is in the public interest to do so. However, before the Minister amends, suspends or cancels any license the licensee may make representations in respect of the proposed amendment, suspension or cancellation.
If a license to abstract and use water expires and is not renewed, or is cancelled, the Minister may require the licensee, at the licensee’s expense, to remove any liens or other restrictions preventing the free use of the abstraction works, order the licensee to restore, at the licensee’s expense, the state of affairs which existed before a license was issued, if doing so is reasonable and practicable under the circumstances; or enter into an arrangement with the licensee or any other person for the maintenance of an impoundment, abstraction infrastructure or effluent discharge works.

A license to abstract and use water may be leased to a third party under certain conditions specified in the Water Act. A license may be passes on to the named successor-in-title at the death of licensee or when a transfer is arranged, but that does not change the license conditions.

A license to abstract and use water does not guarantee the availability of water and the State is not liable if a licensee fails to obtain the permitted quantity of water, which may for example be as a result of drought or any other cause beyond the control of the State.

The Water Act provides for the control of groundwater development and if the holder of a permit to drill, construct, enlarge or otherwise alter a borehole or engage in a borehole drilling program for the purpose of exploring for groundwater has contracted another person to do the work required, then the permit holder or contractor must keep a record of the drillings and other operations carried out (such as test pumping) and furnish the Minister with the information provided by such drillings or operations.

7.3 Groundwater Development

A person who proposes to drill a new borehole, or to improve any existing borehole for the purpose of searching for minerals or other substances, or for road construction or for any purposes other than exploring for groundwater, must inform the Minister of such proposal, furnish the Minister with such data and information as the Minister may require in connection with such borehole drilling or improvement and take such measures as may be required by the Minister for conserving and protecting groundwater. Any excess water collected as a result of any activity related to the exploration for minerals, mining development or mining operations must be disposed of as prescribed by the Minister.

A person may not block or impede access to a state-owned borehole or borehole installation which is meant for public use and the Minister or water point committee concerned may summarily remove such blockage or impediment. The costs of removing any blockage or impediment may be recovered from the person responsible for the blockage or impediment.

A person may not cause or allow any groundwater to run to waste from any borehole, except for the purposes of determining the yield of the borehole or the quality of the water or when the borehole is cleaned, sterilized, or examined to be repaired, or if such water interferes or threatens to interfere with the execution of any underground mining operations or any other underground works, and no other method of disposing of such water is reasonably practicable.

The Minister has power to determine the safe yield of any aquifer for the purpose of allowing a certain quantity of water to be allocated for abstraction and may restrict or terminate the abstraction of water from an aquifer if the safe yield of the aquifer is exceeded. The safe yield is the amount of water that can be abstracted from an aquifer at a rate that will not be harmful to the hydrogeological environment or reduce the inflow into the borehole or affect the quality of the water.

The Minister may impose special requirements and restrictions with respect to artesian wells for the purpose of preventing water losses from the artesian aquifers, or the loss of artesian pressure; or wastage of water spilling out on the surface or the contamination of the aquifer water.
The Minister may also authorize programmes for the artificial recharge of, or the banking of water in aquifers.

A person may not engage in the trade of drilling boreholes or constructing wells unless such person is a licensed borehole driller or well constructor in terms of the Water Act. The Minister must prescribe the professional qualifications, as well as terms and conditions that should be complied with by any person who is issued with a license to practice as borehole driller or well constructor, including the circumstances under which a license may be cancelled or suspended.

### 7.4 Waste water

A person may not discharge any effluent directly or indirectly to any water resource on or under the ground, including through a borehole, or construct any effluent treatment facility or a waste disposal site above any aquifer unless the discharge of effluent or construction of the treatment facility or development of the disposal site is in compliance with a permit.

The Minister may exempt any person from obtaining a permit to discharge effluent from a septic tank, French drain or similar private sewerage facility, but may also withdraw any exemption or amend such an exemption by imposing new or further conditions, or by withdrawing certain conditions.

A person who wishes to apply for a permit to discharge effluent or to construct an effluent treatment facility or disposal site must submit an application to the Minister. The application must include:

(a) The name of the applicant;
(b) The owner and occupier of the land or facility from which the proposed discharge will be made;
(c) The location of the proposed discharge;
(d) The location of the proposed effluent treatment facility, if any;
(e) The location of the proposed disposal site, if any;
(f) Any land, water resource, or environmentally sensitive area to which the discharged effluent will flow, directly or indirectly;
(g) The proposed volume and rate of the effluent discharge;
(h) The proposed duration of the discharge;
(i) The anticipated chemical composition of the discharge, including pathogenic organisms;
(j) The proposed treatment that will be applied to the effluent stream prior to discharge, including a description of any effluent treatment facility that will be constructed prior to commencement of the discharge; and
(k) Any such additional information that the Minister may prescribe.

An applicant for a permit to discharge effluents or to construct an effluent treatment facility or disposal site must, at least 60 days before the application is submitted to the Minister, issue a notice in the Government Gazette to invite all interested persons to submit their objections in writing within 30 days, if any. The application must be accompanied by proof of the publication of the notice, the response from the interested parties, if any, and the prescribed fee.

Upon receipt of an application for a permit, the Minister must give the applicant an opportunity to make representations in support of the application, if there were any objection made. The applicant must also conduct an assessment of the impact of the proposed effluent discharge or the proposed effluent treatment facility or disposal site upon the environment, including the owners and occupiers of land, as well as surface water and groundwater resources in the vicinity of the point where the proposed effluent will be discharged or the disposal site where the effluent treatment facility will be constructed.
The Minister may issue the permit to discharge effluent or to construct an effluent treatment facility or develop a disposal site, with or without conditions after considering:

(a). The contents of the application;
(b). The environmental impact analysis;
(c). The objections by interested persons, if any;
(d). Representations of the applicant, if any; and
(e). Compliance with the water quality criteria prescribed in the Regulations made in terms of the Water Act.

The Minister, after consultation with competent authorities, may prescribe minimum standards of effluent quality with which effluent discharged must comply.

The duration of a permit to discharge effluent or to construct an effluent treatment facility or develop disposal site may not exceed a term of five years, but may be renewed. The permit holder must, at least three months prior to the expiry of the permit, submit an application for renewal to the Minister in the prescribed manner.

The Minister may, at any time during the duration of a permit to discharge effluent or to construct an effluent treatment facility or develop disposal site, review the permit and amend the terms and conditions if it is considered to be in the public interest, but may invite the permit holder to make representations in respect of the proposed amendment.

The holder of a permit to discharge effluent or to construct an effluent treatment facility or disposal site may apply to the Minister for approval to transfer the permit to another person under certain conditions. The Minister, within 60 days of receipt of the application for transfer of a permit may grant the application, with or without additional conditions, or deny the application. At the transfer or death of a permit holder, the permit must pass to the successor-in-title of the permit holder, but the validity period of the permit will remain the same.

The Minister may cancel or suspend a permit in whole or in part, if the permit holder fails to comply with the provisions in the Water Act or any of the conditions of the permit, or fails to commence with the discharge or construction operations within the period stipulated in the permit or, after having commenced with the discharge of effluent or construction of an effluent treatment facility or disposal site, fails to discharge waste water or complete the construction work or if it is in the public interest to cancel or suspend the permit. The Minister may not suspend or cancel the permit without giving the permit holder an opportunity to make representations within 30 days of receipt of the notification of the Minister’s intention to suspend or cancel the permit.

If a permit to discharge effluent or to construct an effluent treatment facility or disposal site expires and is not renewed, or is cancelled prior to its expiry the Minister may order the permit holder to restore, at the holder’s expense, the state of affairs that existed before the permit was granted, if doing so is reasonable and practicable under the circumstances; or enter into an arrangement with the permit holder or any other person for the maintenance of the effluent discharge works or waste disposal site.
8. Discussion of Permit Conditions

8.1 Abstraction of Water

In deciding whether a license to abstract and use water should be issued, the Minister must consider the following criteria:

(a). Whether the proposed abstraction and use of water are consistent with the objectives and principles referred to in the Water Act (Sections 2 and 3 respectively), the National Water Master Plan; and any reservation of water for certain purposes (Section 27);
(b). The impact of the proposed abstraction upon existing water users, including uses by virtue of customary rights and practices, the stream flow regime, other existing and potential uses of the water resource, the sustainability of the water resources and the water reserved or allocated for environmental uses;
(c). The safe yield of the dam or perennial river or aquifer from which the abstraction is proposed;
(d). The conformity of the proposed use with the efficient water management practices;
(e). The need to redress the effects of past racial and gender discrimination;
(f). The likely effect of the proposed abstraction on the quality of any water resource, and on aquatic ecosystems dependent on the resource;
(g). The need to ensure the efficient and beneficial use of water resources;
(h). The existence of any traditional community and the extent of customary rights and practices in, or dependent upon, the water resource to which an application for the license relates; and
(i). Any additional criteria the Minister may prescribe.

The contents of a license to abstract and use water must specify:

(a). The person to whom the license is granted;
(b). The validity period of the license, which is not more than five years;
(c). The place of abstraction and use;
(d). The water use or uses the water is allocated for;
(e). The conditions of use, for example the specific volume of water which may be abstracted, the rate of abstraction, the time when water may be abstracted, the place where a dam may be built in watercourse, the volume of water which may be impounded and stored;
(f). Proper water management practices such as the preparation and approval of a water management plan, efficient water management, water use and conservation, the monitoring of uses, water levels and water quality, the proper discharge, treatment or disposal of any return flow or effluent;
(g) The fact that the license is subject to periodic review and to suspension, amendment or cancellation in accordance with the Water Act;
(h). The frequency of review and
(i). Any other conditions that may be required, such as that the licensee must become a member of a local water user’s association, where appropriate, before water may be used.
8.2 Waste Water Disposal

The criteria for a decision to award a permit to discharge effluent or to construct effluent treatment facility or disposal site:

(a). Is the proposed discharge or construction is consistent with the Master Plan;
(b). What is the water into which the discharge will be made, used for;
(c). The standards for waterborne contaminants adopted by a competent authority;
(d). The impact of the discharge on existing water uses;
(e). The impact of the proposed effluent treatment facility or disposal site upon groundwater;
(f). Any impact of the proposed effluent discharge upon the environment, including owners and occupiers of land and water resources in the vicinity of the proposed effluent discharge or construction of effluent treatment facility or disposal site;
(h). The need to ensure the efficient and beneficial use of water resources; and
(i). Any additional criteria the Minister may prescribe.

A permit to discharge effluent or to construct an effluent treatment facility or disposal site must specify:

(a). The person to whom the permit is granted;
(b). The location of the discharge;
(c). The location of the effluent treatment facility or disposal site;
(d). The limits of any constituent elements of the discharge;
(e). Requirements for waterproofing or covering the effluent treatment facility or disposal site;
(f). The validity period of the permit;
(g). The conditions subject to which the permit is granted;
(h). The frequency of review of the permit; and the fact that the permit is subject to periodic review and to suspension, amendment or revocation under this Act.

A permit to discharge effluent or to construct an effluent treatment facility or disposal site is issued subject to the protection of any water resource to which the discharge will be made as well as any existing or potential uses of the water resource, including environmental uses, by specifying the volume of effluents that may be discharged, the rate of discharge, concentration of certain substances in the effluent, the time, if any, when effluents may not be discharged, the location where a discharge may, or may not be made and adding any such terms regarding the protection of the water resource which the Minister determines to be appropriate.

The object is the protection of any water resource, including ground water, in the vicinity of the effluent treatment facility or disposal site, by specifying the location of the effluent treatment facility or disposal site, limiting the type, volume, composition or concentration of effluent discharged by the effluent treatment facility or stored in a disposal site, specifying the requirements for lining or covering the effluent treatment facility or disposal site, the requirements for operating, managing and closing the effluent treatment facility or disposal site; and adding any such terms for the protection of residents, water users or water resources in the vicinity of the effluent treatment facility or disposal site which the Minister determines to be appropriate.

The Minister must also ensure proper effluent discharge management. The Minister prescribe and specify in the permit the monitoring, analysis and reporting on every discharge, the quality of the
discharge to be monitored and reported on, as well as the devices to be used for such monitoring, including the need for an effluent discharge management plan, the protection of public health and the payment of charges.

9. Other provisions in the Water Act

9.1 Protection of Water Resources

The Minister, by notice in the Government Gazette, may declare an area as water management area for the purpose of protecting any water resource, riverine habitat, watershed, wetland, environment or ecosystem at risk of depletion, contamination, extinction or disturbance from any source, including aquatic and terrestrial weeds. The notice must include a description of the purposes for which the area is so declared, the geographic boundaries of the area, as well as the limitations and prohibitions applicable within the area. The Minister may not declare any area as a water management area without giving the owners or occupiers of land within a proposed water management area the opportunity to make representations regarding the need for the water management area, the proposed boundaries of the area or the land use limitations and prohibitions proposed for the area.

The boundaries of any water management area must be determined in a manner that takes competing uses of the area concerned into consideration and, if the declaration of a water management area results in or requires the acquisition of land through expropriation, every such acquisition, including the award of compensation and appeals related thereto must be conducted in accordance with the law on the expropriation of property in the public interest.

A person may not undertake or cause any activity to be undertaken that impairs or conflicts with the purposes for which a water management area is declared. The Minister may prescribe limitations to be observed within a water management area, such as a prohibition or limitation on the abstraction of water, the erection of any structures, the application or storage of any chemicals, including pesticides or fertilizers the alteration of existing land contours, including any grading or construction of roads or the cultivation of crops or the clearing or harvesting of vegetation, including the felling of trees, or the removal of riparian growth or the draining of wetlands, or the use of wetland resources, the discharge of effluent, the mining, dredging or the reclamation of land and necessary for the protection of a water resource.

If a limitation is imposed that will affect existing licenses or permits issued under this Act, the limitation must, to the extent possible, be assessed and distributed proportionately among all affected license or permit holders, as the case may be.

The Minister may, by notice in the Government Gazette, amend the geographic boundaries of a water management area, or any prohibition or limitation applicable to the area, if circumstances in respect of the area change or so require; or withdraw a declaration of a water management area if the circumstances under which the declaration was made no longer exist.

9.2 Efficient Water Management

The Minister must prescribe procedures on how to develop and adopt efficient water management practices that minimize wastage of water, encourage efficient water use and advance the control of pollution, either for regions in general or for a specific region, or for any area defined by the Minister. In prescribing procedures as to how to develop and adopt efficient water management practices the Minister must consult public and private institutions dealing with environment and water, and water users concerned, and may consider any measures consider necessary.
The Minister must undertake periodic reviews of water users throughout Namibia to determine their compliance with the efficient water management practices. If a water user fails to comply with efficient water management practices, the Minister must issue a notice of non-compliance to the non-compliant water user requesting the user to take corrective measures within a period specified in the notice which period may not exceed 60 days from the date of receipt of the notice. If the non-compliant water user fails to comply with the notice, the Minister may cancel or suspend the license, if the user is licensed, or impose monitoring and such other measures which the Minister determines to be appropriate in the circumstances. The Minister may not take any decision under subsection without affording the water user and any other interested persons the opportunity to show cause why a license may not be suspended or cancelled or monitoring measures and such other measures may not be imposed.

A water user or any interested person who is not satisfied with the decision made by the Minister may file a notice of appeal to the Water Tribunal within 14 days from the date the decision was made.

A water user who has conserved irrigation water by successfully applying efficient water management practices may apply to the Minister to transfer such water, except groundwater, to another person. Upon receipt of the application, the Minister must consider whether the terms and conditions of the proposed transfer is consistent with the terms and conditions of the conservation of irrigation water, any deviation from the terms and conditions of the license to abstract and use water that may impact adversely upon other persons and the environment and the purposes for which water will be used by the new user. The Minister, within 60 days of receipt of the application, may grant the application, with or without additional conditions, or deny the application.

10. Conclusions

From the above it is clear that the KBMC can play an important role in assisting the DWAF to implement water legislation efficiently if they are afforded the opportunity to participate in the decision-making about the award of licenses and permits for the allocation and use of water or the disposal of waste water. The KBMC is therefore advised to approach the DWAF and to insist that full collaboration must be implemented between the parties to protect the interests of the local stakeholders in the water and environmental resources of the basin. This could be achieved with a formal Memorandum of Understanding or an Agreement between the Parties.

The KBMC is advised to approach the DWAF to brief them on the progress with the revision of the Water Act and even to comment on the draft regulations to be made in terms of the Water Act.

The KBMC should request the DWAF to inform them about the interpretation and implementation of the Water Act by means of an appropriate training workshop where all Parties and stakeholders can be aware of and understand how the Water Act will be implemented and what contribution can be made by the KBMC to ensure the proper implementation of and compliance with the legislation.

In this regard there may opportunities to solicit funding for the proposed workshop or perhaps the appointment of a consultant to provide the briefing about the legal and technical implementation of the Water Act.
11. REFERENCES


