Orange Senqu River Commission (ORASECOM)

Project Funding by
German Development Cooperation
SADC Water Sector Cooperation

Orange River Integrated Water Resources Management Plan

Flood Management Evaluation of the Orange River

ORASECOM 003/2007
Date Submitted: October 2008

WRP (Pty) Ltd, Jeffares Green Parkman Consultants (Pty) Ltd, Sechaba Consultants, Water Surveys Botswana and Windhoek Consulting Engineers in association

Water Surveys (Botswana) (Proprietary) Ltd

WRP_FC/0822.cdr

Study Name:	Orange River Integrated Water Resources Management Plan
Report Title:	Water Quality in the Orange River
Submitted By:	WRP Consulting Engineers, Jeffares and Green, Sechaba Consulting, WCE Pty Ltd, Water Surveys Botswana (Pty) Ltd
Authors:	L Hattingh
Date of Issue:	October 2008
Distribution:	Botswana: DWA: 2 copies (Katai, Setloboko)
	Lesotho: Commissioner of Water: 2 copies (Ramosoeu, Nthathakane)
	Namibia: MAWRD: 2 copies (Amakali)
	South Africa: DWAF: 2 copies (Pyke, van Niekerk)
	GTZ: 2 copies (Vogel, Mpho)
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	Environmental Considerations Pertaining to the Orange River
	Summary of Water Requirements from the Orange River
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1 INTRODUCTION

1.1 General

The Orange River originates in the Lesotho Highlands and flows in a westerly direction 2 200 km to the west coast where the river discharges into the Atlantic Ocean (see

Figure 1-1). The Orange River basin is one of the largest river basins south of the Zambezi with a catchment area of approximately 0.9 million km^2.

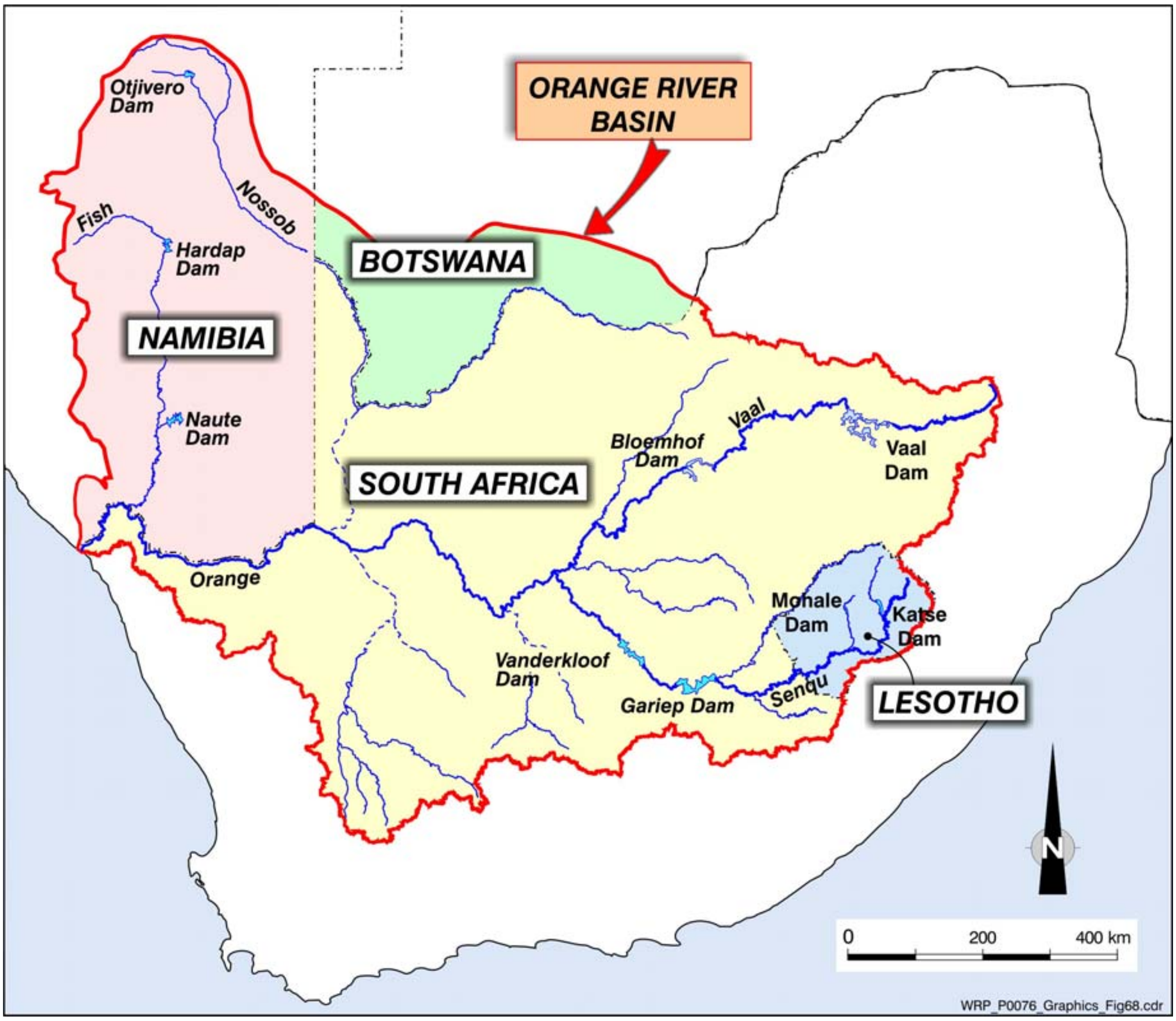

Figure 1-1: Orange River

It has been estimated that the natural runoff of the Orange River basin is in the order of 11 600 million m^3/a of which approximately 4 000 million m^3/a originates in the Lesotho Highlands and approximately 900 million m^3/a from the contributing catchment downstream of the Orange/Vaal confluence which includes part of Namibia and a small portion in Botswana feeding the Nossob and Molopo rivers. Whether or not these two rivers directly contribute to the Orange River is an outstanding issue which will be addressed during the study. The remaining 6 700 million m^3/a originates from the areas contributing to the Vaal, Caledon, Kraai and Middle Orange rivers.

It should be noted that much of the runoff originating from the Orange River downstream of the Orange Vaal confluence is highly erratic (coefficient of variability greater than 2) and cannot be relied upon to support the various downstream demands unless further storage is provided.

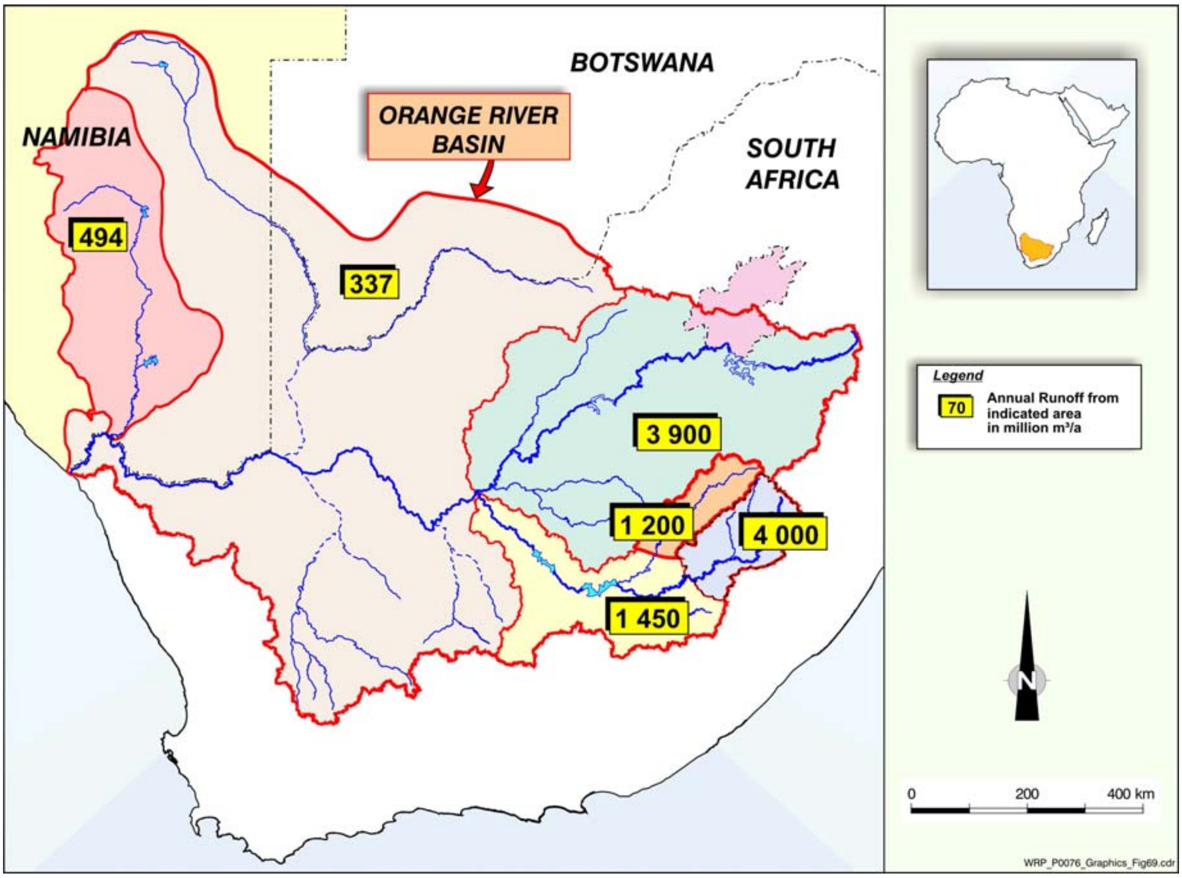

Figure 1-2: Approximate Water Balance for Natural Runoff in the Orange River Basin

The water flowing into the Orange River from the Fish River in Namibia (near the river mouth) could theoretically be used to support some of the downstream demands, particularly the environmental demands at the river mouth. To date, however, the contributions from the Fish River (in Namibia) cannot be utilised to support any downstream demands since these demands are currently supplied with water from Vanderkloof Dam which must be released well in advance since the water takes 2 to 6 weeks to reach the mouth (some 1 400 km away). Any water flowing into the Orange River from the Namibian Fish River will therefore add to the water already released from Vanderkloof Dam since it is currently not possible to stop or store the additional water once it has been released.

The figures indicated in **Figure 1.2** refer to the natural runoff which would have occurred had there been no developments in the catchment. The actual runoff reaching the river mouth (estimated to be in the order of 5 500 million m^3/annum) is considerably less than the natural value (over 11 000 million m^3/annum). The difference is due mainly to the extensive water utilisation in the Vaal River basin, most of which is for domestic and industrial purposes. Large volumes of water are also used to support the extensive irrigation (estimated to be in the order of 1 800 million m^3/annum) and some mining demands (approximately 40 million m^3/annum) occurring along the Orange River downstream of the Orange/Vaal confluence as well as some irrigation in the Lower Vaal catchment and Eastern Cape area supplied through the Orange/Fish Canal. In addition to the water demands mentioned above, evaporation losses from the Orange River and the associated riparian vegetation account for between 500 million m^3/a and 1 000 million m^3/a depending upon the flow of water (and consequently the surface area) in the river (Mckenzie et al, 1993, 1994 and 1995). An approximate water balance for the Orange River is given in **Table 1-1** to provide perspective on the various demands supported from the river.

Table 1.1: Orange River Water Balance at 2005 Development Level

Water Balance Component	Volume (million m³/a)
Environmental Requirement	900 **(1)**
Namibia	120 **(2)**
Lesotho & Transfers to RSA	820 **(3)**
RSA Orange River Demand	2 560 **(4)**
RSA Vaal River Demand	1 560 **(5)**
Evaporation & losses	1 750 **(6)**
Spillage	3 780 **(7)**
Total	**11 490**
Spillage under natural conditions	10 900

Notes (1) - Includes natural evaporation losses from Orange River.

(2) - Includes water use from Orange & Fish rivers.

(3) – With Full Phase 1 of LHWP active.

(4) – Includes transfers to the Eastern Cape.

(5) – Vaal Demand supplied from locally generated runoff.

(6) – Excludes evaporation losses from the as it is already included in component 1.

(7) – Average spillage at 2005 development level

Several new developments have already been commissioned or have been identified as possible future demand centres for water along the Lower Orange River. In Namibia such developments include the Haib copper mine, Skorpion lead and zinc mine (already developed), the Kudu gas fired power station at Oranjemund and several irrigation projects for communal and commercial irrigation along the northern riverbank. Similar potential also exists on the South African side of the river with particular need to develop irrigation for previously disadvantaged farmers. In Lesotho there is considerable development planned for the Lesotho Lowlands area and also the potential for further transfers from the Lesotho Highlands Water Project. In Botswana, the developments that may influence the Orange River are restricted mainly to groundwater abstraction.

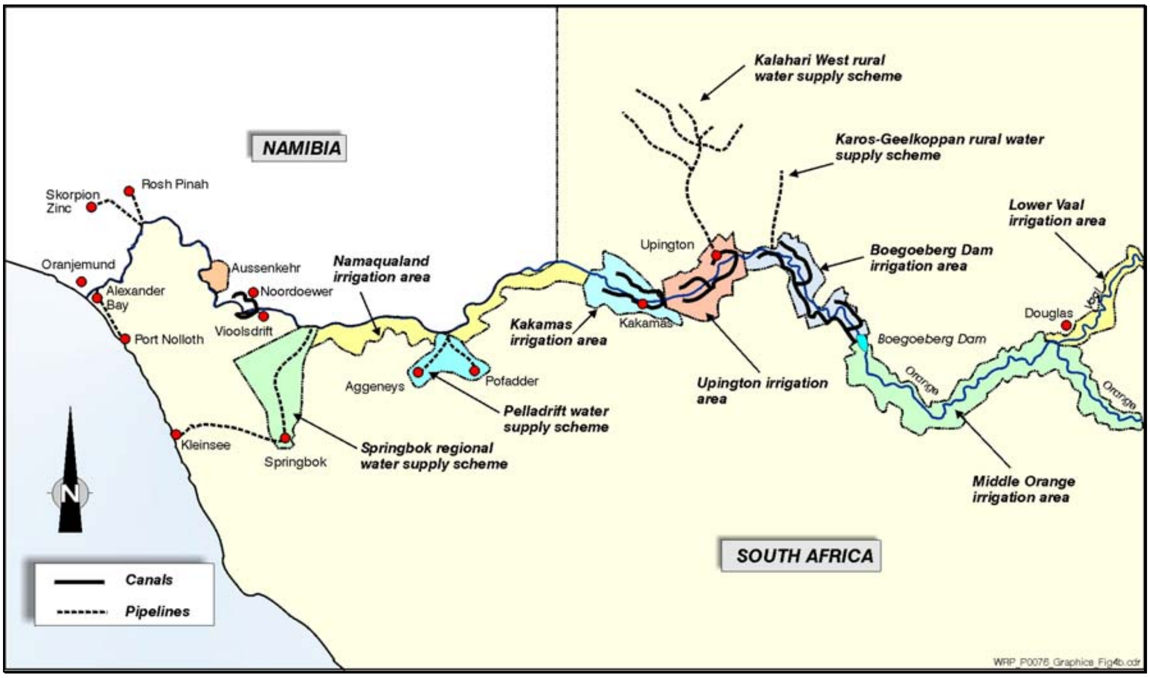

Figure 1-3: Major Water Demands along the Lower Orange River.

In Lesotho, the first phase of the Lesotho Highlands Water Project was recently completed and represents one of the largest water transfer schemes in the world. Some details of the scheme are shown in **Figure 1-5.** It should be noted that the water transfers shown in the figure are approximate values only and are likely to change due to revision of environmental requirements etc.

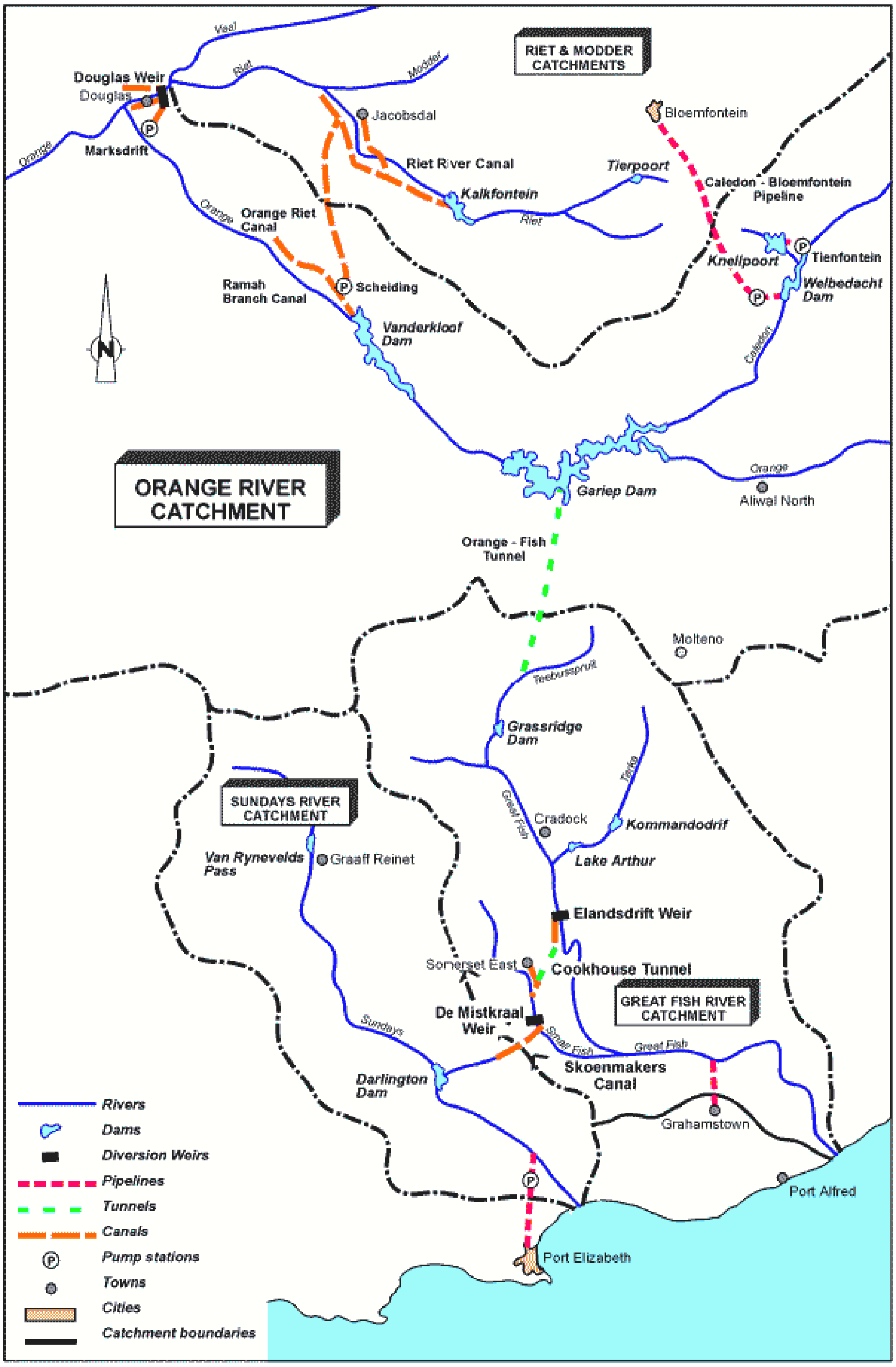

Figure 1-4: Major Water Transfer Schemes from Gariep and Vanderkloof dams.

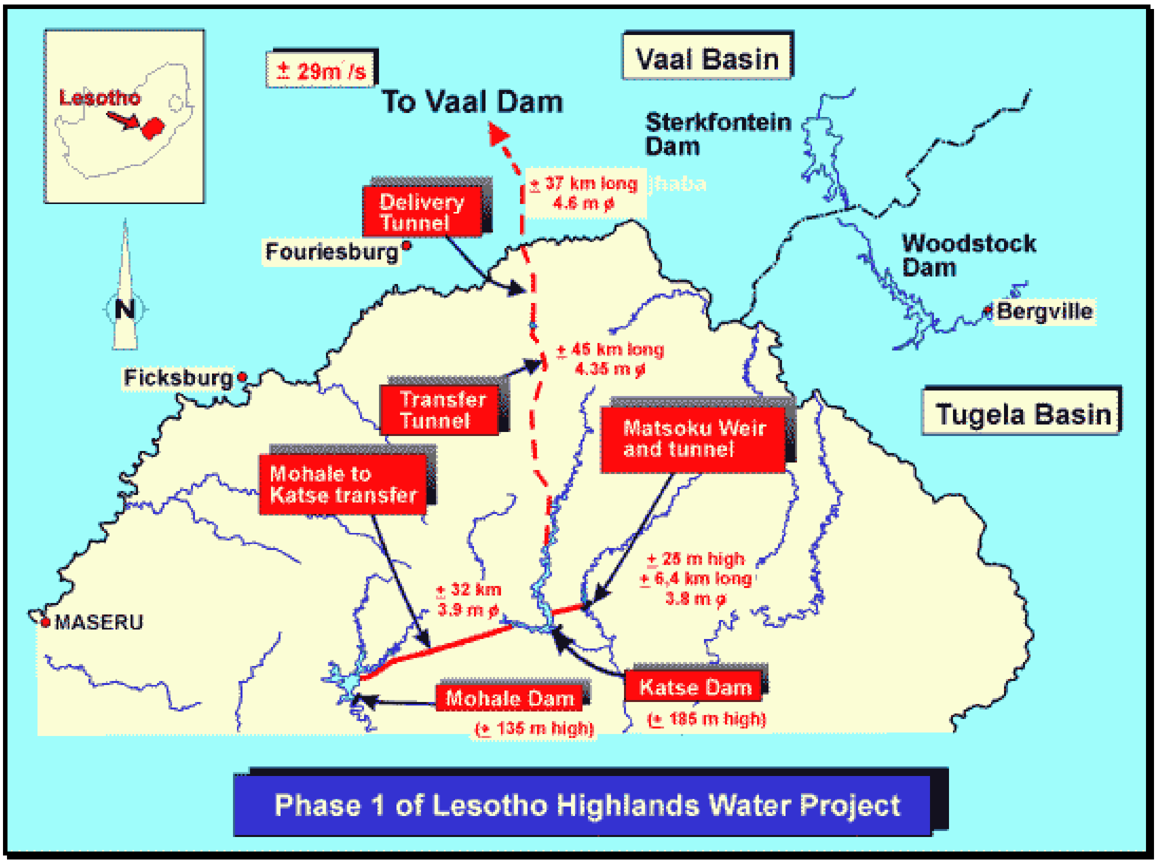

Figure 1-5: Phase 1 of the Lesotho Highlands Water Project.

1.2 Objective of the study

In view of the existing and possible future developments which will influence the availability of water in the Orange River, a project has been initiated by ORASECOM and commissioned and funded by GTZ involving all four basin states (Botswana, Lesotho, Namibia and South Africa. The main objective of the project is to facilitate the development of an Integrated Water Resources Management Plan for the Orange River Basin. The plan will in turn facilitate the following specific objectives:

- Maximise benefits to be gained from Orange River water;
- Harmonise developments and operating rules;
- Foster peace in the region and prevention of conflict;
- Encourage proper and effective disaster management;

- Ensure that developments are sustainable and encourage the maintenance of bio-diversity in the basin, and
- Management of potential negative impacts of current and possible future developments.

In order to achieve the above objective it is envisaged that the resulting Water Resources Development Plan will be founded on the following four basic principles:

- Reasonable utilisation of available water resources;
- Equitable accrual of benefits to basin states;
- Sustainable utilisation of water resources, and
- Minimisation of harm to the environment.

The strategy to be adopted by the project team to meet the objectives should involve the following:

- Sharing of information on existing and proposed future developments;
- Facilitation of a common understanding of key issues based on comparable technical and institutional capacity;
- Development of comparable legislation and institutional structures;
- Adoption of comparable standards and management approaches;
- The development of a Water Resource Management Plan for the future development and management of the water resources of the Orange River.

It is anticipated that the development of the Water Resource Management Plan will be undertaken in phases and the remainder of this document refers to the work involved with Phase 1 of the project. Phase 1 will involve the following:

- A desktop study to establish the status quo within the basin and to create an agreed base from which the subsequent phases of the project can be developed;
- To facilitate capacity building where possible in order to strengthen expertise throughout the four basin states;
- To identify and highlight deficiencies in the knowledge base which must be addressed before the Water Resource Management Plan can be finalised. Some fieldwork may be required in subsequent phases of the project;
- To develop a preliminary Water Resource Management Plan which can be used as the basis from which the final plan can ultimately be developed;

- To develop a draft scope of work for subsequent phases of the project from which a Terms of Reference can be developed by the Client.

An inaugural meeting to discuss the project and in particular the expected content for the Inception Report was held in Botswana on 8 February 2004.

1.3 Purpose and structure of report

The purpose of this report is to establish the status quo of flood disaster management in the Orange River catchment on a reconnaissance level and to make recommendations regarding gaps and possible improvements.

This document includes a brief overview of the areas prone to flooding in **Section 2**. **Section 3** then provides a brief description of the flood forecasting capabilities for the Orange River Basin while **Section 4** and **5** provides an overview of the flood control works and the reservoir operating strategies for all major reservoirs respectively. Finally, **Section 6** provides an overview of existing disaster management strategies.

2 AREAS PRONE TO FLOODING ON A GLOBAL SCALE

The areas that are prone to flooding can be divided in two distinct categories, namely those with human settlement areas (settlements, towns, cities) where flooding can lead to loss of life and direct and indirect financial, social, socio-economic and environmental impacts and irrigation farmland where flooding normally leads to direct and indirect financial, social, socio-economic and environmental impacts (see **Figure A-1** in **Appendix A** for the location of the major human settlement areas prone to flooding).

It is also important to note that **Task 3** (ORASECOM: 2007) summarises the physical characteristics of the various existing water resources infrastructure (including dams and irrigation schemes) and these characteristics will not be repeated in this report.

2.1 Botswana

On a global scale no human settlement or irrigation farmland are threatened as a result of being close to a major river in the Orange River Basin in Botswana.

2.2 Lesotho

The large majority of habitation as well as farming take place in the lowlands in Lesotho (the Caledon catchment). These lowlands are also prone to frequent flooding resulting in the occasional loss of life as well as frequent loss of agricultural production.

2.3 Namibia

The area downstream of Hardap Dam (in particular Mariental town, the Hardap irrigation scheme as well as the major north-south road network) is prone to frequent flooding. It is also important to note that the irrigation areas on the banks of the Orange River are also prone to flooding. After the 2006 flood event an investigation has lead to a decision to raise Hardap Dam to increase its attenuation capacity, to construct a levy system around Mariental town for protection and to clean excess vegetation (reeds) from the river channel.

2.4 South Africa

It is important to note that Emergency Preparedness Plans should exist for the area downstream of each dam classified to have a safety risk according to Dam safety legislation. These plans in general include an inundation map of the dam break flood. There is, however, still a large percentage of required Emergency Preparedness Plans outstanding. It is recommended that these plans be completed as a matter of urgency.

2.4.1 Vaal River System

The main human settlement areas in the Vaal River System prone to flooding are downstream of Grootdraai Dam and Vaal Dam respectively and include towns like Standerton, Vereeniging and Parys. Most of the formal irrigation schemes in this system are situated close to the main rivers and are therefore also prone to flood damage.

A detail inundation map has also been developed for the main stem of the Vaal River from Vaal Dam to the confluence of the Vaal River and the Orange River for different flood sizes.

2.4.2 Upper Orange System (excluding Lesotho)

Except for Aliwal North and Hopetown on the banks of the Orange River and Wepener on the banks of the Caledon River, no other major human settlement is located close to a main river. It is interesting to note that a section of Wepener was relocated as a result of flooding due to the backwater effect of the siltation of Welbedacht dam. Most of the formal irrigation schemes in this system are situated close to the main rivers and are therefore also prone to flood damage.

2.4.3 Lower Orange River System

The main human settlement areas in the Lower Orange River System around especially Upington, Prieska, Keimoes and Kakamas are prone to flooding. Most of the formal irrigation schemes in this system are situated close to the main stem of the Orange River and are therefore also prone to flood damage.

3 FLOOD FORECASTING CAPABILITIES

It is important to note that the South African Development Community has a co-ordinated initiative called "Regional Flood Watch" that is available on its website (http://www.sadc.int/floods/rfw.php). It summarises flood and rainfall information from a large number of both international and local information sources and provide a country view where necessary.

3.1 Botswana

The Botswana Department of Meteorological Services (http://www.weather.info.bw/) provides a number of rainfall forecasting services in association with the US National Oceanic and Atmospheric Administration as well as the South African Weather Service. It can in general be categorised as long and short to medium term forecasts and are focused primarily on aviation and agriculture. The long-term forecast normally takes the form of a pre-season assessment while the short to medium term forecasts takes the form of rainfall forecasts using mathematical models, satellite and radar information.

3.2 Lesotho

Similar to its Botswana counterpart, the Lesotho Meteorological Services (http://www.lesmet.org.ls/) provides a number of rainfall forecasting services. It can in general be categorised as long and short to medium term forecasts and are also focused primarily on aviation and agriculture. The long-term forecast normally takes the form of a pre-season assessment while the short to medium term forecasts takes the form of rainfall forecasts using mathematical models and satellite imagery.

3.3 Namibia

The Namibia Meteorological Service (NMS) (http://www.meteona.com/) provides a number of rainfall forecasting services which can possibly be used as early flood warning. It can in general be categorised as long and short to medium term forecasts. The long-term forecast normally takes the form of a pre-season assessment while the short to medium term forecasts takes the form of rainfall forecasts using mathematical models. It is recommended that the accuracy of the NMS short term prediction models should be tested independently over a period of a couple of years before a final decision is made regarding its applicability in operational decision-making.

In addition to rain forecasting, use are also made of a rainfall and water level monitoring system by Namwater as well as rain gauging by NMS during rainfall events to determine the extent and magnitude of the event.

The NMS was planning to construct a radar system at Windhoek for rainfall prediction as well as monitoring purposes. It was planned that the range of the station would include the Hardap catchment and possible also the catchment downstream of Hardap Dam that joins the Fish before Mariental town. This station has subsequently been put on ice. It is recommended that the feasibility and implementation of such a station be investigated.

3.4 South Africa

The South African Weather Service (SAWS) (http://www.weathersa.co.za/) provides a number of rainfall forecasting services which are used as early flood warning. It can in general be categorised as long and short to medium term forecasts. The long-term forecast normally takes the form of a pre-season assessment while the short to medium term forecasts takes the form of rainfall forecasts using mathematical models using information from satellites as well as radar.

In addition to rainfall forecasting by SAWS, use are also made of a rainfall and water level monitoring system by the South African Department of Water Affairs and Forestry (DWAF) as well as rain gauging by SAWS during rainfall events to determine the extent and magnitude of the event.

Interviews with officials representing entities within DWAF highlighted the following general problems with respect to flood forecasting capabilities:

- A decreasing number of operational rainfall gauging stations;
- Vandalism of gauging station equipment, especially solar panels and cellular modems;
- An insufficient number of real-time flow gauging stations, both in controlled and uncontrolled water management systems;
- Most flow gauges are designed for low flow conditions and not to cope with extreme floods;
- Communication problems in floods situations;
- Existing rainfall-runoff forecasting models need improvement;
- Inadequate manpower available for operational and flood documenting functions; and
- Limited flood line analyses information available for hazard determination.

4 FLOOD CONTROL WORKS

No specific structures exist in the Orange River Basin that was specifically constructed for flood control. Dams, however, in general have an attenuating effect on floods. The attenuation of a flood is directly related to size of the storage capacity of the reservoir of a dam (the larger the capacity the more attenuation of a flood would take place). Dams with gated spillways, however, can be operated differently depending on the size on the incoming flood. In the remainder of the chapter the existence of dams with significant storage especially those dams with gated spillways will be discussed in more detail (see **Figure A-1** in **Appendix A** for the location of the major dams as well as whether they have uncontrolled or gated spillways).

It is also important to note that **Task 3** (ORASECOM: 2007) summarises the physical characteristics of the various existing water resources infrastructure (including dams) and these characteristics will not be repeated in this report.

4.1 Botswana

As Botswana have no major dam situated within the Orange River Basin.

4.2 Lesotho

The main flood control structures in Lesotho comprise of Katse Dam and Mohale Dam which forms part of the Lesotho Highlands Scheme. Both these dams have uncontrolled spillways and their outlet works have primarily been designed to release environmental flows. Natural flood attenuation as a result of the size of each reservoir is therefore the only flood control that would take place during flood events. It should, however, be noted that the releases from the outlet works of both these dams could cause some localized flooding in the vicinity of the dam walls especially during “sunny day” releases.

None of the other structures for example Matsoku Weir and Muela Dam is of sufficient size or has a large enough catchment for significant flood attenuation.

4.3 Namibia

There are seven dams within the Orange River Basin in Namibia. The largest dam (Hardap Dam) is the only dam with a gated spillway while all the other dams (Oanab Dam, both Otjivero Dams, Daan Viljoen Dam, Tilda Viljoen Dam and Naute Dam) have uncontrolled spillways and outlet works that have only been designed to release small flows. Natural flood attenuation as a result of the size of these reservoirs with uncontrolled spillways is therefore the only flood control that would take place during flood events.

It is important to note that the releases from Hardap Dam could cause flooding downstream of the dam wall especially during "sunny day" releases. Sufficient warning of such releases is therefore essential.

4.4 South Africa

4.4.1 Vaal River System

The main flood control structures on the main stem of the Vaal River System comprise of three gated dams namely Grootdraai Dam, Vaal Dam and Bloemhof Dam. There are also a number of smaller gated structures on the main stem for example Vaal Barrage and Vaalharts Weir. It is important to note that the releases from these dams/weirs could cause flooding downstream of the dam walls especially during "sunny day" releases. Sufficient warning of such releases is therefore essential.

The main flood control structures on various tributaries comprise main dams with uncontrolled spillways and outlet works that have primarily been designed to make releases for the various water uses as well as environmental flows. Natural flood attenuation as a result of the size of each reservoir is therefore the only flood control that would take place during flood events. These dams include:

- Upper Vaal Sub-system
  - Saulspoort Dam;
  - Sterkfontein Dam;
- Middle Vaal Sub-system
  - Erfenis Dam
  - Allemanskraal Dam;
  - Koppies Dam;
  - Klipdrift Dam;
  - Boskop Dam
  - Klerkskraal Dam;
  - Rietspruit Dam;
- Lower Vaal System
  - Spitskop Dam;
  - Taung Dam;

  - Wentzel Dam;

4.4.2 Upper Orange River System (excluding Lesotho)

The main flood control structures on the main stem of the Upper Orange River System comprise of two uncontrolled dams namely Gariep Dam and Vanderkloof Dam. It is, however, important to note that the both these dams have significant outlet works as well as hydro-electrical power stations that can make releases that could cause flooding downstream of the dam walls especially during “sunny day” releases. Such releases have resulted in the loss of life in recent years. Sufficient warning of such releases is therefore essential. There are one gated dam (Welbedacht Dam) on the Caledon River. This dam has, however, silted up to such an extent that its attenuation capacity has greatly reduced since its completion in the 1960’s.

The main flood control structures on various tributaries comprise main dams with uncontrolled spillways and outlet works that have primarily been designed to make releases for the various water uses as well as environmental flows. Natural flood attenuation as a result of the size of each reservoir is therefore the only flood control that would take place during flood events. These dams include:

- Caledon Sub-system
  - Knellpoort Dam;
  - Armenia Dam;
  - Egmont Dam;
- Modder/Riet Sub-system
  - Kalkfontein Dam
  - Tierpoort Dam;
  - Krugerdrift Dam;
  - Rustfontein Dam;

4.4.3 Lower Orange River System

The main flood control structures on the main stem of the Lower Orange River System comprise of a number of smaller structures with uncontrolled spillways for example Boegoeberg Dam and Neusberg Weir. These structures offer very limited attenuation to floods on the main stem.

There is only one significant flood control structure on a tributary namely Smart Syndicate Dam. This dam has an uncontrolled spillway and outlet works that have primarily been designed to make releases for irrigation. Natural flood attenuation as a result of the size of the reservoir is therefore the only flood control that would take place during flood events.

5 RESERVOIR OPERATING STRATEGIES FOR ALL MAJOR RESERVOIRS

It is important to understand that the majority of dams are operated by both long term operating strategies as well as short term operating rules for use during flood conditions. The purpose of the long term operating strategies normally is to ensure the optimum use of the relevant water resource (these operating rules are discussed in more details under **Task 3** (ORASECOM: 2007)). With regards to the short term operating rules (including flood routing procedures) that are used during flood conditions, international accepted practice have it that the routing procedures should satisfy the following in order of importance:

- The safety of the dam as first priority (the impact of a dam failure would be catastrophic in terms of possible loss of life, direct and indirect financial, social, socio-economic and environmental impacts compared to any other impact or issue); and
- Second priority would be to minimise possible loss of life (maximise public safety) as well as to minimise other impacts during flood events (for example direct and indirect financial, social, socio-economic and environmental impacts) – especially during flood events probability of exceedance of more than 0.5%.

These short term operating rules (including flood routing procedures) are especially applicable to dams with controlled spillways and/or significant flood outlet works as no short term operating rule is applicable to dams with uncontrolled spillways and insignificant outlet works as the operator in this case would no control over the releases from the dam.

5.1 Botswana

As Botswana have no major dam situated within the Orange River Basin there is therefore no reservoir operating strategies in place.

5.2 Lesotho

There are Operations and Maintenance Manuals as well as Emergency Preparedness Plans available for both Katse Dam, Mohale Dam as well as Muela Dam.

5.3 Namibia

For Hardap Dam the flood routing procedures were updated in 2007 to satisfy the above-mentioned international practice as a consequence of the 2006 flood event. A detail "Flood

Management Strategy" is annually compiled by NamWater and updated on an annual basis in October/November for the upcoming flood season. The purpose of this manual is to set down guidelines that facilitate the activities and responsibilities that are critical for flood releases from Hardap Dam and includes:

- Responsibility for flood control;
- Chain of communication and action; and
- Annual procedures which include updating the telephone contact list, pre-season activities, activities during the rainy season during both communication breakdown and normal communication periods (described in more detail in following section) as well as post-season meetings.

In general operation decisions are made on an hourly basis in the Windhoek offices of Namwater during flood events using all available information from the existing early warning and monitoring system together with a spreadsheet-based flood routing procedure. This decision is then communicated to the operator at the dam. It is also important to note that the procedures followed compare favourably with similar procedures used for gated dams in South Africa.

Should communications with the operator breakdown for more than a certain period of time, the operator will use the short operating rule set out in the "Flood Management Strategy" to operate the dam.

5.4 South Africa

Short term operating rules for all the gated dams (Vaal Dam, Grootdraai Dam etc.) as well as dams such as Gariep Dam and Vanderkloof Dam with significant outlet works is normally compiled by Directorate: National Water Resources Planning Systems of DWAF. In addition to this Operation and Maintenance Manuals as well as Emergency Preparedness Plans should be compiled for each dam classified to have a safety risk according to Dam safety legislation.

The Operation and Maintenance Manuals normally includes the short term operating rules while the Emergency Preparedness Plans include the following:

- An inundation map of the downstream area; and
- Responsibility, chain of communication and action during emergencies.

In addition to this a Flood Management Center (FMC) is operated by DWAF’s national office. The main functions of the FMC are among other things:

- The continuous, real-time monitoring of rainfall and flows in the Vaal and Orange Rivers; and
- The management of these river systems in extreme flood situations.

It is important to note that both these rivers are managed as a system and not as individual dams to minimize flood damage and to maximize storage after the flood situations.

The following information is received by the FMC and is used for flood-related modeling and flood forecasting:

- Real-time rainfall and flow data; and
- Weather forecasts.

In return the FMC provides:

- Flood warnings to Regional Offices, international neighbours and the public, as appropriate;
- Flood management decisions for major dams;
- Real-time flow data on the internet; and
- Post-flood calculations and documentation.

6 EXISTING DISASTER MANAGEMENT STRATEGIES

6.1 Botswana

Following the United Nations International Decade for Natural Disaster Reduction, the Government established a National Committee on Disaster Preparedness (NCDP) in 1993. However, in 1996, the Government formulated the National Policy on Disaster Management. The programme dealt with disaster management comprehensively by giving equal focus to all disaster management elements (prevention/mitigation, preparedness, response and recovery).

The overall responsibility for disaster management rests with the Office of the President. In 1998, the National Disaster Management Office (NDMO), responsible for overall coordination of disaster management in the country established. Its major responsibility is to ensure a high state of disaster preparedness and capacity to deal with any eventuality. It also has to facilitate integration of disaster management into sectoral polices and programmes. In addition to this there is also an inter-ministerial National Committee on Disaster Management, the National Disaster Management Technical Committee which is a multi-sectoral technical advisory body composed of professionals from all stakeholders represented in the NCDM and District Disaster Management Committees for each city/town and District to oversee the implementation of disaster management in districts.

The National disaster relief fund was established in 1996 and is administered by the NDMO. Its purpose is to provide assistance to natural disaster victims to meet their life sustaining needs such as shelter, food and provision of sanitary facilities.

Though the Policy and the above structures exist, the country doesnot have other instruments like a National Disaster Management Plan and relevant legislation in place.

6.2 Lesotho

Lesotho first promulgated its Disaster Management Act in 1997 which was followed by the development of a National Disaster Management Plan and the Disaster Management Plan to operationalise the plan. As a consequence the Disaster Management Authority (DMA) (a department in the Office of the Prime Minister) was established as well as the Board of Directors and the multi-sectoral working groups at national, district and community/village levels. Finally, a Disaster Management Fund has been established to which funds are committed on an annual basis and which is managed by the DMA.

6.3 Namibia

In Namibia disaster management is the responsibility of the Emergency Management Unit (EMU) in the Office of the Presidency. A National Disaster Plan has been compiled by the EMU. The Disaster Plan serves as a guideline for co-ordination of disaster programmes and activities. It also makes provision for a National Emergency/Disaster Fund managed by the EMU. The National Flood policy and strategy forms part of the National Disaster Plan and are the responsibility of the Minsiter of Agriculture, Water and Rural Development. At lower levels the Regional, Constituency and Village Emergency Management Units are responsible or co-ordination and management of emergency activities.

6.4 South Africa

In contrast with Botswana, but similar to Lesotho, South Africa first promulgated its legislation (Disaster Management Act No 57 of 2002) which was followed by a Disaster Management Framework that set out the operationalisation of the act. As a consequence both the Intergovernmental Committee on Disaster Management as well as the National Disaster Management Advisory Forum (NDMAF) was established. These institutions are responsible for changes in policy. In addition to this a National Disaster Management Centre (NDMC) has been established and is functional as well as Provincial and Municipal Disaster Management Centers. Flood disaster relief funds are administered by DWAF on behalf of the NDMC.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

7.1.1 Areas prone to flooding on a global scale

Sufficient information is available on areas prone to flooding to provide a clear picture for the purposes of this study. Should one however want to develop a detail flood disaster management plan more detail information in the form of inundation maps for different floods sizes for all the main rivers would be required.

7.1.2 Flood forecasting capabilities

Flood forecasting capabilities exist for the whole Orange River Basin. Uncertainty however, exists on the use of rainfall forecasts in operational decisions. Concern have also been expressed regarding the lack skilled human resources and financial resources, an insufficient, diminishing and vandalized monitoring network and the accuracy of the especially short term rainfall prediction models.

7.1.3 Flood control works

Sufficient information is available on flood control works for the purposes of this study.

7.1.4 Reservoir operating strategies for all major reservoirs

Sufficient information is available on reservoir operating strategies for the purposes of this study. Should one however want to develop a detail flood disaster management plan more detail information of the short term reservoir operating strategies for each dam would be required.

7.1.5 Existing disaster management strategies

A detail flood disaster management plan would require more detail information on specific flood disaster management strategies applicable in each country as well as an integrated approach.

7.2 Recommendations

The following recommendations are made as a result of this task:

- Inundation maps for different floods sizes with certain probabilities of occurrence should be compiled for all the main rivers;
- The Emergency Preparedness Plans should be compiled for all dams in the

Orange River Basin;

- The various problems identified with flood forecasting as well as South Africa's Flood Management Center should be investigated in more detail and a integrated solution should be proposed to the stakeholders;
- The short term rainfall prediction models used in Namibia should be tested independently over a period of a couple of years before a final decision is made regarding its applicability in operational decision-making;
- The feasibility and implementation of a radar system at Windhoek for rainfall prediction as well as monitoring purposes should be investigated;
- Evaluated the short term reservoir operating strategies for each dam in the River Basin;
- Investigate the specific flood disaster management strategies applicable in each country and propose an aligned and co-ordinated approach for this River Basin.

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INTEGRATED WATER RESOURCE MANAGEMENT PLAN
FOR THE ORANGE-SENQU RIVER BASIN

Orange River Basin: Areas prone to flooding and flood control structures

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