Interactive Environmental Learning and Action in the Kuiseb (ELAK)

Proceedings of the Stakeholders Workshop

Gobabeb Training and Research Centre (GTRC), Gobabeb, Republic of Namibia
5th December 2001

Report compiled by Mr. Andre Bates and Mr. Jefta Goreseb
Desert Research Foundation of Namibia, Windhoek
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Report compiled by Mr. Andre Botes and Mr. Jefia Goreseb
Desert Research Foundation of Namibia, Windhoek
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Interactive Environmental Learning and Action in the Kuiseb (ELAK)
Stakeholders workshop
Gobabeb Training and Research Centre (GTRC), Gobabeb, Namibia
5th December 2001

1. Introduction

Interactive Environmental Learning and Action in the Kuiseb, in short ELAK, is a project funded by the European Union and implemented by the Desert Research Foundation of Namibia. The DRFN sees its role as facilitator to gather all stakeholders together for consultative planning of Basin activities. ELAK’s focal points are based on innovative approaches among all stakeholders within and dependent on the Kuiseb River Basin and factors such as the social, environmental and economic situation of the Kuiseb Basin which need to be addressed. Based on these focal points, ELAK had a stakeholders workshop on the 5th of December 2001 at Gobabeb. The aim of the workshop was to inform all the stakeholders about ELAK, to ascertain their current plans regarding the Kuiseb Basin, to exchange and share information and to plan the road ahead in order to work towards a common goal.

2. Welcoming speech

Mr. Andre Botes, the Project Manager, welcomed everybody to the stakeholder workshop and thanked everybody for taking his or her time to attend the workshop. Mr. Botes elaborated on how the project can play a role in the development of the people within and dependent on the Basin. Lastly Mr. Botes expressed his hope for the workshop to be a platform of interactive learning and sharing of ideas. ELAK is not there to dictate how activities should be planned, but to facilitate joint planning by all stakeholders to achieve a common goal.

3. List of participants

Since it was a stakeholder’s workshop, potential people/organisations within and dependent on the Kuiseb River were invited to the workshop. The following people participated in the workshop:

<table>
<thead>
<tr>
<th>Name</th>
<th>Address</th>
<th>Tel no</th>
<th>E-mail</th>
<th>Fax no</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. Andre Botes</td>
<td>P.O. Box 20232</td>
<td>061-229855</td>
<td><a href="mailto:andre@drfn.org.na">andre@drfn.org.na</a></td>
<td>061-230172</td>
</tr>
<tr>
<td>DRFN</td>
<td>Windhoek</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mr. B. Kruger</td>
<td>P.O. Box 20232</td>
<td>061-229855</td>
<td><a href="mailto:bertus@drfn.org.na">bertus@drfn.org.na</a></td>
<td>061-230172</td>
</tr>
<tr>
<td>DRFN</td>
<td>Windhoek</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mr. J. Goreseb</td>
<td>P.O. Box 20232</td>
<td>061-229855</td>
<td><a href="mailto:jeflag@drfn.org.na">jeflag@drfn.org.na</a></td>
<td>061-230172</td>
</tr>
<tr>
<td>DRFN</td>
<td>Windhoek</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mr. A Brummer</td>
<td>P.O. Box 5017</td>
<td>064-2013215</td>
<td><a href="mailto:abrummer@walvisbaycc.org.na">abrummer@walvisbaycc.org.na</a></td>
<td>064-205590</td>
</tr>
<tr>
<td>Walvisbay Municipality</td>
<td>Walvis Bay</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The participants strongly felt that the following organisations should be included as stakeholders in the Kuiseb Basin and be invited to the next workshop.

<table>
<thead>
<tr>
<th>Namibia Water Resources</th>
<th>Walvis Bay EPZ</th>
<th>Fishing Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ministry of Mines and Energy</td>
<td>Rural Water Supply</td>
<td>Ministry of Environment and Tourism</td>
</tr>
<tr>
<td>Namport</td>
<td>Commercial farmers</td>
<td>Ministry of Agriculture Water and Rural Development (DEES + DWA)</td>
</tr>
</tbody>
</table>

4. Purpose of the workshop

Mr. Botes elaborated on the purpose of the workshop as being:

1. Information- sharing on ELAK
2. Overview of stakeholders current plans
3. Work towards a common vision
4. The road ahead
5. Program

All stakeholders agreed on the program of the day to be:

1. Welcoming and purpose of the workshop
2. ELAK-overview
3. Stakeholders presentations
   • Walvis Bay Municipality
   • Swakopmund Municipality
   • Rossing mine
   • Namwater
   • Topnaar Community
4. Work towards a common vision
5. Contributions and Expectations
6. The way forward

6. Presentations

1. Mr. Andre Botes of Desert Research Foundation and the ELAK Project Manager gave a short overview of the project activities as well as some background information on Basin Management in general. Through this project, the DRFN hopes to achieve equitable access to and sustainable development of freshwater and other natural resources by all sectors dependent on the Basin in order to promote long-term social and economic development.

Overview on ELAK (See annex A for a presentation)
2. Presentations by Stakeholders

Each stakeholder was requested to inform the participants of their current plans regarding usage of natural resources of the Kuiseb River Basin.

2.a. Walvis Bay Municipality

Mr. Brummer informed the group that they envisage total water demand to increase to between 5 and 5.5 million m$^3$ per annum. The estimate growth rate for Walvis Bay is around

![Graph: Potable Water + Purified Effluent Consumption (m3/a)]

6% and about 50% of the total water demand are used by Industry. It is proposed that should big industries like an oil refinery or steel factory being established at the coast, the industries then would be responsible to erect a desalination plant to cater for their water demand.

Mr. Brummer concluded that with the current growth rate of Walvis Bay and the estimated availability of water, they would not extract more than the sustainable level in the next 20 years.

2.b. Swakopmund Municipality

The meeting was informed that Swakopmund is currently supplied with water from the Omdel Scheme. The reason might be due to the poor condition of the Swart Bank pipeline. The current water consumption is around 2.7 million m$^3$ with a peak of 3.4 million m$^3$ during the period 1994/95.

The municipality is of opinion that Tariff Structures are the best way to control water demand. Since such structures were introduced, water demand decreased to the current level.
Based on the current growth rate of the town, it is estimated that the demand will increase to 3 million m$^3$ by the year 2010.

One of the reasons for reduction in demand was a change in policy from the Rössing mine’s side. The mine used to pay all water bills for staff that resulted in wastage of the scarce resources. Staff is now responsible for their own accounts.

2.c. Rössing mine (See annex B for a presentation)

Rössing Uranium mine introduced alternative mining practices to reduce the demand of fresh water. During 1977 their total water consumption was around 10 million m$^3$ per annum and the mine managed to reduce that to a current usage of 2 million m$^3$. Their aim is to bring it further down to about 1.5 million m$^3$ per annum.

Graph x in annex three clearly shows the reduction, in Rössing’s consumption. The current total annual demand for the central Namib Area is some 11 to 12 million m$^3$ per annum.

Although Swakopmund and Rossing currently get water from the Omdel scheme, it is important to collaborate in this way (ELAK) to monitor our scarce resources.

2.d. NamWater (See Annex C for a presentation)

ASSESSING VULNERABILITY TO DROUGHT AND POSSIBLE EFFECTS OF CLIMATE CHANGE ON WATER RESOURCES IN A SEMI-ARID COUNTRY

A C Mostert (Pr.Sci.Nat.), G van Langenhove and B de Bruine

P/B 13193, Windhoek, Hydrology Division,
Ministry of Agriculture, Water and Rural Development,
Department of Water Affairs, Republic of Namibia
Lower Kuiseb Aquifers

Background

The scarcity of water in the Kuiseb is not a recent phenomenon. Mr. Wessels began his presentation with a quote from the year 1874:

“No water has flowed over the bed of the Kuiseb into the bay for twelve years, so you can imagine that water is not one of the obstacles to be met with. Sand Fountain is a pit dug in the bed of the river, and yields a scanty supply of very brack water. It has not rained at the bay for 18 years but fogs are common and fleas more than common. I’ve never seen their numbers or their appetite. The only known disease at the bay is intoxication. Drinking water is brought from Cape Town, and they will give you a bottle of English ale worth 25 cents sooner than a drink of water.”  

Gerald McKiernan (a hunter Walvis Bay, August 1874)

Abstraction & Demand

1986 - 2000: abstraction averaged 7.7 Mm³/a
1986 - 2000: Walvis Bay average consumption - 4.45 Mm³/a
2000: abstraction totalled 5.8 Mm³/a
2000: Walvis Bay consumption totalled 4.6 Mm³/a
2018: Projected NamWater Demand - 6.1 Mm³/a (Calitz, 2001)

Runoff

- 80 year mean: 20 Mm³/a
- 1921 - 1970: 10 yr moving average - above 80 yr mean
• 1970 - 2000: below 10 yr moving average

A recent Summer Desertification Programme study founded that about 46% of natural catchment flow is intercepted by farm dams in the catchment during small floods (DRFN, 2001). The aquifer is only recharged in the event of big floods.

Runoff - Flood Return

The latest measurements showed that the water level in the Kuiseb aquifer is back to the 1988 levels. It is estimated that more than 500 million m$^3$ is stored under the dunes. A recent investigation also revealed that some water is flowing under the dunes in channels from the Swart Bank area to Sandwich harbour. It is estimated that about 3 million m$^3$ is lost via these channels.
There is a high degree of uncertainty amongst scientists on the total water demand of trees in the Kuiseb River. The following gives an indication of the variances:

- Blom (1978) : $0.83 \text{ Mm}^3/\text{a}$
- Bate & Walker (1980): 15 - 20% of Stored Reserves ($24 \text{ Mm}^3/\text{a}$)
- Sonntag (1985) : $0.7 \text{ Mm}^3/\text{a}$
- Namwater (unofficial): 0.4 - 0.8 $\text{ Mm}^3/\text{a}$

**Sustainable Yield**

Sustainable yield is the amount of naturally occurring groundwater that can be withdrawn from an aquifer on a sustained basis, economically and legally, without impairing the native groundwater quality or creating an undesirable effect such as environmental damage. Sustainable yield of an aquifer is in direct relation with the recharge to the aquifer from both subsurface through flow and infiltration (artificial or natural) from runoff or rainfall. Kuiseb Aquifers Sustainability is closely related to runoff in the Kuiseb River.

During discussions regarding the aquifer, the question was raised how to handle Inter-Basin transfers and whether it should be part of the discussions at this forum. This issue needs to be elaborated on during the next meeting.
Presentation by Mr. Dausab on behalf of the Topnaar community

Mr. Dausab thanked the organisers for inviting them to the workshop. Since they as Topnaars are one of the stakeholders this is the right platform to inform other stakeholders about the water users in the Kuiseb area.

The Topnaar community has 14 settlements along the river whereby 7 settlements depend on the NamWater pipeline and the other 7 settlements on the boreholes (wheel pump or diesel engine). Most of the water supply systems where damaged during the last floods. Government is currently in the process upgrading the water supply systems. New solar energy pump systems are installed, pipelines are and water tanks are installed and distributed along the settlements with the help of Rural water supply. The Topnaars have established water point committees to ensure proper management of the water points.

One of their major concerns is the increase in mining activities by people; this can have a negative effect on the Kuiseb. The meeting felt that this issue should be discussed with the Ministry of Mines and Energy and that the Ministry should keep ELAK updated. The Topnaar community’s policy is to support water saving initiatives and hope that the coastal towns and Rossing mine will implement water usage or saving methods for the betterment of the mankind.

Mr. Dausab also informed the meeting that the growth and production of the !Nara plants indicates that the underground water is recharged.

7. Work towards a common vision

With the background information presented at the meeting, participants were requested to participate in brainstorming sessions to begin the process to formulate a common vision for the Kuiseb River. The representatives present decided that it was too early to finalise the formulation of a common vision, especially when some stakeholders were not present. Smaller groups were tasked to formulate a common vision from the ideas on the pin-board resulted from a brainstorming session as minuted below.
Group work carried out towards the formulation of proposed visions as mentioned above.

From your individual perspective, visualizing the Kuiseb Basin, 10-20 years from now, WHAT DO YOU SEE?

Interactive multi-stakeholder conservation + demand management
- Effective Management of the Basin
- Defined water level is maintained in the Kuiseb to prevent damage to the trees
- Water resources management
- Improved water + catchment management systems
- Participation by all stakeholders regarding basin management
- Better understanding of upper + lower Kuiseb by all
- Optimized + safe extraction methods from aquifer
- Sustainable water supply
- Alternative sources of portable water to be explored

Very high water tariff for people using over 20m³/month
- More reliable recharge of aquifer

Integrated water demand management base on technical data
- Water distribution systems are well maintained to prevent leakage
- Alternative sources of portable water to be explored

Environmental Sustainability
- Maximum biodiversity maintained
- Biophysical part of Kuiseb basin maintained
- Supplier of other natural resource (food, grazing etc.)
- Green Kuiseb with lots of trees

Socio and Economic sustainability
- No rural community along the Kuiseb
- All residents in the Kuiseb make good living
- Sustainable utilization of all natural resources within the catchment
- Reduce exploitation of underground water

Equitable access to water
- Reliable water supplier
- Water for all
- Still no storage dam in the Kuiseb
- Water resources development

Water conflict
The groups came up with the following six proposals:

- Multi disciplinary Kuiseb Management
- The Kuiseb Basin sustainably provides for the livelihoods of all its stakeholders while maintaining ecological integrity
- Integrated water conservation and demand management entailing social, economic and environmental sustainability
- Kuiseb Basin enhancing economic development and management
- Sustainable and equitable use of water

After some elaboration on the various options, the meeting agreed on the following as a potential vision for the Kuiseb River Basin: "A Healthy Kuiseb River Basin"

This issue will be further discussed during the next stakeholder meeting to be held in Swakopmund during March 2002.

8. Contributions and expectations

The layout below show the contribution and expectation pledge by organisations who were present at the workshop.

<table>
<thead>
<tr>
<th>Name of the stakeholder</th>
<th>Purpose</th>
<th>Contributions</th>
<th>Expectations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swakopmund Municipality</td>
<td>To provide + maintain safe,sufficient + affordable services and to</td>
<td>Share in knowledge + experience</td>
<td>Continuity of Basin Management</td>
</tr>
<tr>
<td>Rossing Mine</td>
<td>1. Port of bulk water users&lt;br&gt;2. Interested in sustainable development&lt;br&gt;3. Mining of Uranium&lt;br&gt;4. Input into economy</td>
<td>Technical expertise&lt;br&gt;Data collection&lt;br&gt;Awareness training&lt;br&gt;Research</td>
<td>Information sharing&lt;br&gt;Learning for Omdel dam basin committee</td>
</tr>
<tr>
<td>NamWater</td>
<td>Bulk water supply</td>
<td>Bulk water resources/water supply&lt;br&gt;Infrastructure to make water a reality</td>
<td>Full cost recovery</td>
</tr>
<tr>
<td>Topnaar Community Foundation</td>
<td>Survival</td>
<td>?</td>
<td>Sustainable access to resources</td>
</tr>
<tr>
<td>DRAGO</td>
<td>To do long term ecological research and training</td>
<td>Data outreach expertise, research and Training</td>
<td>Information/Co-operation and Transparency</td>
</tr>
</tbody>
</table>
9. The way forward

As facilitator, the ELAK project requested participants to elaborate on what they feel the next steps in the implementation of the project should be. The meeting concluded that the next steps should be:

1. Reconfirm / elaborated on common vision.
2. Draft Memorandum of Understanding to be discussed by all stakeholders.
4. Namibia Water Resources Management Review to chair the committee.
5. Incorporate the interested people.
6. Prior to next meeting, brief other stakeholders who were not present.

It was agreed by all participants to have the stakeholder meetings at different venues. Swakopmund municipality offered to be the host for the next stakeholder meeting to be held in March 2002. All participants agreed that such meetings are very important and useful and we should meet on a regular basis to improve communication and collaboration.

10. Closing remarks

Mr. Andre Botes closed the workshop and thanked the participants for their effort, specifically the spirit under which the workshop has take place. He also stressed that the workshop was worthwhile and wished everybody best of luck and safe journey back home.
Annexure A
Interactive Environmental Learning and Action in the Kuiseb
Central problems

- Desertification
- Impoverishment
- Sectoral or stakeholders goals resulting in conflicts over natural resources
- Economic and Biophysical environment
- Inadequate response by decision makers
- Inequitable water allocation within the catchment
Background

ELAK is an initiative of:

- Desert Research Foundation of Namibia (DRFN)
- Funded by the EU
ELAK focuses on innovative approaches among all decision makers within and those dependent on Kuiseb River basin

This approach involves:

- Facilitation among stakeholders
- Interaction among stakeholders
- Interactive learning and action
- Common vision across the stakeholders is developed, well understood and shared
- Data Management
- Information sharing, exchange and access
- Education and outreach
- Monitoring and Evaluation
- Community involvement
To work towards the
Overall goal

Contribute towards improved understanding of water resources and management in Namibia to enhance the livelihoods of Namibians dependent upon natural resources within the Kuiseb basin
Activities

Consultations
- Conduct and facilitate workshops
- Information gathering, sharing and exchange
- Identify needs through stakeholders
- Establish comm. mechanisms

Monitoring
- Undertake M+E
- Provide Feedback

Interaction
- Establish MoU describing a common vision
- Establishment of relevant groups

Research
- Undertake relevant studies and research
- Exchange visits to relevant areas
Why Kuiseb River basin?

- Ephemeral river with prevailing aridity and variable rainfall
- Most populated and heavily used of the westward flowing ephemeral rivers
- Stakeholders' goals/objectives result in conflict over Natural resources
- Located within a contrasting/unique area (dunes and gravel plain)
Basin Management

Future of basin depends on:

Sustainable use of natural resources

To do this; need to know:

- Condition of land & water
- Impact of social, cultural & economic activities on natural resources.

TO

Integrate human needs with environment needs.
Typical steps in Basin Management

- Outreach and awareness
- Collect basin information
- Analyse & evaluate information
- Prioritise concerns & issues
- Assess priority issues
- Develop management strategies
- Prepare basin plans
- Implement basin plans
- Monitor & Evaluate
Basin Management Committee

Committee appointed within the basin to address:

- Equitable usage and proper management of water resources
- Promote community participation through appropriate activities
Continue...

- Flood Management
- Efficient water use
- River regulation
- Balancing needs

To assist with conflict resolution and make recommendations
Basin Management Stakeholders

Topnaar community
Commercial farmers
Namibia Water Resource Management Review
Directorate Rural Water Supply
Ministry of Environment and Tourism
Walvisbay Municipality
Swakopmund Municipality
Rossing Mine
Namwater
DRAFT WATER BILL

The new draft Water Bill is supporting the idea of having Basin Management Committees in order to Plan and Manage water resources effectively.

This sets the scene for ELAK's role of achieving its goal through stakeholders on an open and transparent manner.
To achieve a common goal

Many hands are better than one hand
Annexure B
Water Management at Rössing Mine
Water sources of Rössing mine

- Fresh Water: 22%
- Khan River: 3%
- Recycled: 75%

Figures for 2000
Tailings dam 1976 - 1987
Paddock system since 1988
Process water circuit 2000

Storage in tailings 3600
Evaporation 2100
Acid plant 300
Uranium plant 5500

INPUT
Fresh water

LOSSES

Tailings dam

Processing plant

Seepage control systems 1100
Seepage dam & barge 5300
Tailings pools 15400

RECYCLING

27600

21800

Figures in cubic metres per day
Rössing mine water consumption
Water use in the Central Namib area
Annexure C
ASSESSING VULNERABILITY TO DROUGHT AND POSSIBLE EFFECTS OF CLIMATE CHANGE ON WATER RESOURCES IN A SEMI-ARID COUNTRY

A C Mostert (Pr.Sci.Nat.), G van Langenhove and B de Bruine

P/B 13193, Windhoek, Hydrology Division, Ministry of Agriculture, Water and Rural Development, Republic of Namibia
INTRODUCTION

• Driest sub-Saharan country
• Semi-arid to arid climatological/hydrological
• Erratic convective rainfall
• High seasonal rainfall variability
• River sustains sensitive environments
SCOPE OF INVESTIGATION

- Evaluation of surface water resources
- Schlesien runoff data

Procedure followed:
- Multiquadric surface fitting - area rainfall totals
- Hydrological routing of area rainfall totals and runoff through the catchment to calibrate parameters for NAMROM
- Extend the model back to the beginning of the rainfall period
- Generation of stochastic runoff and rainfall records
- Determine safe yields/reliability characteristics
- Change in frequency and magnitude of flows
- Possible effect of climate change on flows and yields
CATCHMENT CHARACTERISTICS

• Mountainous and hilly
• Hard and impermeable surfaces
• Well developed drainage system
• Closest towns are Windhoek Walvisbay and Swakopmund
• Land used for commercial stock farming
DONKERSAN DAM SITE

- Farm Donkersan
- Catchment approximately 3100 km²
- Dam site is 55 km upstream of Schlesien (6350 km²)
- Schlesien runoff record
- Elevation ranges from 1947 to 869 m AMSL
- Steam length of 240 km
- Well developed drainage systems
- Channel systems are well pronounced up to Rooibank
- On Average, flow reaches Rooibank every second year
- There have been periods of up to eight consecutive years of no flow at Rooibank
DOWN STREAM OF DAM SITE

- Topography changes to alluvial plains
- Dunes to the south
- Kuiseb river ends in the Namib dunes downstream of Rooibank
- Last time river reached Atlantic Ocean?
SPACE-TIME CHARACTERISTICS OF RAINFALL

FIGURE 3: SCHLESIEN MULTIVARIATE MEAN RAINFALL

RAINFALL (mm)

HYDROLOGICAL YEARS

- Rainfall
- 5 Year moving mean rainfall
- Mean rainfall
EVAPORATION

• No data for the dam site

• Used Gobabeb data and evaporation m

• Schlesien Nett evaporation 2435 mm/a

RUNOFF

• Data is available for Schlesien, Greyling

• Gobabeb and Rooitank

• No data available for the dam site
ADITIONAL INFORMATION

• Siltation, expected to be high
• Dam basin characteristics
• Storage capacities
• Dead storage's of the dam
• Generation of runoff record for the dam site
RAINFALL/RUNOFF MODELING

• Sub-catchments
• Run a monthly multiquadric model/rainfall
• Observed runoff record
• Regression equation
• Generation of stochastic rainfall and runoff record(s)
NAMROM

- Initial Loss
- Loss factor
- Loss exponent
- Antecedent season index
- Produces a stochastic rainfall and runoff record
SYNTHESESED VS OBSERVED RUNOFF

FIGURE 5: SCHLESIEN SYNTHESISED RUNOFF VS OBSERVED RUNOFF
STORAGE/DRAFT ANALYSES

- Donkersan Dam site
- Dead storage 5%
- 95% and 80% safe yields were calculated
YIELD/RELIABILITY CURVE FOR DONKERSAN DAM

YIELD RELIABILITY CURVES FOR DONKERSAN DAM

FSC of 6.67 Mm³
FSC of 35 Mm³
FSC of 46.17 Mm³

(%)
<table>
<thead>
<tr>
<th>MAGNITUDE (ANNUAL FLOW, Mm³)</th>
<th>STOCHASTIC 80% SAFE YIELDS</th>
<th>95% SAFE YIELDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>94.2</td>
<td>34.1</td>
</tr>
<tr>
<td>&gt; 1</td>
<td>77.5</td>
<td>32.0</td>
</tr>
<tr>
<td>&gt;= 5</td>
<td>68.1</td>
<td>24.8</td>
</tr>
<tr>
<td>&gt;= 10</td>
<td>41.6</td>
<td>19.7</td>
</tr>
<tr>
<td>&gt;= 20</td>
<td>26.7</td>
<td>11.8</td>
</tr>
<tr>
<td>&gt;= 50</td>
<td>6.9</td>
<td>4.6</td>
</tr>
</tbody>
</table>

EFFECT ON DOWNSTREAM FLOWS FOR DONKERSAN DAM (35 Mm³)
CLIMATE CHANGE

- Reduced rainfall
- Increased evaporation
- Rerunning of the models
STATISTICS OF DECREASING SIMULATED RUNOFF DATA FOR DONKERSAN

<table>
<thead>
<tr>
<th>ANNUAL RUNOFF STATISTIC</th>
<th>RAINFALL REDUCTION (%) FOR THE SYNTHESISED RUNOFF RECORD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0%</td>
</tr>
<tr>
<td>AVERAGE (Mm³)</td>
<td>18.91</td>
</tr>
<tr>
<td>MEDIAN (Mm³)</td>
<td>7.09</td>
</tr>
<tr>
<td>% RUNOFF REDUCTION</td>
<td>0%</td>
</tr>
</tbody>
</table>
THE EFFECT OF RAINFALL REDUCTION ON THE DONKERSSAN DAM YIELDS

<table>
<thead>
<tr>
<th>Assumptions for Storage Volumes</th>
<th>Yields Obtained from the Stochastic Runoff Record</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Supply Capacity (Mm³)</td>
<td>80% Safe Yields (Mm³/a)</td>
</tr>
<tr>
<td>Initial Storage (Mm³)</td>
<td>Rainfall Reduction Factor %</td>
</tr>
<tr>
<td>Dead Storage (Mm³)</td>
<td>0%</td>
</tr>
<tr>
<td>35.00</td>
<td>13.081</td>
</tr>
<tr>
<td>Total (%) Reduction in Yield</td>
<td>0%</td>
</tr>
<tr>
<td>35.00</td>
<td>8.880</td>
</tr>
<tr>
<td>Total (%) Reduction in Yield</td>
<td>0%</td>
</tr>
</tbody>
</table>
CONCLUSIONS

• Synthesised/Stochastic runoff records
• Yield/reliabilities
• Considerable reduction in downstream flow
• % Reduction of runoff > % reduction of rainfall
• The reduction is reflected in the yields as well